The Competitiveness of Polish Agriculture in the Context of Integration with the European Union

Katarzyna Zawalińska

Warsaw University
Department of Economics

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I dedicate this work to my family

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ANOVA	Analysis of Variance
APA	Agricultural Property Agency
ARR	Agricultural Markets Agency
AWU	Annual Work Units
c.i.f.	cost of insurance and freight
CA	Comparative Advantage
CAP	Common Agricultural Policy
CEEC	Central and Eastern European Countries
CRS	Constant Returns to Scale
CSE	Consumer Subsidy Estimate
DEA	Data Envelope Analysis
DRC	Domestic Resource Costs
DRS	Decreasing Returns to Scale
EC	European Commission
EU	European Union
f.o.b.	free on board
GUS	Polish Central Statistical Office
ha	hectare
IERiGŻ	Institute of Agricultural and Food Economics
IFS	International Financial Statistics
IMF	International Monetary Fund
IRS	Increasing Returns to Scale
OECD	Organisation for Economic Co-operation and Development
PLN	Polish new zloty (Polish currency after denomination)
PSE(P)	Producer Subsidy Estimate (Percentage)
RCA	Revealed Comparative Advantage
SMP	Skimmed Milk Powder
TFP	Total Factor Productivity
ToT	Terms of Trade
VRS	Variable Returns to Scale

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1 Introduction

1.1 Background

All the countries that have decided to join the European Union (EU) have implicitly assumed that they will be able to successfully compete on the Single Market with the other 15 member countries. Poland signed the Association Agreement with the European Union in 1991 and thereby undertook to face the challenges that would be posed by a high level of competition throughout the EU. Though Poland is widely perceived as one of the most successful Transition Economies, after several years it has become clearer that some sectors have been far less successful than others. Of the least successful sectors, agriculture stands out.

During the period of centrally planning,agriculture was the only sector in Poland that was dominated by private producers (this was extremely rare in the CEE region). One might therefore expect it to be the best prepared for competition in a market economy. However, paradoxically, this sector has experienced many serious problems adjusting to market competition, and productivity in the sector lags far behind that of other sectors. This was a significant challenge for Poland even before EU accession reared its head, and improving competitiveness in this sector will remain a major task also after accession to the Common Agricultural Policy.

After signing the Association Agreement the debate concerning the competitiveness of the Polish agricultural sector vis-à-vis the EU intensified and has since then passed through various phases. Initially, when the future of the Common Agricultural Policy (CAP) was far less certain than now, discussions centred on the possible future for the CAP and, in turn, on the competitiveness of Polish agriculture under various scenarios of CAP reform. Later, Polish agricultural competitiveness was broadly discussed within discussions concerning the narrowing of the initially high EU-Poland price gap for agricultural and food products. The size of this gap had been perceived until then as a major determinant of how accession would affect both sides. The focus of public debate has since then gradually shifted from primary agriculture alone to a wider view of the rural and agro-food economy, with an increasing emphasis on off-farm activities. During this phase some interesting studies appeared, many of which questioned the (un)competitiveness of the Polish agricultural sector vis-à-vis agriculture in the existing EU-15 states. This was reinforced by a series of emerging differences between Polish and EU officials and academics in looking at the issue (SAEPR/FAPA, 2000a, 2001; Orłowski, 2001). One EU viewpoint was that Polish agricultural products had considerable competitive potential as they were cheaply produced, at low prices and with fewer subsidies than in the EU. Many expressed fears that Polish production would flood the EU markets. At the same time, the Polish agricultural sector was perceived in the EU as unproductive, backward, and hence unable to compete on the Common Market without demanding huge support from the EU budget.

Then, after the European Commission's position on EU accession negotiations was for the first time explicitly stated in 2002, new controversies arose. This coincided with the publication of various studies analysing the rationales of both Polish and EU negotiating positions and including possible implications for competitiveness. At this stage of negotiations the debate was subordinated to questions about the exact amount of direct payments under the CAP, the specific use of structural funds, levels of production quotas, length of transition periods and other contentious issues.

Today, after negotiations have been finalised and the Accession Treaty signed on April 16th, the debate about competitiveness has not receded into the background. If the Polish agricultural sector wants to develop and positively contribute to economic growth it must be competitive not only vis-à-vis the agricultural sectors of other Central and Eastern European Countries (CEECs) and the existing EU-15, but also vis-à-vis other sectors of the Polish economy. This 'domestic' dimension to the sector's competitiveness derives from the mechanisms of comparative advantage, which will be the subject of more detailed discussion later in this thesis.

Many factors remain a cause for concern in terms of the competitiveness of Polish agriculture. These include: (i) the persistent (since 1993) negative balance in agro-food trade with the EU; (ii) selective and unsatisfactory progress in the restructuring of both the agriculture and processing industry in Poland; (iii) deteriorating incomes and profitability of agricultural production; (iv) other economic and social problems (unemployment, both official and hidden, poverty, poor access to public services like education, health system, etc.).

It is not possible to look at the competitiveness of the agricultural sector in the 1990s without a broader analysis and understanding of the overall economic context of transition. Like other sectors, Polish agriculture after 1989 was faced with macroeconomic pressures stemming from the shift to a market economy and convergence with the EU: the sector was, for example, under structural pressure stemming from price and trade liberalisation, macroeconomic policy that was subordinated to the disinflation process, the restructuring process of state-owned properties, etc.

This thesis, in part at least, assesses the influence of macroeconomic variables on the agricultural sector and investigates the sector's responsiveness, that is, its ability to maintain or improve its competitiveness by improving productivity through its use of factors.

