

Historical Changes in Land-Labour Relationships in Western Europe¹

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1. Introduction

The relative importance of the agricultural sector declines with economic development. This phenomenon is well documented by the decrease in the share of the agricultural labour force in the total labour force, and the agricultural contribution to the GNP. The price- and income-inelastic demand for agricultural goods, the provision of production-enhancing and labour-saving technological changes and the low opportunities for product innovations have been identified as the main reasons behind this empirical observation².

These characteristics pose restrictions on the ability of the agricultural sector to keep pace with the development of factor incomes in other sectors. This weakens the position of agriculture in the competition for scarce resources and promotes the transfer of resources into other sectors (labour and capital; the latter in the form of savings)³. There has been intensive debate among politicians, economists and scholars in other fields of science, especially in history and sociology, over which type of agricultural organisation promotes the most efficient mobilisation of its potential contributions to economic development⁴. In this study, the various points of view

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² A discussion of these determinants can be found in Chenery and Syrquin (1975).

³ Beside the provision of factor inputs, other ways exist in which greater agricultural productivity contribute to an economy's development. These are the supply of foodstuffs and raw materials to other expanding sectors, the demand of the rural population for products of these sectors and the relaxing of the foreign exchange constraint. See Kuznets (1965).

⁴ The political dimension spans from the agricultural emancipation movement in the eighteenth and early nineteenth century in Western Europe to the collectivization of agriculture in the former Soviet Union in the 1920s, and the present discussion of the

taken in these discussions cannot be even briefly summarised. Most of the economic analyses focus on a decomposition of labour productivity in the land-man and land productivity. This decomposition not only forms the basis for a global analysis of development within a given country, but is also used in order to compare the efficiency of agricultural adjustment processes between different countries.

The main purpose of this paper is to question the usefulness of this macroeconomic approach for explaining and evaluating structural change in agriculture. We will not only discuss the quality of the available data for the analysis of this problem, but also question the implications derived from this approach for identifying the efficiency of agricultural production. On the basis of a neo-classical approach to agricultural production, which explicitly takes the options for factor allocation into consideration, we offer an alternative – the microeconomic approach for the analysis of structural change. Nonetheless, we will not be able to perform a comprehensive empirical analysis, but rather will present some observations that may justify our approach.

In Section 2, we will present the conventional view of land-labour relationships by showing the development of land-man ratios within various countries. The aim of this analysis is not only to provide a general impression of changes that have occurred in Western European countries, but also to identify such periods in which different adjustment processes in agricultural production have taken place. The data covers Germany, France and the United Kingdom in the period from 1880-1990⁵. In Section 3, we

privatization of state-owned land in eastern Germany. For the latter see Hagedorn (1996). Compare also the discussions about land reforms in developing countries in de Janvry (1981).

⁵ This period is chosen due to the availability of data. This means that the effects resulting from the agricultural emancipation movements from the early eighteenth to the mid - nineteenth century (enclosures in the United Kingdom, the Prussian reforms in Germany, and the French Revolution) are reflected in the agricultural structures observable at the end of the nineteenth century and have to be treated as given. A discussion of these processes can be found in Clapham (1948), Allen (1994), Slater

will present a simple model which explicitly considers various options for the allocation of agricultural resources. Section 4 deals with the implications of the model with regard to structural change. Typical patterns of structural adjustment will be deduced from this model and then compared to the actual development within the countries. The empirical analysis relies upon data on farm size and agricultural labour input. The problem as to what extent this model is suitable as a basis for an analysis and evaluation of structural changes in agriculture will be discussed in Section 5. This section also provides a conclusion of our analysis by summarising the main arguments.

2. Land-Labour Ratios and Agricultural Production Technologies

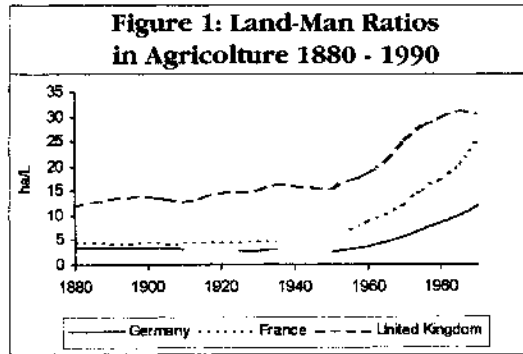
2.1 Development of Land-Man Ratios. In order to give an initial impression of the changes in land-labour relationships, we will present data on the development of land-man ratios⁶. We define land input as the aggregate of arable land, meadows and pastures. Although no distinction is made with respect to the intensity of usage, this definition nevertheless corresponds to the amount of land actually used for agricultural production. Our index of labour input consists of the total number of male and female persons employed in agricultural production. No adjustment is made with respect to the time, which these groups effectively devote to agricultural production. So, our definition can be regarded only as a general approximation to actual agricultural labour input⁷.

(1968) and Henning (1988). In our selection of countries, we will be a long way from describing all the potential options European countries may have chosen during their development. However, the comparison of France and the United Kingdom is one of the most common in the literature that discusses the interactions between structural arrangements in agriculture and economic growth. Germany was added to these two countries, because of the availability of the data.

⁶ A description of the construction of the data sets is available in the Appendix.

⁷ The implication of this approximation will be discussed in more detail in Sections 3 and 4 below. See also Schmitt (1988) and (1989).

Figure 1 shows that the period under investigation can be divided into two sub-periods. The first ranges from 1880 until the



beginning of World War II and the second from 1950 until the present. During the first period, the land-man ratio remains relatively constant in France, whereas in Germany this proportion shows a slight decrease and in the United Kingdom a slight increase. In contrast to the first period, the second period was characterised by rapid growth in land-man ratios.

Slight changes in land-man ratios during the first period do not necessarily imply lack of gains in efficiency in agricultural production. A commonly used method to determine such gains is to decompose labour productivity (Y/L) as follows:

$$\frac{Y}{L} = \frac{Y}{A} \frac{A}{L}, \text{ with } \frac{Y}{A} \text{ land productivity}$$

or in growth rate form,

$$W_{Y/L} = W_{Y/A} + W_{A/L} \cdot \frac{A}{L} \text{ land-man ratio,}$$

Annual growth rates of land and labour productivity ($W_{Y/A}$ and $W_{Y/L}$ respectively) are represented in Table 1. Between 1880 and 1937, only a relatively small increase in land as well as in labour productivity can be observed. The smallest changes occurred in the United Kingdom, where land productivity even showed a slight decrease. In Germany and France labour productivity increased at

nearly the same rate. In Germany land productivity rose more rapidly than labour productivity, whereas in France the ratio was reversed. However, as the development of land-man ratios suggests (Figure 1), the differences between the growth rates of land and labour productivity were relatively small; this implies that the increases in both productivities contributed almost equally to the gains in efficiency in agricultural production.

		labour land productivity	
France	1880-1937	0.91	0.73
	1951-1990	5.55	2.06
Germany	1880-1937	1.03	1.30
	1951-1990	5.95	2.22
United Kingdom	1880-1937	0.44	-0.02
	1951-1990	3.60	1.75

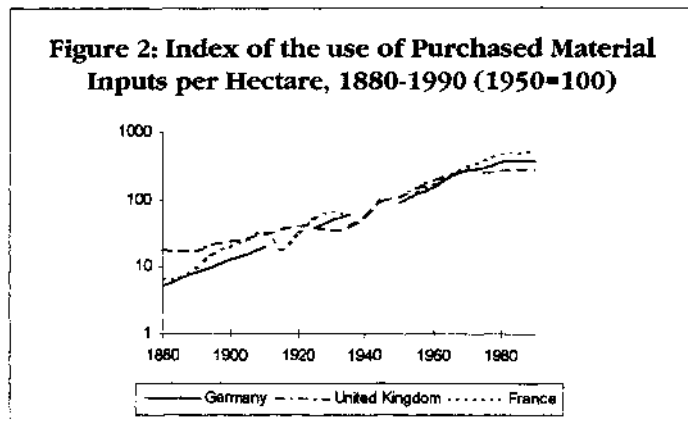
Table 1 shows that after 1950, labour productivity as well as land productivity rose at a significantly higher rate than in the first period. Since the growth in land productivity contributed much less to an increase in labour productivity compared to that before World War II, the land-man ratios in the given countries increased significantly, as depicted in Figure 1.