Agriculture is undoubtedly one of the most complex and problematic production sectors in Poland, though it is not exceptional in terms of attempts to resist the macroeconomic pressures at play in the Polish economy. This sector is also interesting for the following reasons. Firstly, agriculture remains an important sector for the Polish economy – although its contribution to GDP has been decreasing considerably (from 8.2% in 1990 to 2.9% in 2001), it employs 28% of the total national labour force (GUS, 2002) and consumer spending on agro-food products is also relatively high, at about 35% (in the EU it is 18%) (European Commission, 1998a). Secondly, any attempts to deal with problems in the sector (for example reducing hidden unemployment) affect the wider economy and necessitate activities that have ramifications far beyond policy in the sector alone. Thirdly, during negotiations with the EU problems of low productivity, inefficiency and weak competitiveness of Polish producers became more publicly apparent and this study can contribute to the public debate by offering various empirical findings on changes and determinants of the competitiveness of Polish farm producers. Last but not least, this is an interesting sector from a historical perspective. It was the only sector which remained in private hands even under the centrally planned economy, which makes it even more fascinating to find out how it has been performing in the new reality.

1.2 The research problems and scope of the analysis

The main question this study seeks to answer is whether or not the competitiveness of the Polish farm sector during the transition period 1990-2000[1] improved, in the context of the strong global adjustment pressures within which it was obliged to operate (e.g. low international agricultural prices) and Polish systemic reforms (stabilisation, liberalisation, etc.), which led to between-sector rivalry for the best domestic production factors. Most of the forces we analyse stem largely from globalisation of the world economy, combined with Poland's integration into the EU (and catching-up process), as well as the Polish economic transformation. We also ask if Polish producers have been able to increase their productivity sufficiently to counter negative pressures at work in the sector and what has been the overall result of their behaviour on sector competitiveness?

This work is also an attempt to reconcile macroeconomic and microeconomic perspectives, which are all too often applied separately in studies on the sector's competitiveness in transition economies. As such, it draws mainly on the theory of dynamic comparative advantage, but also refers to theories of growth. The thesis also analyses *dynamic comparative advantage* as a result of three main elements: *changes in relative agricultural prices (output-input)*, *changes in total factor productivity* and *adjustments in factor proportions*. Since productivity is widely perceived as one of the most important offsetting responses that agricultural producers have to combat to any unfavourable and unavoidable pressures stemming from outside the sector, much attention will be paid to research on the *determinants of total factor productivity* and differences among Polish farms in this respect, also in comparison to other CEE and EU countries.

[1] I call this period 'transition', although one might argue how long this transition has lasted, and whether it is still justifiable to talk about transition in 2000. I take the view that this can be justified by the fact that Poland is still classified as an economy in transition in publications like the EBRD's "Transition Report" and the classifications of many other international Institutions (e.g. The World Bank and IMF). I therefore use the term 'transition' in line with their usage.

The relatively broad terms used in the thesis title obviously need to be narrowed and sharpened somewhat to allow for a more detailed insight into the problem at hand in this work. The following are working definitions of the terms used:

(i) *Competitiveness*: is analysed based mainly on the concept of dynamic comparative advantage and its breakdown into changes in productivity, efficiency of factor use and relative prices in the sector. This allows for comprehensive analyses not only of the level of competitiveness but also of its long-term determinants. The superiority of a dynamic (over a static) approach to comparative advantage is that it provides far more rational conclusions and bases for economic choices (Siwiński, 1970).

(ii) *Agricultural activity and producers*: this work does not consider the entire agricultural chain from producers to consumers for empirical reasons and obvious time and focus constraints. Limited data availability is also a key factor. As such, activity levels (of certain products) and farm performance are mainly analysed empirically in this work.

(iii) *Time period 1990-2000*: the analysis is divided into two periods – research on product level in the period 1990-2000, and analysis on farm level between 1996-2000. The 1990s was a time of rapid economic change, with pressures working on the sector in the main manifested in changes in key relative and absolute prices, such as the real exchange rate, wage rates, interest rates, and others. In trade theory, these changes mean changes in comparative advantages.

(iv) *The European Union Integration Context*: many studies have analysed the problem of integrating Polish agriculture into EU structures, most of them attempting to estimate the likely future impact of accession on Polish agricultural production, prices, etc. This thesis, however, treats integration slightly differently. It looks backwards, treating it as an important driving force for changes in the economy that have indirectly but significantly influenced the sector's competitiveness. Firstly, it is treated as a force speeding up the economic convergence process, which in turn intensified exchange rate appreciation, liberalisation, restructuring, etc. Secondly, any implications and recommendations that may stem from this study refer to Polish competitiveness within the Common Agricultural Policy as a target policy for Poland from mid-2004.

This work develops four main hypotheses, derived from a combination of theoretical knowledge (Chapter 2), findings from previous empirical studies in the literature (Chapter 3) and conceptualisation of the theoretical framework in which we assess competitiveness (Chapter 4). The work's key hypotheses are explored in Chapters 5 and 6, and are complemented by various research questions (the summary of all the hypotheses, research questions and results is provided in Chapter 7).

The first hypothesis centres on the mechanisms by which international prices and domestic relative macroeconomic prices are passed on to the agricultural sector. It also addresses the effectiveness of agricultural policy in alleviating the influence of both forces (especially during periods when they were in operation simultaneously and imposed a significant external pressure on the sector). The second hypothesis questions whether producers have managed successfully to adjust to such pressures, given the need to raise productivity considerably. The third hypothesis deals with determinants of productivity and contributes to an understanding of productivity obstacles and boosters in the sector. The fourth hypothesis deals with the relative significance and importance of productivity determinants.

1.3 Outline of the study

The thesis consists of seven chapters. This introduction is followed by Chapter 2, which deals with definitions and theories of competitiveness in the economic literature. The ultimate objective of the chapter is to present theories and measures used for assessing competitiveness and to explain where the concept of dynamic comparative advantage fits into the existing theoretical framework and broad set of measures. Chapter 3 narrows the literature review to empirical works specifically on the competitiveness of Polish agriculture, the aim being to locate the thesis in the context of existing research and indicate how it both acts to continue and develop the existing knowledge on the subject. Chapter 4 has a theoretical character, though is no longer a review but a detailed description of the analytical framework that will be used in the empirical part of the thesis to verify hypotheses. Its aim is to show interactions between the variables being modelled (i.e. relative agricultural prices, productivity, efficiency, etc.) and give insights into other variables which are crucial to an understanding of the overall analysis (world agricultural prices, exchange rates, interest rates, border measures, direct market interventions, etc.). Chapter 5 contains the first empirical element of the thesis. The first main hypotheses are formulated and verified, concerning changes in competitiveness, the influence of macroeconomic variables on the agricultural sector, and sector productivity responsiveness. Chapter 6 covers the second part of the empirical work, on TFP determinants and differences among farms. Here the last two hypotheses are derived and tested. The chapter ends with a summary of the empirical results and leads into the last chapter, Chapter 7, which summarises the thesis and draws conclusions from all the research findings. Here also policy recommendations are formulated and some suggestions for further research are proposed at the end.

2 Concepts of Competitiveness in the Economic Literature

This chapter revises different concepts and definitions of competitiveness. The aim of the chapter is to point out the various measures and concepts functioning in the current literature on the subject and focus especially on how the concept of dynamic comparative advantage (which constitutes the base for later empirical research) provides a background against which to explain competitiveness.

Few topics in economics over recent years have generated as much discussion and controversy as competitiveness (Dunning et al., 1998). This is probably because the concept has so many dimensions. Firstly, its range of possible applications is wide - from individual and company activity to sector and sector cluster activity, through to regional and state levels (Porter, 1990; Dunning et al., 1998). Secondly, competitiveness can be conceived of either as potential (assessed ex-ante) or revealed (assessed ex-post). Thirdly, it finds its roots planted in diverse theories: trade theory, managerial and business theories, etc. Fourthly, the concept also has a temporal element – short-term and long-term competitiveness may be thought of in very different terms(Boltho, 1996). Last but not least, it is a relative term, with potentially diverse points of reference, for example, differences across nations (external competitiveness) or sectors within nations (internal competitiveness) (Woś, 2001 a, b), all of which cause further complications.

Another source of confusion over competitiveness stems from various misunderstandings found in, and inadequacies of, applied theories. Abbott and Bredahl (1994:13) distinguish two types of 'mistake' often found in the literature and in the popular press: firstly, a misunderstanding of the theory is they suggest, when '*some answers purported to explain competitiveness simply violate economic theory, while others seek to apply theory to a question for which it is not appropriate. That is, the wrong theory is used to examine a question*'. Secondly, most of the inadequacies of applied theories stem from the fact that '*there is no unified general theory to address competitiveness*', so at each level of analysis different concepts are useful and should be used for empirical studies on the subject (Abbott and Bredahl, 1994:17).

Not surprisingly, the exact meaning of competitiveness has been extensively discussed, but yet without an agreed definition of the concept (Boltho, 1996; Banse et al., 1998; Guba, 2000 and many others). On the one hand, only a few dictionaries attempt to explain the term (one will not, for example, find it in the well known Palgrave Dictionary of Economics, 1998), while on the other hand, most research that touches on the concept tends to choose to define it to fit its own research purposes. Therefore, paradoxically, there are many definitions of competitiveness, though no universal consensus. The simplest existing definition, which also appears to lend itself to a layman's intuitive understanding, is as follows: 'c*ompetitiveness is the capacity to sell one's products profitably*' (Cockburn et al., 1998:2). Most definitions appear to share roots, if little else, in this simple rule.

2.1.1 International competitiveness

Politicians, businessmen and economists alike refer to international competitiveness in their everyday discussions when looking at the external (export, import, market share, or trade balance) performance of different countries. Various indicators are issued showing changes in, or levels of, various countries' competitiveness (such as the relative price or cost indices regularly published by the IMF or the competitiveness indicators issued by the OECD[2]). Yet, Krugman (1994) for one, argues that competitiveness is a meaningless term when applied to national economies. As Helleiner (1989) did earlier, Krugman criticised the concept of economy-wide competitiveness, even calling it a 'dangerous obsession'. He argued that a country defined in aggregate terms cannot be competitive in all economic activities as this would lead to currency appreciation until some activities become internationally non-competitive. Exchange rate over- or under- valuation can temporarily affect the competitiveness of all activities, but will tend to correct itself automatically through balance of payments mechanisms (Cockburn, et al., 1998). Another of Krugman's (1996) objections was that the concept of international competitiveness involves the idea of inter-country rivalry. This idea is misleading, he argued, since countries, unlike companies, do not compete with each other, despite the popular perception that they do. Competition between nations can never be a win-lose game, he argued, since, even if a nation became the least efficient producer of everything, there would still be gains from trade as long as there were some differences in efficiency between sectors within the economy. Various studies have argued, in turn, that Krugman's ideas are themselves somewhat misplaced. For example, Dunning (1995) defended the concept of a nation's international competitiveness, arguing that '*for competitiveness to have no relevance [...] it would have to be the case that every region or country trading with another is doing so on the basis of an optimal allocation of resources. This [however] is unlikely [...]*'.