The data discussed thus far suggest that a vital change took place in the availability and in the use of resources in agriculture after 1950. Since land input remained relatively constant over time, the most dramatic changes can be expected to have occurred in labour, machinery and other purchased material inputs. From Figure 1, it follows that labour input in agriculture remained relatively constant until the 1940s. After World War II, migration from agriculture into other sectors of the economy started, leading to a steady increase in land-man ratios. The changes of the other inputs since 1880 will be analysed, using Figures 2 and 3⁸.

⁸ The description of these figures follows arguments that result from the 'induced innovation hypothesis'. See Hayami and Ruttan (1985).

2.2 Adjustments in Agricultural Production Technologies. Figure 2 presents the development of the use of purchased material inputs in agriculture. For the period after 1950, the aggregate 'intermediate consumption' as represented in the national account statistics was used for an approximation of these inputs. Unfortunately, corresponding data were not available for the time period prior to World War II. The series were completed by assuming that the use of purchased material inputs was proportional to the use of fertiliser input measured by the simple aggregate of nitrogen, phosphate and potassium.

Contrary to the development of land-man ratios, no significant break can be observed in the use of purchased material inputs. Figure 2 shows that the changes in the use of these inputs in Germany could be approximated by a straight line, implying a relatively constant rate of change over time. The same conclusion also holds for the other two countries, although there were more periodical variations in the index.



It would be beyond the scope of this study to analyse the various determinants in the use of purchased material inputs. However, in the following analysis, some patterns common to all three countries will be presented without making reference to the actual importance of the different factors within the countries.

The principles of plant nutrition were discovered in the first half

of the nineteenth century⁹. However, although knowledge about these principles had been widely propagated, the level of mineral fertilisation was relatively low until the end of this century. In this period, apart from manure produced on the farms, the main source of nitrogen fertiliser was guano, which had to be imported into Europe. An increase in fertiliser input was not only fostered by innovations outside of agriculture (such as the development of the Haber-Bosch process to produce ammonia or the Thomas-process, an innovation which provided phosphorus fertiliser as a by-product of steel production), but also by complementary innovations within the agricultural sector like new seed varieties that were more responsive to a higher intensity of fertiliser use. However, until the 1930s, the levels of mineral fertiliser application only approximated to that of manure fertiliser (Dovring 1965a).

Pesticides are the second major group of purchased material inputs. Scientific methods for the development of these inputs were discovered mainly after World War II. As in the case of fertilisers, an increase in these inputs was due to a set of complementary innovations (which included process innovation for already existing pesticides and the discovery of scientific methods which permitted the development of new pesticides) as well as those effects of modern agricultural production which may have increased the susceptibility of plants to various diseases (e.g. high intensity of fertiliser use, slow crop rotation, high plant density etc.).

Because it includes animal production, changes in land productivity are only a rough indication of the impact of these innovations. Nonetheless, an impression of the impact of fertilisers and pesticides on agricultural production can be deduced from Table 1. The low growth rates of land productivity shown until the 1930s resulted not only from the low intensity of fertiliser usage, but from the concentration of their usage on relatively large farms and farms close to industrial centres, which could profit from a well-developed

⁹ The principles of modern fertilization were discovered at about the same time by Boussingault in France, von Liebig in Germany, and Lawes in the United Kingdom (Dovring 1965a).

infrastructure. Subsequent improvements in the complementary innovations increased not only the availability of fertilisers and pesticides, but also reduced the prices of these inputs. In this manner, together with a steady increase in the plants' responsiveness to the application of fertiliser, the use of mineral fertilisers and pesticides became a standard method to increase the per hectare production and the income generated from agriculture¹⁰.

Figure 3 shows the development of machinery input. For the period from 1950 to 1990, the time series corresponds to the equipment used for agricultural production in each country. These data were not available for the time prior to World War II. Therefore, the series had to be completed by using the data on horsepower input as estimated by Andrews et al. (1979) and Wade (1981).

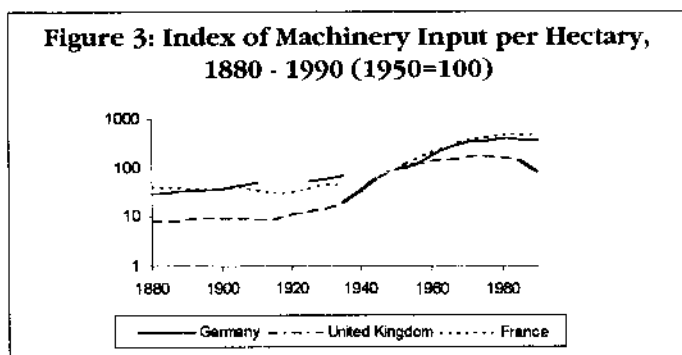
While the use of purchased material inputs was characterised by relatively constant rates of change, the development of machinery input per hectare can be divided into at least three phases. In the first phase, until the 1940s, machinery input increased at a relatively slow rate. From the 1940s to the 1970s, each country experienced a very high growth rate of agricultural mechanisation. During the last 20 years, this rate slowed down again and machinery input increased at almost the same rate as previous to the 1940s¹¹.

Figure 3 reveals not only the inter-temporal differences in agricultural mechanisation, but also shows that inter-country differences in machinery input were much more pronounced than

¹⁰ Whether these adoptions have led to the effects Cochrane (1958) has described in his treadmill theory cannot be analyzed in this context. However, the change in real producer prices and the increasing impact of advances in biological technologies may support this view (see Table 2 below).

¹¹ Doving (1965a) identified three main stages in the application of modern technology to agriculture: first, the improvement of existing tools such as the iron plough; second, the introduction of new implements either drawn by animals or motor-powered such as threshers or reapers; and third, the introduction of motorized power. The introduction of improved tools took place mainly during the period before 1880, so that the main source of agricultural mechanization, as represented by our series, resulted from the introduction of new implements and power-driven machines. Although internal-combustion engines or steam driven machines might have been available, they did not come into common use until 1950.

in the case of purchased material inputs. While France and Germany show a similar development throughout these three phases, mechanisation in the United Kingdom spread much more rapidly in the first period and then much more slowly in the final stage. Although we do not present data on the actual machinery input per hectare, this development suggests that before 1940 agricultural production in the United Kingdom was much more mechanised than in either of the other two countries. Differences in land-man ratios represented in Figure 1 confirm this conclusion.