The notion of international competitiveness is usually discussed in two time dimensions. In the short-term, the international competitiveness of a country is most frequently equated with its *real exchange rate* (Cockburn et al, 1998). Thus, lack of competitiveness would suggest that a country, at full employment, was running a persistent (and unwelcome) current-account deficit, which would in due course require adjustment, usually via a mixture of deflation and depreciation (Boltho, 1996). In other words, the country would suffer from an inappropriate real exchange rate level (Corden, 1984). In the long-run, the international competitiveness of a

[2] The OECD has a database 'International Trade and Competitiveness Indicators' where four indicators of international competitiveness are quoted: the ULCM - Index of unit labour costs in the manufacturing sector expressed in local currency; the ULCMDR-Index of relative unit labour costs in the manufacturing sector (overall competitiveness); the PXMDR-Index of relative export prices of manufactured goods (overall competitiveness); the CPIDR-Index of relative consumer prices of manufactured goods (overall competitiveness)

nation is a much vaguer concept. Most analysts use a broader definition of competitiveness and focus on structural factors such as productivity, innovations, skills and so on (Fagerberg 1996). Then competitiveness is usually equated with strong performance of economies relative to other countries (where strong performance can mean economic growth, success in exports and increased well-being). The most popular definition of long-term international competitiveness is that used by the US President's Commission on Industrial Competitiveness from 1985, later also adopted officially by the OECD (1992:237), which states that it is *'the degree to which a nation can, under free and fair market conditions, produce goods and services which meet the test of international markets, while simultaneously maintaining and expanding the real incomes of its people, over the long- term'*.

2.1.2 From national competitiveness to the competitiveness of firms

Porter (1990) offers another approach to defining national competitiveness, referring down to the level of regions, industrial clusters and enterprises. In his work *The Competitive Advantage of Nations* Porter adds industry-level competition to a model of national competitiveness based on the aggregate competitiveness of industrial clusters (Dunning, 1995). Porter claims the basic units of analysis in understanding national advantage are industry and industry clusters, but that the competitive advantage achieved by many industries in a single country tends to evolve together, which he suggests, means that nations (taken as an aggregate) do differ in terms of stages of competitive advantage (Porter, 1990).

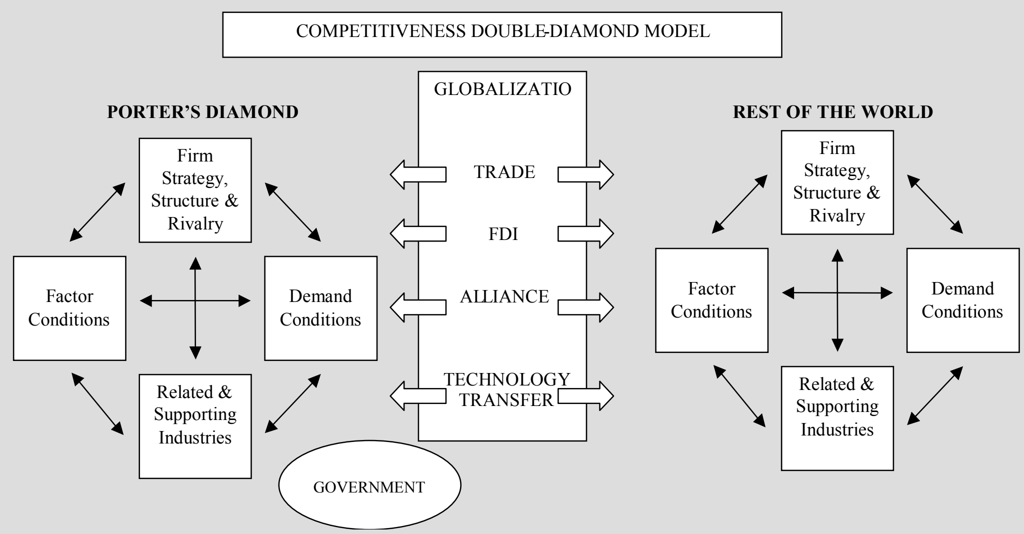
At the level of the firm, Porter defines two types of ***competitive advantage**:* low cost and differentiation. The former is the '*ability [...] to design, produce, and market a comparable product more efficiently than [...] competitors'*, while the latter is the *'ability to produce unique and superior value to the buyer in terms of product quality, special features,or after-sale service'* (Porter 1990:37). Both definitions translate into higher productivity. Low-cost firms produce given outputs using fewer inputs than competitors and differentiated firms achieve higher revenues per unit than competitors (Porter, 1990). The *competitive advantage* of a country or region *'is the set of activities in which enterprises based in the country tend toward international competitive advantage'*. As for the main determinants of national advantage, Porter specifies four elements: (i) factor conditions (i.e. the nation's position in factors of production, such as skilled labour or infrastructure, necessary to compete in a given industry); (ii) demand conditions (i.e. the nature of domestic demand for the industry's product or service); (iii) related and supporting industries (i.e. the presence or absence in the nation of supplier industries and related industries that are internationally competitive), and (iv) the strategy, structure, and rivalry of the firm (i.e. domestic conditions governing how companies are created, organised and managed and the nature of domestic rivalry). The model has a 'diamond' shape (as presented on the left hand side in the Figure 2-1 in Box 2-1). However, authors such as Dunning (1993) and Rugman (1993), have challenged this, arguing that for small open economies, the most important element is conditions in key neighbour markets abroad, rather than domestic conditions. In so doing they extend the original concept of Porter's model to a 'double diamond' of competitive advantage (as presented in Box 2-1) by adding the variable of a given country's relationships with the rest of the world. Therefore, in their concept, the diamond of a small economy is critically dependent on the diamonds of other economies and on the activities of multinationals who invest within the diamond.