In the following pages, we will not discuss the reasons for this difference in the level of mechanisation, but some of the motives for mechanisation and their subsequent alterations over time. Before World War II, the new machines adopted were mainly drilling machines, harvesters and milk centrifuges. Because these kinds of equipment do not have the same labour-saving characteristics as potato and beet harvesters or the milking machine, Doving (1965a) concludes that the reasons for their implementation were not simply the need to save labour, but for the most part, intentions to increase output, improve quality and save the crops from natural hazards. The increase in the use of machinery inputs, together with the relative constancy of land-man ratios during the first period, may confirm this view. However, the conclusion may be misleading: it cannot be denied that the improvement in agricultural machinery adopted between 1880 and 1937 also had labour-saving effects. It can be expected that the new

equipment may have reduced the need for manual labour especially in labour peaks, i.e. when labour was relatively scarce compared to other seasons. Unfortunately, this effect is not documented in our time series, so that a final evaluation of this hypothesis is not possible at this time.

Since the 1950s, agricultural mechanisation was characterised by: (1) the development of machines which were increasingly labour- saving compared to the machines in the early phase of mechanisation; and (2) the introduction of power-driven equipment. The main reason for the adoption of these innovations was the acceleration of overall economic development which led to a steady increase in wages, which in turn provided incentives for the substitution of capital for labour. Simultaneously, this fostered the migration of agricultural labour into non-agricultural sectors. The effects of these adjustments are well documented by the increase in labour productivity as shown in Table 1.

Although we have not discussed the changes in agricultural output such as the introduction of new systems of crop rotation and adjustments in the structure of agricultural output (the increasing importance of animal production, the intensification of potato and sugar beet production etc.), an initial conclusion for the process of agricultural adjustment can be drawn from the time series. This data suggest that the changes in production, and especially in factor input, result from several interdependent factors. These include complementary innovations outside the agricultural sector, the availability and costs of industrial inputs as well as subsequent improvements in agricultural inputs. Furthermore, the paths observed indicate that the development and especially the adoption and diffusion of these innovations did not occur due to factors totally independent of the agricultural production, but rather have resulted from economic incentives generated within the agricultural sector.

2.3 Land-Man Ratios and the Efficiency of Agricultural Production. Thus far, our comments have concentrated on the development of land-man ratios within the given countries. However, Figure 1 shows not only that land-labour ratios have changed over time, but also that there were significant differences between these countries. The highest level of land supply per labour unit is observed in the United Kingdom. In 1880, the land-man ratio was about three times higher than that of France or Germany. In principle, even though the land-man ratio in France showed a tendency towards reaching the same level as that in Britain, differences are still observable in the 1990s.

Such differences have been used in order to justify the assertion that France (contrary to what happened in the United Kingdom) was not able to exploit the potential of agriculture for overall economic growth in the nineteenth century. The exploitation of economies of scale resulting from the favourable structural conditions in the United Kingdom was offered as a main source of these differences in the efficiency of agricultural production. Even if this argument is modified by considering the differences in land and labour productivities or institutional arrangements, it still dominates, to a great extent, especially in the earlier literature¹².

Arguments on the backwardness of agricultural structures are not only applied to inter-country comparison, but are also frequent in inter-sectoral comparison of the efficiency of labour input within a given country. From the lower labour productivity observed in agriculture, one concludes that underemployment of agricultural labour exists, and that these resources need to be mobilised by public policies in order to foster overall economic growth¹³. This kind of argument is not only present in the literature on development, but also dominates in the justification of agricultural

¹² See Clapham (1948), O'Brien and Keyder (1978) or Nardinelli (1988). Ruttan (1978) doubted this simplified view by taking the overall performance of the economies into account. Schmitt (1990) questioned the structural retardation hypothesis by considering the farm households' options for allocating their labour capacity.

¹³ See Dovring (1965b). This line of argumentation is especially present in the literature about economic dualism. See Lewis (1954) and Fei and Ranis (1961).

policies in Western European countries. The problem of this hypothesis is that it does not properly consider different forms of organisation in agricultural production. Since the theoretical arguments against the hypothesis will be developed in Section 3, we will defer our discussion to a later section.

Similar arguments were stressed when explaining the differences in the efficiency of agricultural production between Britain and the eastern part of the German Empire during the early twentieth century. It was argued that, after 1900, British agriculture had failed to adjust to the changing environment whereas human capital accumulation enabled the large holdings in the eastern part of the German Empire to achieve efficiency gains resulting from dynamic adjustments with respect to purchased material inputs and agricultural equipment (Perkins 1981)¹⁴.

It is difficult to discuss all the arguments which led to this conclusion. However, it is a question whether or not the slight decrease in land productivity in the United Kingdom between 1880 and 1937 can be used as an indicator for the failure of British agriculture to implement the necessary structural adjustments in this period. The free-trade policy in the late nineteenth and early twentieth century, together with improvements in transport facilities, led to a drastic decrease in producer prices for wool and cereals. At the same time, prices for goods that were difficult to transport, such as fresh vegetables or milk, had increased. In conjunction with these changes in relative prices, a specialisation occurred in agricultural production. However, since there was a relatively low availability of innovations during the early twentieth century, it is to be expected that the output reduction effect could not be compensated by an increase in productivity. A final solution to the question of whether the productivity of British agriculture had declined can only be given by estimating total factor productivity. However, as one would expect, the hypothesis that a stagnant agriculture had failed to react

¹⁴ Perkins (1981) argued further that this process was fostered (1) by the German import tariffs on agricultural goods and (2), ironically, by the diffusion of farming techniques developed in the United Kingdom. See also Ahrens (1969).

according to economic incentives must be rejected. The changes in the agricultural output structure and the slight increase in land-man ratios contradict the conclusion of a stagnant British agriculture¹⁵.

3. Theoretical Approach to Labour Allocation in Agriculture.

The impact of the different kinds of farming organisation will be the subject of this and the following sections. Our main hypothesis is that agriculture, as already mentioned regarding the use of purchased material inputs and agricultural mechanisation, has several links with the other sectors of the economy which have to be taken into account for the optimal allocation of all disposable resources. We will discuss the implication of this hypothesis with a simple model borrowed from household theory.

We assume two farm households with an identical composition and preference structures for income and leisure. Both households have the same production technology and the same prices of agricultural inputs and outputs. The only difference considered in this model concerns land endowment by assuming that household I cultivates less land than household II. Assuming competitive markets for agricultural inputs and outputs, decisions determining the agricultural production can be modelled by a restricted profit function $\pi(\mathbf{p}, L, A)$, where \mathbf{p} , L and A represent a vector of input and output prices, labour and land input, respectively.

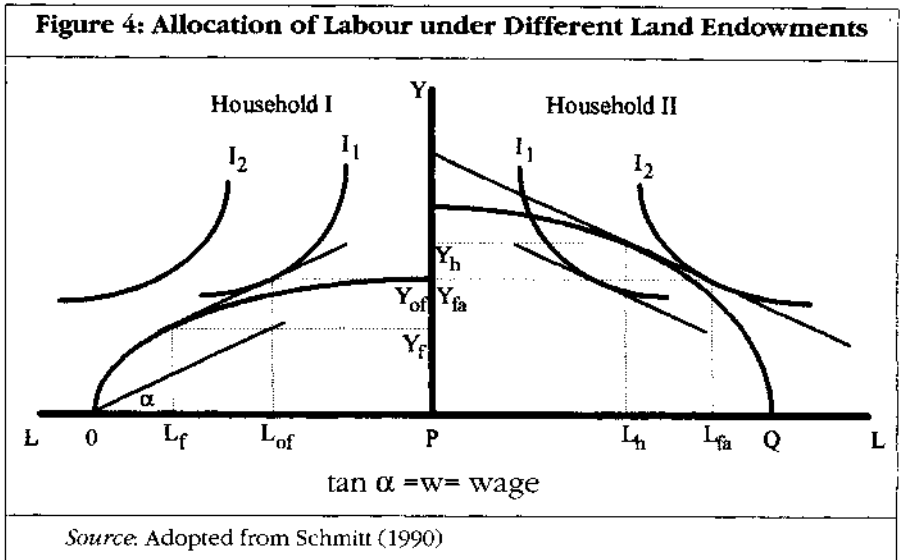
Under the standard neo-classical assumptions concerning technology¹⁶, the restricted profit functions have the concave forms as shown in Figure 4. Assuming utility maximisation and taking land endowments as given, each household faces the problem of efficiently allocating labour. Figure 4 shows two possible solutions to

¹⁵ See Ó Gráda (1994) for a more detailed discussion of determinants and reactions in British agriculture during this period. Ó Gráda declared that total factor productivity showed a slow but steady increase. Furthermore, the short-run supply situation proved relatively inelastic but positive. However, the long-run adjustment was clearly elastic.

¹⁶ See Varian (1992).

this problem, which, depending on land endowment, lead to a different organisation of agricultural production.

The left side in Figure 4 shows the allocation decisions of the small farm. Agricultural income possibilities are relatively restricted due to low land endowment. If labour were allocated to agricultural production only, the household could produce an income level which lies on the restricted profit function. However, since the opportunity cost of labour is not zero, household I will allocate labour among agricultural and non-agricultural activities. An efficient allocation is reached when, first of all, the opportunity cost represented by the angle 'a' is equal to the marginal productivity of labour input in agricultural production, and secondly, when it is equal to the marginal rate of substitution of the isoquants. This allocation rule leads to an agricultural labour input of OL_f . The amount of the off-farm labour supply is given by L^L_{of} . The income generated from this allocation is represented by PY_{of} . Allocating labour for on-farm and off-farm activities leads to a higher income than if all of the labour resources were devoted solely to the agricultural production, since a utility level above the agricultural income possibility curve can be reached.



The land endowment of household II is sufficiently large to absorb its total labour supply. The preference structure leads to a family labour input in agriculture of QL^{fa} . Because at point L^{fa} the marginal productivity of agricultural labour input is still greater than the wage rate, it is efficient for household II to increase farm employment by hiring non-family workers until an equality is reached. The optimal amount of total farm labour input exceeds the maximum available family labour by the distance between L^h and L^{fa} . The total income from farming is given by the distance PY^h . In order to determine the compensation of non-family labour, $L^{fa}L^h$ must be multiplied by the wage rate. Thus, the income of household II is PY^{fa} .

The argument followed thus far is based on the assumption that the land endowment of the two farms is held constant. However, land rents are not identical and the households are able to increase their income through a transfer of land. When land is freely disposable between the two households, it will be reallocated until both have the same land endowment and the differences in the organisation of agricultural production have disappeared.

For the above structure to be an efficient sectoral allocation of resources, the farms must have at least one determinant which is not identical for both. This difference will be sufficient to allow the demand curve for land to differ between the two farms, and therefore, will induce the various structures of resource allocation. In the literature, several conditions yielding this difference in agricultural structures have been analysed. One of the earliest discussions was introduced by Chayanov (1966), who pointed to the differences in family size and its implication for agricultural production. More recently, through the work of Becker (1965), Nakajima (1969), Strauss (1986) and Schmitt (1991), substantial extensions have been added to Chayanov's analysis. Several studies exist which stress the influences of different variables on structural arrangements in agriculture. These include the following interdependent factors: natural differences in agricultural production functions, different qualities of the soil, fixed factors of production, differences in the farmers' abilities, age structure of the

agricultural population, accumulation of human capital, differences in opportunity costs, and so forth.

Not all of these determinants can be discussed in detail. We therefore restrict our comparative static analysis to three major aspects: the development and diffusion of innovations, a change in output prices and increases in wage rates. An increase in the wage rate has two effects on household I. First, because the agricultural income possibility curve is concave, the agricultural labour input has to be reduced in order to maintain the efficiency condition that marginal productivity of labour has to be equal to the opportunity cost. Along with this adjustment, total labour input is also affected. In general, whether total labour supply will increase or decrease depends on the preference structure of the household¹⁷. However, if the substitution effect is not overcompensated by the income effect, the total labour supply will rise. Due to this adjustment, the non-agricultural labour input of household I increases for two reasons: the first results from the increase in the total labour supply and the second from the reduction of agricultural labour input.

Similar adjustment processes will occur in household II. The impact on hired labour occurs for two reasons. The first is due to the increase in the wage rate which leads to an increase in the opportunity cost of leisure. It can be expected that this will lead to an increase in family labour supply, which in turn will lead to a reduction in the demand for hired labour. The second reason takes place as a result of the reduction in total labour demand, since due to higher wages, it is no longer optimal for household II to employ labour input L^h .

The conclusions discussed so far occur under the assumption that farm sizes will not be adjusted. When the two households

¹⁷ This is due to the fact that labour input is affected by a substitution and an income effect. When considering only the substitution effect, the adjustment process proceeds along the indifference curve. The increase in wages increases the opportunity cost of leisure and will call for an increase in labor input. However, the income effect results from the move to an other indifference curve and depends on whether leisure is a superior or inferior good. Therefore, the reaction of total labour input cannot be predicted *ex ante*. See Varian (1992).

compete for the allocation of land, further consequences have to be considered. It can be shown that the shadow price of land declines with an increase in the opportunity costs. However, because the reallocation depends on the relative extent of the changes in the demand curves for land, which in turn rely on the intensity of the use of individual inputs, it is not possible to predict the actual adjustment within the general specification of agricultural production technology, as used in this paper.

An increase in agricultural producer prices will push the agricultural income possibility curve upwards. As a result of the increase in the marginal productivity of labour, both households will expand their agricultural labour input. The adjustments of total labour input for household I and the family labour input for household II depend on their preference structures. Higher prices do not only affect the allocation of labour directly, but lead to an increase in wages: a shift in the demand curves for land will occur. Without explicit assumptions about production technology, it can only be expected that the demand for land will rise. Whether the competitive position of household I will be improved more than that of household II cannot be predicted.

Under the assumption of constant prices, technological change leads to outward shifts of agricultural income possibility curves. Therefore, in general, the effects will be similar to those caused by higher producer prices. However, more concrete statements about the adjustment processes can be deduced when various kinds of technological change are considered; biological and mechanical innovation will affect the agricultural income possibility curve in different ways.