A static conception of competitive advantage appears to point to technology, productivity and efficiency as the long-term determinants of competitiveness. Porter, however, also developed the idea of ***dynamic competitive advantage,*** which is referred to as competitive development, innovation and upgrading, where the last element is defined as the *'movement toward more sophisticated sources of competitive advantage and toward positions in higher-productivity segments and industries'* (Porter, 1990:543).

Generally speaking, therefore, the concept of competitive advantage recognises that (i) most international trade and competition is between *companies*, not countries, but (ii) that there are country-specific characteristics that affect the likelihood of a company's success internationally, and (iii) that these characteristics have varying relevance for different activities (industries). Productivity improvements and efficiency in maintaining sustainable competitive advantage underpin this argument (Porter, 1990).

Box 2-1 Models of competitive advantage

Figure 2-1



Source: Dunning (1993)

The concept of competitiveness of the firm appears in most studies to be synonymous with the concept of firms' long-term profitability. Neo-classical producer theory suggests that it is a firm's drive to maximize profits, subject to the technical constraints of their production function, that determines the amount it sells and, consequently, its competitiveness (Cockburn at al., 1998). Therefore, a firm increases its competitiveness either by reducing costs or by increasing revenues. Reduction of costs can be achieved mainly by improvements in technology and efficiency of production, which leads to increase in productivity, so that at least the condition of equalisation of inputs used with their opportunity costs must be satisfied, while an increase in revenues can be achieved through expanding the market share for the product (Dunning et al., 1998). Many studies have used large samples of successful firms in attempts to uncover the underlying determinants of firm-level competitiveness. Most of them appear to discover that the level and source of a firm's Research and Development (R&D) are crucial for its competitiveness (Franco,1989).

In the case of industry, the concept of competitiveness has become more complex than that of a single firm. While it is clear that individual firms compete within industries, industries are not generally thought of as being in competition with one another (Dunning et al., 1998). One of the most widely quoted definitions of industrial competitiveness is that officially adopted by the US Department of Energy, which says that '*industrial competitiveness is the ability of a company or industry to meet challenges posed by foreign competitors'*.

It is also possible, and especially common in agricultural studies, to assess competitiveness of products (more thoroughly discussed in the next chapter, where studies on the competitiveness of Polish agriculture are presented). This concept seems to be the closest to a classical understanding of competitiveness based on trade theories. The methodology for assessing competitiveness in producing certain products depends on which economic unit we consider – a whole market, sector or specific firm. Competitiveness of certain products depends on the competitiveness of their producer, hence the competitiveness of non-processed goods depends on the competitiveness of the firms that produce them, while in turn that of processed-goods depends on the competitiveness of the processing firms and/or industries that produce them.

2.1.3 Foundations of competitiveness in trade theory

No economic theory or concept has contributed as much to an understanding of competitiveness as trade theory, in its various forms, which '*highlight[s] the crucial mechanisms for assessing competitiveness on country, sector and firm level'* (Berkum and Meijl, 1999:1). Duren, et al. (1991:1467) point out that each definition of competitiveness has trade and productivity as core notions. Indeed, trade theory has laid foundations for explaining competitiveness and has provided useful approaches to the concept by explaining patterns of international specialisation in production and related patterns of trade flows. Among the main determinants of competitiveness that one can usefully borrow from trade theory are divergence in technologies and specialisation, relative factor endowments, price distortions and returns to scale (Cockburn et al., 1998)

However, the central principle in trade theory which aids an understanding of competitiveness is that of ***comparative advantage***. Adam Smith (who developed the idea of absolute advantage) was the first to provide an analytical framework in which the logic of comparative advantage could later be explained. He proffered the first credible arguments underpinning the role of trade, arguing that gains realised in a single enterprise from the division of labour along the lines of absolute advantage may also be obtained as a result of international specialisation and trade. Some years later, David Ricardo, in his work 'On the Principles of Political Economy and Taxation' provided a hypothetical example of Smith's earlier argument (Portugal and England trading cloth and wine) and explained the theory of comparative advantage[3] in which any two countries trading with each other can benefit from specialisation and trade (Michie, 2001). His concept is explained as follows: '*A country has a comparative advantage in producing a good, relative to another country or the rest of the world, if the relative cost of producing the good is lower than it is abroad'* (Oxford Dictionary of Economics, 1997).

While Ricardian trade theory identified differences in *technological efficiency* as the source of comparative advantage, Heckscher and Ohlin demonstrated that cross-country variations in relative *factor endowments* can also shape the pattern of trade. Later, many mathematical and empirical studies emerged to quantify and test this theory. To mention only a few, Jones (1965) provided the mathematical foundations for the two-factor, two-good general equilibrium model in which differences in technologies, factor endowments or alternatively *consumer preferences* may produce comparative cost advantage (Michie, 2001). As an example of an empirical study in this case Deardorf's work (1984) is important because it identified three empirical regularities that had been weakly explained by the theory of comparative advantage: substantial intra-industry trade, high volumes of trade between relatively similar countries and insignificant resource reallocation during episodes of substantial trade liberalisation. In response to these findings, and using insights from industrial organization, Helpman and Krugman (1985) proposed new models in which e*conomies of scale* and *imperfect competition* provide additional or alternative incentives for international trade.