Due to their divisibility, biological innovations can be adopted without being significantly influenced by farm size. Consequently, the adoption of advances in biological technology will lead to similar increases in the productivity of labour for both households and thus will lead to a rotation of the agricultural profit function around the points 0 and Q, respectively. Thus, the comparative-static effects of these innovations will be similar to those of increases in

producers prices. In contrast, new machinery often requires a minimal farm size in order to be employed efficiently. Furthermore considering the labour-saving character of new mechanical innovations, non-proportional shifts of the profit function can be expected. The highest increases in productivity will occur when labour input is relatively low, while at a high labour input, the new machinery has only small effects on the profit function. Therefore larger farms can expect greater gains when applying new machinery than smaller farms. This will improve the relative competitive position of the larger farms in the land market and thus will lead to a reallocation of land in favour of these farms.

The comparative static analysis presented so far concentrates on the reallocation of factors of production on the assumption that the fixed factor which induces differences in the allocation of labour is held constant. However, in the long run, this determinant will also be variable, and the households will face the problem of whether they should reinvest in this factor or whether they should direct their financial resources to an alternative, non-agricultural use, which might in fact be associated with the closing down of their agricultural production. It can be expected that the latter will occur more likely in household I than in household II.

If, through investment in agricultural resources, household I can achieve the same level of the fixed factor as household II, its position on the land market will be improved, and a reallocation of land in favour of household I will take place, until both households have the same level of land input. This will push the restricted profit function of household I upwards, but the agricultural income possibilities of household II downwards. Both households will be able to produce a utility level I' , with $I^1 < I' < I^2$. An investment opportunity outside the agricultural sector will reduce the income possibilities of agricultural production, but at the same time, it may increase the opportunity costs of labour so that household I can achieve a utility level I'' , with $I' < I'' < I^2$. In this case, it is optimal for household I to select non-agricultural investment. Moreover, the decrease in agricultural income opportunities and the increase in

wages may cause a situation in which it is no longer optimal to remain in agricultural production. If household II faces the same investment opportunities, it will select the agricultural investment decision because this will allow it to reach a utility level of $I^2 > I^1$ ¹⁸.

4. Organisation of Agriculture and Structural Change

4.1 A Theoretical Approach to Structural Adjustment. The model in Section 3 provides the basis for a more detailed analysis of the structural adjustment processes in agriculture. An initial result concerns the appropriateness of partial productivity measures for a comparison of the efficiency of agricultural production. Because the conventional data on labour input do not sufficiently distinguish between the different possibilities for allocation, labour input in the countries where peasant farming dominates is overestimated. Simultaneously, land productivity is underestimated, since the households do not allocate as much labour to agricultural production as they would if the opportunity costs were zero.

From Figure 4, it follows that, as far as at least one determinant related to the households is not identical, differences in farm size and in the organisation of agricultural production can be expected. Given a perfect labour market, households which run small farms will be likely to allocate labour to on-farm and off-farm employment. In contrast, when the income possibilities for agricultural production are large enough, labour input larger than the capacity of the household is required. The gap is closed by employing hired labour.

These hypotheses concern the differences in organising labour input in agriculture at a given time. We are not able to give a detailed explanation of the changes in agricultural structure. In order to explain at least some of the principles behind these processes, we will continue with the discussion of structural adjustments by

¹⁸ Typical examples of this kind of decision problem concern the replacement of equipment and buildings as well as the investment of the potential successor to the farm in human capital.

retaining the differentiation of periods identified in Section 2.

The early period from 1880 to 1937 was characterised by a relatively low reduction in producer prices as well as relatively low levels of technological change. This is shown by the growth rates of land productivity and the land-man ratio for advances in biological and mechanical technology, respectively (Table 2). Although overall economic growth was not as substantial as in the period after 1950, it was nonetheless significant. As a consequence, wage rates showed a relatively high increase in real terms. Since the reduction in producer prices and biological innovations influence agricultural income possibilities in opposite directions, the total impact of these determinants can be disregarded. The main source of structural change can be traced from the interdependent influences of advances in mechanical technology and increases in wage rates. Higher wages and a constant interest rate will call for a substitution of capital for labour. Since new equipment is the carrier of mechanical innovations, this substitution is usually accompanied by advances in mechanical technology. However, the low rates of growth suggest that the forces compelling such structural change were relatively weak, so that only a limited reallocation of land in favour of the larger farms can be expected.

		technical change		prices	
		man-land ratio	land productivity	output	labour
France	1880-1937	0.18	0.73	-0.16	1.16
	1951-1990	3.49	2.06	-1.74	4.06
Germany	1880-1937	-0.26	1.30	-0.48	1.00
	1951-1990	3.72	2.22	-2.04	3.52
United Kingdom	1880-1937	0.46	-0.02	-1.01	0.41
	1951-1990	1.84	1.75	-2.23	2.65

After 1950, agricultural production was influenced by the strong

impact of mechanical and biological innovations. These induced the great decline in real producer prices and the high increases in real wage rates. Taking the increase in land productivity as an indicator of the advances in biological technology, one can see that the effects of biological innovations and the decline of producer prices on agricultural income possibilities are nearly compensating each other. Contrary to the first period, substantial increases in wages and mechanical technical changes required significant adjustment processes in agricultural structure.

The rapid increase in wages after 1950 had called for a substantial substitution of capital for labour. Thus, machinery input will increase and labour input will decrease. Moreover, because new capital goods are the carrier of advances in mechanical technologies, the agricultural income possibility curves will be affected as well. First, the adoption of improved machinery often requires a minimal scale of application in order to be employed efficiently. So, it can be expected that the income possibilities of the large households will increase more than the income possibilities of the smaller farm. Furthermore, because of the labour saving characteristics of new machinery, the productivity-increasing effect will be the greater when labour input is relatively low, while at higher labour inputs, the change of the agricultural production function can be almost neglected.

Thus, the high rates of advance in mechanical technology call for a reallocation of land in favour of the larger farms. This will not only increase the average farm size, but also will lead to a reduction of agricultural labour input. The latter effect will also result from an increase in opportunity costs. Furthermore, if the required changes in the agricultural sector are large enough, it may become optimal for the relatively large farms to change their organisational structure, i.e. to move to an organisational structure in which family labour had to be optimally allocated between agricultural and non-agricultural uses.

The arguments presented so far ignore the effects which result from the exploitation of economies of scale. Precise predictions about the extent of these effects cannot be stated but, as the growth

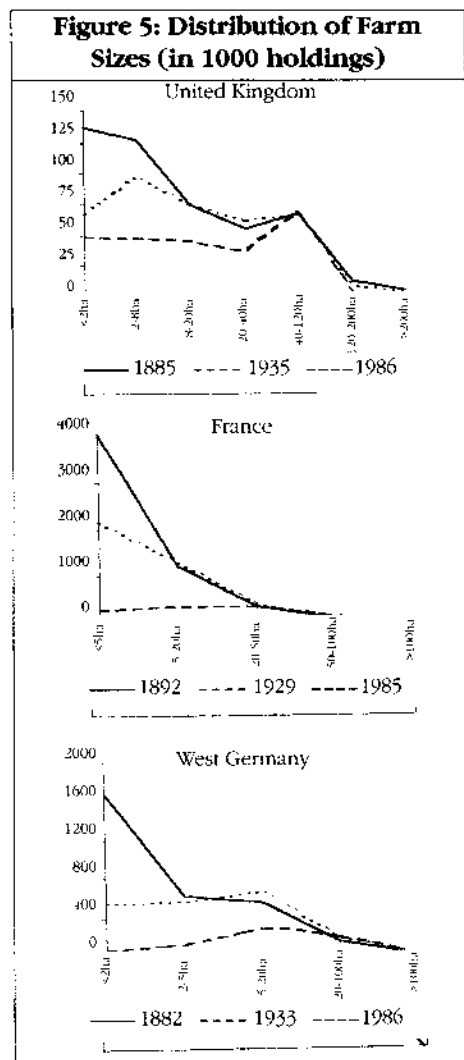
rate of the average farm size since 1950 indicates (see Figure 5 below), economies of scale cannot be denied *ex ante*¹⁹. Furthermore, due to the major advances in mechanical technologies since 1950, it could have been expected that larger farms were able to exploit economies of scale more than small farms. Consequently, the larger farms could have improved their position in the land market and would have displaced the small farms from the land market. As a result of this adjustment, agricultural households, as described on the right side of Figure 4, would have become dominant in agricultural production.