However, dynamic counterparts soon arrived on the scene to take on such static theories. These were rooted in the theory of endogenous growth and trade models with ***dynamic comparative advantage*** itself determined by the growth process (Michie, 2001). Krugman (1987) and Lucas (1988) developed models in which *learning-by-doing* produces growth and may also reinforce patterns of specialisation over time. Grossman and Helpman (1991) produced a model in which profit-seeking

[3] Robert Torrens also contributed to formulating the theory of comparative advantage

investments in research and development are the driving force of the growth process. Important and interesting from the policy point of view is that both approaches illustrate that temporary trade protectionism can permanently alter the pattern of comparative advantage. It is, however, ambiguous if such protection improves welfare (only Grossman and Helpman, 1991 show that this is possible).

This thesis focuses primarily on the concept of ***dynamic comparative advantage*** as an indicator of changes in the competitiveness of the agricultural sector. It is defined as '*temporal shifts in national comparative advantage based on shifts in relative factor prices and development of new or improved factors'* (Harrington, 2002). There are several reasons why these relative prices may shift in the economy. Relative wages of unskilled and skilled labour may shift as a result of international trade; the supply of skilled and technical labour may increase with development and investment; the availability of physical infrastructure may increase with investment due to changes in internal factor costs (resulting from the fact that certain natural resources become more economically available due to industrial development or trade, etc.).

An important benefit of the concept of dynamic comparative advantage is that it provides links between the performance of the whole economy, the rest of the world and a single sector or industry. These links will be clarified and explained further in Chapter 4, where the decomposition of dynamic comparative advantage is presented, and also in Chapter 5, where such links are empirically verified.

2.2 Measures of competitiveness

If the definition of the concept of competitiveness is varied, measures of competitiveness also vary, depending on the dimensions and level of the economy at which competitiveness is analysed. The most popular measures are described and classified in this section. One possible classification method is to divide them into two broad categories. The first category deals with the *ex-post* indicators which measure competitive performance (e.g. the degree of competitiveness or ranks of competitiveness). The second involves *ex-ante* analyses, in other words, potential competitiveness (underlined 'natural advantages'). The latter measures investigate the determinants of competitiveness and not its outcomes. These measures are also used for projecting the future competitive position of a sector or industry. Some authors also add another type of measure by analysing the *competitive management process* (Poczta, 2002 after Buckley, et al. 1988). All the above outlined measures of competitiveness are detailed in Appendix 2-1 at the end of this chapter.

2.2.1 The main indicators of ex-post competitiveness

Several approaches are used to analyse the past performance of competitiveness. The most popular ones, stemming from the definitions presented in the previous sections of this chapter, are: real exchange rate, trade and market shares and indicators of the attractiveness of the country to investors, such as GDP growth, FDI inflow, etc.

2.2.1.1 Real exchange rate (RER)

The real exchange rate is a measure which can help in assessing international competitiveness of a particular economy because it shows the relative costs of the common reference basket of goods between countries (or price ratio of tradables to non-tradables) converted into a common currency (Obsfeld and Rogoff, 2002). The costs of producing tradable goods differ significantly between countries mainly due to different prices of non-tradable inputs used in producing such commodities (and to a lesser extent due to tradable inputs which are determined by differences in trade policies among countries). Therefore, a relative increase in the cost of non-tradable inputs which is equivalent to an appreciation of the real exchange rate leads to higher production costs, provided there is no change in techniques or technology (or factor productivity) (Frohberg and Hartman, 1997) – see Appendix 2-1, Equation 2-2.

In Poland, as in other CEECs, persistent real appreciation of the domestic currency has been a characteristic feature of the entire transformation process. Although many authors have attempted to show that real exchange rate appreciation in transition countries may have been the result, at least to some extent, of productivity increases in the traded goods sector (Harrod-Balassa-Samuelson effect)[4], enhancing each countries' competitiveness, this does not alter the fact that at the same time such appreciation puts severe pressure on the wider economy and its constituent sectors (as domestic products become more expensive in terms of foreign currencies). As such, this may have gradually led to a lack of competitiveness if productivity failed to increase sufficiently strongly to keep pace with it (EBRD, 1999). This is looked at in more depth in the context of a discussion into the competitiveness of the Polish agricultural sector in Chapter 4, Section 4.2.

2.2.1.2 Trade and market shares

The relationship between trade and competitiveness is straightforward: the higher the share of the market (either domestic or foreign), the larger the competitiveness of the

[4] To mention only a handful: Halpern and Wyplosz (1997), Krajnyak and Zettlemeyer (1998), Maliszewska (1998), Balazs (2002).

firm or country selling the product. Many different indicators have been developed to measure competitiveness based on market and trade shares. Although most of them have been designed for international comparison, they may also be used to contrast the competitiveness of different regions, though most of them are based on trade rather than domestic market information (Frohberg and Hartman, 1997).

The first indicator, proposed by Balassa (1965), *Revealed Comparative Advantage (RCA),* compares the value of exports of a given commodity against its share in the analysed country's total exports and exports of this good in total global exports (as indicated in Appendix 2-1, Equation 2-3). Many other indicators have been developed from Balassa's indicator, among them the most popular are the Relative Export Advantage Index (XRCA) and the Relative Import Penetration Index (MRCA).

The Relative Export Advantage Index (XRCA) is defined as the ratio of a country's export share of a certain product in the total global market to the same country's share in total world exports of all other commodities (see Appendix 2-1, Equation 2-4). Values above unity suggest that the country has comparative advantage in the considered product category, whereas values below unity mean competitive disadvantage. In turn, the Relative Import Penetration Index (MRCA) considers imports instead of exports, and its interpretation is reversed (values above unity indicate comparative disadvantage)[5] – see Appendix 2-1, Equation 2-5.