However, it must be questioned whether or not agricultural holdings could exploit the advantages of larger holdings. This question stresses the importance of transaction costs in the employment of non-family labour. Because of the difficulties in controlling and measuring the quality of labour input, the transaction costs associated with non-family labour can be expected to be relatively high²⁰. As a result, the benefits from hiring additional labour will be relatively low, which in turn implies that only restricted possibilities exist to exploit the advantages of large farms. Furthermore, the rapid increase in wages since 1950 has made this characteristic of non-family labour input even more important. Consequently, it can be expected that the households with an organisation as analysed on the left side of figure 4 will not be displaced, but that they will still play a dominant role in agricultural production.

¹⁹ Various estimates of agricultural production functions shows that economies of scale in agriculture are relatively small. See for example Niendieker (1991) and Michalek (1988) for Germany.

²⁰ The existence of transaction costs will result in a reduction of hired labour, i.e. in a reduction of farm size measured by total labour input. Pollack (1985) looked at the family farm as a response to the difficulties of supervising workers. He grouped the advantages of family governance into four categories: incentives, monitoring, altruism and loyalty. The disadvantages of family governance may result from size limitations, the lack of human capital, the difficulties in evaluating and disciplining family members and the spill-over of conflicts among family members. The reasons why family and non-family workers might be imperfect substitutes are "the incentive and monitoring advantages of family organization ... and the idiosyncratic information and knowledge of local conditions that family members are likely to possess" (p. 52). See also Schmitt (1997).

4.2 *The Patterns in the Development of Farm Size and Labour Input.* In this section, the hypothesis discussed in Section 4.1 will be compared with data on structural adjustment in France, Germany and the United Kingdom. We will restrict our attention to



changes in farm size, the organisation of labour inputs and changes in the socio-economic classification of farm households²¹.

First we will concentrate on the distribution and development of farm sizes in the three countries. Figure 5 shows that there were and still are significant differences in the distribution of farm sizes among these countries. In the United Kingdom, a distribution with two peaks could be observed in the period up until the 1930s, whereas in Germany and France, the distribution of the number of farms steadily declined in the early period. Apart from this difference in the shape of the distribution, the structures of farm sizes appear relatively homogeneous in the three countries. Especially at the end

²¹ We will discuss only the determinants mentioned in Section 4.1. By using this procedure, we will not be able to present a full theory of structural change because the interdependent impact of changes in relative prices for products and inputs, institutional arrangements and transaction costs will be neglected. However, at least we can discuss some principles concerning the adjustment of farm structures and labour allocation over time.

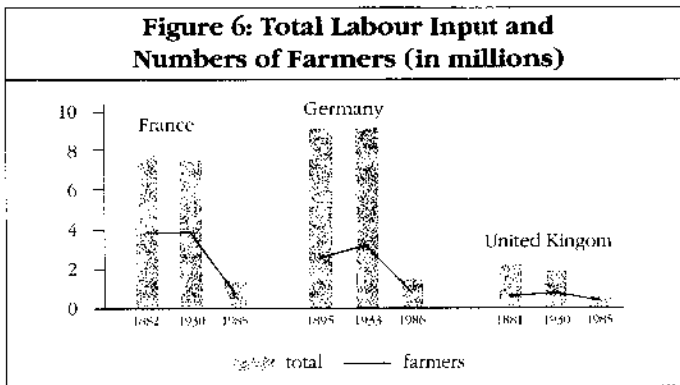
of the nineteenth century, relatively small farms were dominant in each country. The distribution of farms in Figure 5 shows that an analysis based only on average data may lead to false conclusions concerning the structures of farms. For example, the high land-man ratio shown for the United Kingdom suggests the domination of large farms with organisational structures as analysed on the right side of Figure 4. However, as revealed in Figure 5, most of the farms were located in the groups with 5 ha or less, farm sizes in which income from off-farm labour supply is likely.

Furthermore, changes in the distribution of farm sizes in each country are also very similar. In the early XXth century, a reduction in the number of farms occurred mainly in the groups of small farms, while the number of larger farms remained almost unchanged. A significantly greater decrease in the number of farms has taken place since the 1950s. In this period, the reduction concerns not only the smaller farms but other groups as well. As a result of these adjustments, the distribution of farm sizes in all countries changed into a form in which medium-sized farms predominated. Given the development of land-man ratios since World War II (Figure 1), the reduction in the number of farms has been accompanied by a high level of migration of labour from agriculture into other sectors.

The development of farm size corresponds to the results we derived from the comparative-static analysis. Although we have not yet included the data on the allocation of labour, the distribution of farm size provides an initial indication of the different kinds of labour input within agriculture. In order to confirm this proposition, we will compare the development of the number of agricultural workers and the number of farmers (Figure 6).

Changes in labour input within each country have already been discussed in our analysis of the development of land-man ratios. Before World War II, labour input in agriculture was relatively constant. Meanwhile, since the 1950s, an accelerated decrease in labour input can be observed. Although the number of farmers does not correspond exactly to the number of farms²²,

the data provide at least some information on the reallocation of labour and land inputs over time. The number of farmers has decreased since the 1950s, but at a much slower rate than total labour input. This indicates that the change in total labour input has not resulted in a similar reduction in the number of holdings. This, in turn, implies that the structural adjustment stems more from a reduction in labour input than from a reallocation of land.



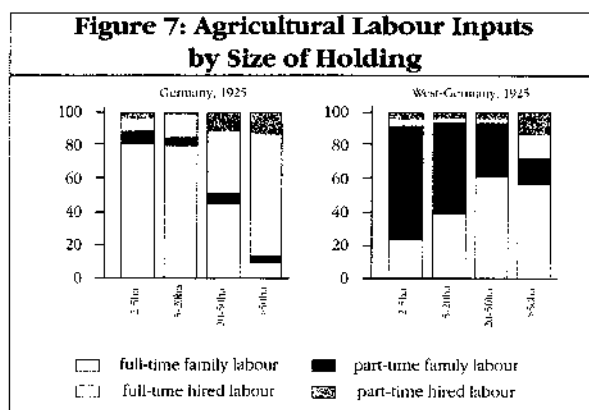
This pattern of change is due to the increase in the demand for labour by the other sectors. It could be argued that the impact of mechanical innovations and the existence of economies of scale must have led to a greater reduction in the number of farms than in the amount of employment. This would suggest that the organisation of labour, as discussed on the right side of Figure 4, would become the dominant issue for agricultural production. Clearly, the increase in the average farm size indicates (Figure 5) that the existence of economies of scale cannot be denied. But as the pattern of development of labour inputs and the number of farmers suggests, larger farms could not have improved their position in the land market sufficiently to make these adjustment

²² The reasons for this are that not all farm operators are considered as farmers and that one farmer may run more than one farm.

processes occur. This pattern of adjustment coincides with our arguments on the role of economies of scale and transaction costs in agricultural production.

Although Figure 6 provides no information on this subject, as a result of transaction costs and the differences in opportunity costs, it can be surmised that structural adjustment is usually accompanied by a reduction in hired labour. The data presented in Figure 7, which provides information on the organisation of agricultural labour input according to farm sizes at different times in Germany²³, support this hypothesis.

The patterns of labour allocation according to the various farm



sizes correspond to the predictions of the theoretical model. Labour input in small farms is mainly provided by family members, whereas in larger farms, the share of family labour declines in favour of hired labour. Furthermore, the importance of part-time family labour declines when farm size increases. These principles of allocation prevailed in 1925 as well as in 1991.

However, the importance of family labour input and hired labour input between 1925 and 1991 changed significantly in favour of family labour. This development confirmed our view

²³ Because of the availability of information, we can discuss only the pattern that occurred in Germany. However, it can be expected that similar allocation patterns would be observed in France and the United Kingdom.

that the reduction in the agricultural labour force was mainly due to the decline in hired labour. In addition, Figure 7 reveals that the structural adjustments also led to a reallocation of family labour input. In 1925, even among small holdings, the largest proportion of family labour was solely employed in agricultural production, while part-time family labour was of minor importance. In 1991, full-time family labour was the main type of employment only for holdings larger than 20 ha. In contrast, for holdings smaller than this, part-time family labour was the main source of labour input.

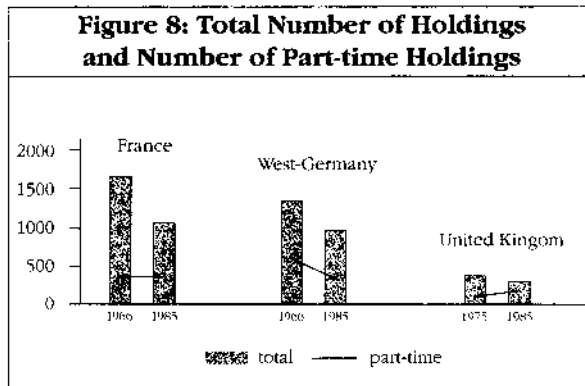
The theoretical model demonstrates the increasing importance of family labour and the decline in hired labour²⁴. An increase in the opportunity costs of labour together with the nonproportional shifts in agricultural income possibilities causes not only a decrease in family labour for small farms, but also in hired labour for large farms. Simultaneously, these changes require a reorganisation of the allocation of family labour input in large farms. The effect on the total income possibility curves leads household to move from an organisational structure with non-family labour to one in which income can be maximised by an optimal allocation of labour among agricultural and non-agricultural employment. As shown in Figure 7, this process did actually occur during the structural adjustment processes.

Changes in the organisation of agricultural labour inputs are equivalent to changes in the socio-economic classification of farm households (Figure 8). The Figure shows a decline in the number of farms, as already discussed in Figure 5. Moreover, as our discussion on the importance of part-time labour has already suggested, the number of part-time farms will not experience a reduction similar to that of the total number of

²⁴ As explained in Section 3, mechanical innovations do not proportionally affect the marginal productivity of labour. Where the size of farm is known, their labour-saving effects will improve productivity particularly where the inputs of labour is relatively low, whereas at higher labour intensities the impact on agricultural income possibilities can be almost neglected.

farms. This implication is confirmed by the data in Figure 8. In France, the number of part-time farms remains relatively constant, in the United Kingdom, it increases slightly, while in Germany, a decline can be observed. However, in absolute as well as in relative terms, the reduction in the number of part-time farms was smaller than that of the total number of farms.

Within the context of Figure 6, we have already discussed the possible influence of economies of scale on agricultural



production. The information provided in Figure 8 confirms our view that, because of the transaction costs associated with hired labour, economies of scale cannot be fully exploited. Therefore, it is efficient for farm households to allocate their labour capacity among various purposes. This income combination not only allows farm households to increase their income, but also allows them to efficiently compete for the allocation of land.

5. Summary and Conclusion

In this paper, we have discussed the suitability of two different theoretical approaches for a positive analysis of structural adjustment processes in the agricultural sectors of France, Germany and the United Kingdom. We began with a simple macroeconomic model: the decomposition of labour productivity to the land-man

ratio and land productivity. This decomposition was not only used to distinguish between the different periods of agricultural adjustment, but was also applied to identify patterns of technological change within the agricultural sector. It was concluded that prior to 1950 the forces affecting these adjustment processes had been relatively weak in comparison to the last decades. Nevertheless, some patterns of technological adjustment can be identified.

In the period from 1880 to 1940, advances in biological as well as mechanical technologies were relatively low in all three countries. In France and Germany, the increase in labour productivity was mainly achieved by increasing land productivity, i.e. by relying on advances in biological technologies, while in the United Kingdom, the efficiency gains were primarily as a result of the advances in mechanical technologies. The effects of technological changes were much more substantial after World War II. In this period, the impact of mechanical innovation on agricultural production was much more significant than the impact of biological innovations in all three countries. This pattern of development was not only demonstrated by the changes in productivities but also by the development of fertilisers and pesticides as well as machinery input per hectare.

Although this macroeconomic view of structural adjustment processes provides insights into the technological adjustment processes within the agricultural sector, its applicability for an overall determination of the efficiency of the different agricultural systems is rather limited. This follows not only from the low availability of appropriate data necessary in order to define agricultural labour input consistently, but also from the conceptual considerations concerning allocation of resources to agricultural production. These restrictions were theoretically demonstrated in a simple microeconomic model which was based on the assumption that agricultural households maximise their utility and that resources are allocated according to relative prices and contrasting factor. The latter produced an unequal land endowment for households, which

in turn gave rise various organisational option for agricultural production. The solutions presented in this paper concern two polar forms of organisation: part-time farming for the smaller farm and full-time farming with hired labour for the larger farm.

On the basis of comparative static analysis, hypotheses about the patterns of structural adjustment within the agricultural sectors were derived for the three countries. The hypotheses concern the distribution of farm size, the number of farms, the allocation of labour to agricultural and non-agricultural uses and changes in the socio-economic classification of households. The interdependent effects of higher wages and the advances in mechanical technology were identified as being the main sources influencing structural change in agriculture. For all three countries, the theoretical considerations predict that the structural adjustment processes will result in a decline in the amount of agricultural labour input, an increase in average farm size, and a reorganisation of labour allocation in favour of part-time farming. These patterns of structural change were confirmed by empirical analysis. Since the 1950s, the forces inducing structural change have been substantially greater than in the previous period. Consequently, more dynamic adjustment processes are observed in these recent decades.