The difference between XRCA and MRCA can be expressed in the form of the Relative Trade Advantage Index (RTA), first used by Scott and Vollrath (1992). The competitive advantage revealed by this indicator is implicitly weighted by the importance of relative export and relative import advantages. Hence, it is not dominated by extremely small export or import values of the commodity considered. A positive value indicates a competitive advantage, and a negative one, a competitive disadvantage – see Appendix 2-1, Equation 2-6. One advantage of RTA is that it considers imports and exports together, which from the point of view of trade theory is an advantage, especially due to the increase in intra-industry trade (for more information refer to Frohberg and Hartman, 1997). If, for example a country only acts as a transit country, the XRCA might indicate high levels of competitiveness that would be purely artificial. Therefore, very often these indicators are showed together with the Intra-Industry Trade Index (IIT), which measures the intensity of imports and exports for the same good (see Appendix 2-1, Equation (2-7).

Despite the fact that RTA is a more comprehensive and superior measure of competitiveness it is not totally immune from the same weaknesses that hamper the other two. There are numerical problems with all three measures. Pitts et al. (1995), for example, questions the usefulness of these indexes for cross-country analyses, since the size of a country affects the values. Frohberg and Hartman (1997) criticise

[5] MRCA can, however, be misleading since it can be heavily distorted due to protection of domestic markets. In the extreme case of an import ban or a prohibitively high import tariff, this measure indicates a high level of competitive advantage, while in fact the reverse may be the case (Frohberg and Hartman, 1997).

the usefulness of the measure for Transition economics. This is because there are difficulties with interpretation of such measures if they show large annual fluctuations, which in turn may be due to structural changes characteristic for countries in transition.

Other measures of trade and market shares also exist, e.g. Trade Coverage (TC), Competitive Position Indicator (Ct) and Price Ratio Algorithm (PRA), though they are all based on the same logic as those described above (also presented in Appendix 2-1). They are referred to in the next chapter, which focuses on the results of previous empirical studies into the competitiveness of Polish agriculture.

2.2.1.3 Indicators of the country attractiveness to investors

Another group of *ex-post* indicators of competitiveness are those which assess the general well-being or attractiveness of a country. Among them the most important is foreign direct investment (FDI). The key question is: how precisely does FDI affect competitiveness? This is not easy to answer unambiguously. It is widely thought that any causality that exists between them can actually can operate both ways: FDI increases competitiveness and the latter attracts the former (Bonelli, 1998). But large inflows of FDI do not necessarily assure competitiveness or act as a good indicator of it. This can be exemplified by looking at various transition countries, which despite attracting large FDI inflows have not been able to avoid financial crisis, as the Czech Republic and Asian countries in 1997 well illustrate. In contrast, Poland initially attracted relatively lower levels of capital inflows than for example the Czech Republic and avoided crisis. But does this mean that it was more competitive?

By and large, however, the amount of FDI into a country is indeed seen as a positive sign of its overall competitiveness. The same is the case with sectors and regions which are able to attract investment. The logic is that any of these units which is able to attract FDI must have an advantage in certain production conditions that the investing firms cannot find elsewhere (Frohberg and Hartman, 1997). However, again there is two-way causality. If, for example, those investments are aimed at opening markets for producers from their own countries this will rather mirror the competitiveness of the donor country and the weakness of the hosting country; otherwise they point to a competitive advantage of the country or region attracting FDIs. However, it is difficult to distinguish between the two and hence it is difficult to assess competitiveness based on FDI (Frohberg and Hartman, 1997).

The literature also includes various attempts to incorporate FDIs into indices of competitiveness, which are usually extensions of the XRCA index (Traill and Gomesda Silva, 1994 discuss this in more depth).

2.2.2 Main indicators of the potential of competitiveness

The measures presented in the previous section measure the past performance of competitiveness. Some of them can be used for assessing the impact or competitiveness of new policies if they are not very different from those in the past. However, they are not useful when simulating completely new effects and their influence on competitiveness, as e.g. the potential impact on competitiveness of CEECs integration into the EU, etc. For that kind of analysis methods which take more systematic account of all components of a firm/sector performance are more useful. These are measures of potential competitiveness.

2.2.2.1 Domestic Resource Costs (DRC)

Domestic Resource Costs (DRC) is the most common measure of this type. It is deeply rooted in neo-classical trade theory and can be used to calculate both static and dynamic comparative advantage.

Formally speaking, DRC is a ratio which compares the social opportunity costs of domestic production against the value added it generates, expressed in international prices (Tsakok, 1990:119). The numerator includes domestic resources and non-traded inputs (i.e. the value of domestic capital, labour and land) valued at opportunity costs (shadow prices) and the denominator includes domestic output and tradable inputs valued in border (international) prices. All the prices are adjusted to the farm level (as such having to take account of transaction costs) – see Appendix 2-1, Equation 2-11.

DRCs are interpreted as an indicator of the international competitiveness or efficiency of domestic production. If the ratio is below one (DRC<1) the country is competitive in producing a given good. In other words, it indicates that the economy saves by producing a product domestically because the opportunity cost of its domestic resources is less than the net foreign exchange it gains from exports or saves on import-substituting products. The opposite is true for a DRC>1 (Tsakok, 1990:119).

The key advantage of this measure is that it can be worked into in a dynamic comparative advantage approach. As Nishimizu and Page (1996) showed, changes in competitiveness measured by DRC can be formally broken down into distinct changes, in: (i) international prices (output-input and factor prices), (ii) total factor productivity, and (iii) techniques of production (factor proportions). This dynamic approach is detailed in Chapter 4 (Section 4-3 and Box 4-1).