In this paper, we were only able to outline some of the principles of structural adjustment processes and the importance of the various determinants in the three countries. However, one main result of our analysis is that conclusions concerning the advantages of specific structural arrangements which are derived from simple aggregate models must be carefully interpreted, since they do not take into consideration various possibilities for the allocation of resources in agricultural households. The microeconomic model we discussed as an alternative to the macroeconomic approach provides, even in its very simple version, more fruitful results with respect to explaining and understanding structural change. Since our approach ignores the influence of agricultural policies, the differentiation of labour with respect to age, ability etc., the impact of changes in the price

structures for products or purchased material inputs, the institutional arrangements affecting the allocation of land or labour, the transaction costs associated with different forms of organisation, the climate as well as other factors, we are still far from providing a comprehensive explanation of structural adjustment processes. However, it can be expected that an extension of the household model which considers these factors will not only allow a broader understanding of the adjustment processes, but will also help to explain the presence of different agricultural structures between and within these three countries.

Appendix

Construction of the data set

This historical comparison has to deal with the problem that the boundaries of France, Germany and the United Kingdom had changed in the period under investigation. From 1871 until the end of World War I, Alsace-Lorraine was under control of the German Empire, but since 1919 it has been French. However, after World War II Germany lost not only Alsace-Lorraine, but after referendums, also other regions to its neighbours. As a result, the territory of the German Empire shrank by almost 15%. A further reduction of its territory occurred after World War II, when two German states were established and the territory east of the rivers Oder and Neiße became part of Poland and the Soviet Union. After 1922, the Republic of Ireland became independent and the United Kingdom encompassed only Great Britain and Northern Ireland.

Unfortunately, we could not take account of these changes in such a way that consistent data sets could be produced. So, France was considered in its historic borders; the same holds in principle for Germany in the period previous to World War II²⁵. However, Alsace-Lorraine was never included in the German data. For the period since 1950, the data cover only the territory of the FRG before German reunification. The series for the United Kingdom cover mainly Great Britain. It was unavoidable that in some indices, the territory of the Ireland or Northern Ireland are included in the data set. However, by relating most of our data on production, labour and machinery input and purchased inputs to the amount of agricultural land, we hope that inconsistencies in the time series have been kept relatively small²⁶.

²⁵ For the distribution of holdings, data on provinces were available. Therefore, the data covers the territory of the former Federal Republic of Germany.

²⁶ This procedure follows from the assumption that the intensity of factor input per unit of land was relatively similar among the individual provinces or states within the countries. However, as the data on land-man ratios for Germany indicate, there had been substantial differences in the average intensities among German provinces; otherwise, it would not be explainable that the land-man ratio increased significantly after World War I (see Figure 1).

Land: Land input was defined as the aggregate of arable land, meadows and pastures.

France	1880-1955	Wade (1981)
	1955-1970	Tangermann (1973)
	1970-1991	EUROSTAT (various issues, a)
Germany	1880-1949	Andrews et al. (1979)
	1949-1991	STBA (various issues, a)
United Kingdom	1880-1965	MAFF (1968)
	1965-1969	Andrews et al. (1979)
	1969-1991	EUROSTAT (various issues, a)

Labour: The total number of male and female persons employed in agricultural production was used as an approximation for agricultural labour input.

France	1880-1951	Mitchell (1992)
	1951-1991	OECD (various issues, b)
Germany	1880-1938	Hoffmann (1965)
	1950-1991	STBA (various issues, b)
United Kingdom	1880-1931	Mitchell (1992)
	1931-1975	Andrews et al. (1979)
	1975-1991	OECD (various issues, b)

Machinery: Data on agricultural equipment were taken as a proxy for machinery input. The series were completed by linking them to data on horsepower input.

France	1880-1955	Wade (1981)
	1955-1991	OECD (various issues, a)
Germany	1880-1959	Hoffmann (1965)
	1959-1967	Tangermann (1973)
	1967-1991	OECD (various issues, a)
United Kingdom	1880-1955	Wade (1981)
	1955-1991	OECD (various issues, a)

Purchased material inputs and agricultural output: These series derive from data on intermediate consumption and final agricultural output in constant and current prices as provided by the respective national account statistics. The series on purchased inputs were linked to data on aggregate fertiliser consumption in the three countries.

France	1880-1937	Wade (1981)
	1951-1972	SAEG (various issues)
	1972-1983	EUROSTAT (various issues, c)
	1983-1991	EUROSTAT (various issues, b)
Germany	1880-1959	Hoffmann (1965)
	1959-1991	BML (various issues)
United Kingdom	1880-1937	Wade (1981)
	1949-1967	Andrews et al. (1979)
	1967-1972	SAEG (various issues)
	1972-1983	EUROSTAT (various issues, c)
	1983-1991	EUROSTAT (various issues, b)

Price index of GDP: Estimated as an implicit deflator by the quotient of the Gross Domestic Product in current and constant prices. The German series for the period from 1880 to 1938 were constructed by using Net Domestic Product calculations at factor cost.

France	1880-1950	Mitchell (1992), (1938-1950; consumer price index)
	1950-1991	OECD (various issues, c)
Germany	1880-1938	Hoffmann (1965)
	1950-1991	OECD (various issues, c)
United Kingdom	1880-1900	Mitchell (1992)
	1900-1983	Liesner (1985)
	1983-1991	OECD (various issues, c)

Wages: Index of money wages in industry

France	1880-1988	Mitchell (1992)
	1988-1991	I.N.S.E.E. (1992)
Germany	1880-1959	Mitchell (1992)
	1959-1991	BMAS (various issues)
United Kingdom	1880-1988	Mitchell (1992)
	1988-1991	CSO (1993)

Index of agricultural producer prices: Implicit deflator estimated by the relation of the series to agricultural output in current and constant prices (sources: see agricultural output).

Changes in real agricultural producer prices: Estimated by the difference of the changes in agricultural producer prices and the GDP deflator.

Changes in real wages: Estimated by the difference of the changes in money wages and the GDP deflator.

Distribution of farm sizes and number of holdings:

France	1892	Clapham (1948)
	1929	I.N.S.E.E. (1953)
	1985	EUROSTAT (1996)
Germany (only the territory of the Federal Republic of Germany)	1882	Kaiserliches Amt für Statistik (1900)
	1933	Statistisches Reichsamt (1934)
	1986	EUROSTAT (1996)
United Kingdom		Marks (1989), only England and Wales

Number of farmers:

France	1882	Clapham (1948)
	1930	the same proportion of farmers in the total agricultural labour force as in 1940 was assumed; see I.N.S. (1946)
	1985	EUROSTAT (1996)
Germany	1895	Kaiserliches Amt für Statistik (1900)
	1933	Statistisches Reichsamt (1934)
	1986	EUROSTAT (1996)
United Kingdom		Marks (1989)

Labour input by size of holdings:

Germany	1925	Statistisches Reichsamt (1929)
	1991	BML (1993)

Number of part-time holdings: EUROSTAT (1996)

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Abbreviations

BMAS	Bundesministerium für Arbeit und Soziales
BML	Bundesministerium für Ernährung, Landwirtschaft und Forsten
CSO	Central Statistical Office
I.N.S.	Institut National de la Statistique
I.N.S.E.E.	Institut National de la Statistique et des Etudes Economique
SAEG	Statistisches Amt der EG
STBA	Statistisches Bundesamt

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