This measure however, is also not free from weaknesses, in particular the valuation of shadow prices for inputs. As Masters and Winter-Nelson (1995) show, the measure is biased, as in case of activities which rely on a high level of non-tradable inputs it usually indicates them as inefficient. The bias is especially noticeable if the various options being compared include very divergent combinations of traded and non-traded inputs. In addition, the distinction made between the costs of tradable and non-tradable components is often rather ambiguous. Finally, methodological difficulties stem from difficulties in gathering the necessary input-output coefficients for analysis, as they are very detailed (Frohberg and Hartman, 1997).

Various indicators derived from DRC measuring comparative advantage use the same information in a slightly different way. They include Rates of Bilateral Competitiveness (RBC), Net Economic Benefit (NEB) and the Social Cost Benefit (SCB). Each is presented and interpreted in Appendix 2-1.

2.2.2.2 Accounting methods

This method is based on comparisons of costs and/or gross margins (the difference between costs of variable inputs and gross revenue) across firms to indicate which have a competitive advantage. This analysis can be applied to single commodities, and is as such always carried out at the product level. The index is based on a detailed breakdown of the various cost items of production and therefore provides detailed insight into the differences among enterprises across regions or countries in terms of competitiveness (Frohberg and Hartman, 1997).

However, the method also has certain limitations, to mention only two. Firstly, it does not take into account alternative costs - gross margins do not offer any insight into whether quasi-fixed factors can be paid in accordance to what they would earn if they were used in the production of other commodities. Secondly, data requirements are very strong - the data required is so detailed and based on certain country accounting practices that it is hardly comparable between countries (for more details please refer to Frohberg and Hartman, 1997).

2.2.2.3 Computable General Equilibrium (CGE) and other mathematical models

The last category of measures which can be used for assessing potential competitiveness are simulation models. They would seem to be the most comprehensive tool for measuring competitiveness, but because they are costly, time-consuming to build and very demanding in term of data they are not often employed for this purpose (as Confucius said, no need to use a cannon to kill a mosquito).

Models which include commodity and sector, and explicitly include the key elements of the structures are more appropriate. Therefore, equilibrium models are preferable to other types of mathematical models, since they depict both supply and demand in a detailed way and can therefore comprehensively explain competitiveness and comparative advantage, themselves general equilibrium concepts (Frohberg and Hartman, 1997)

All in all, although mathematical models are suitable for comparing competitiveness across countries they are not often employed for measuring just competitiveness, due to their tough requirements in terms of manpower, data and time, but more often they are built to analyse the impact of various policy scenarios. There have been many studies based on partial and general equilibrium models, which have analysed the impact of EU accession on the Poland's and other CEECs' agricultural sectors, to name but a few: Orłowski (1996), Josling, et al. (1998), Guba and Piskorz (1998), Banse, Münch, Tangerman (1999), SAEPR/FAPA (2000), Bauer (2001), European Commission (2002)[6]

2.3 Differences in interpretation and policy advice

The above-presented measures of the two main approaches to competitiveness, *ex-post* and *ex-ante*, differ not only in the measures they use but also in their interpretations. In fact, the differences between them result from distortions originating either from policy interventions or imperfect competition. In a world without any policy interventions they should be equivalent to each other. However, since policies can influence the competitiveness of products (especially in the agricultural sector), the two kinds of measures can radically differ. The larger the gap, the more distortive the policies are.

For example, if an indicator of potential comparative advantage is low this indicates that the analysed product has a lower level of specialisation in relation to other products in the analysed economy. It most certainly does not mean that the product cannot be exported and win revealed high comparative advantage. On the other hand, low exports of a given product or even no exports (lack of revealed comparative advantage) does not mean that that country lacks also potential comparative advantage in producing that particular product (Guzek et al.,1999).

Interpretations and policy recommendations alike differ in the case of these two approaches. From the *ex-post* indicators we can see in the export of which product competitiveness is revealed. Therefore, the main policy recommendations stemming from this kind of approach are usually to develop the country's export potential in goods for which it already has a high export specialisation. However, based on potential indicators of competitiveness, policy advise would be to develop the export based on indicators of financial efficiency and profitability (rather than former export performance), and this would entail specialisation and export products which have

[6] A good overview of various models developed before 1999 assessing the impact of EU enlargement on the CEECs is presented in Nielsen (1999).

the highest Ricardian rather than Balassaian type of comparative advantage (Guzek et al., 1999).

2.4 Conclusions

- There is no single theory nor ideal measure of competitiveness. However, most theories stress technology and productivity as the prime determinants of long-term competitiveness (Abbot and Bredahl, 1994). Furthermore, measures of competitiveness include either a *technical component* (productivity or efficiency) or a *relative price component* (prices of inputs and outputs or private versus social prices) or both (Bureau and Butault, 1992), although they also vary considerably (with regard to methodology, as well as manpower and data requirements).
- However, all of the measures have strengths and weaknesses. As such, researchers have to choose the method and measure which best suits their research goals, and for which they can obtain data. Given this overview of theories and measures of competitiveness and given the aims of this study, the theory of dynamic comparative advantage and its most popular measure - domestic resource costs (DRC) – are preferred. First of all, this measure allows a combination of micro- and macroeconomic analyses. It shows how productivity has to respond to changes in relative prices and its dynamic breakdown grasp these relations implicitly. It differs from many other measures which are either solely of a macroeconomic character (real exchange rate, trade shares, etc.) or microeconomic (e.g. indicators of profitability, productivity), which makes them less likely to address competitiveness comprehensively.
- Also, from the policy point of view this study is more interested in analysing potential competitiveness as it allows for policy recommendations aimed at supporting long-term competitiveness with measures targeted at specific (structural) problems. Such an approach to farm policy provides for higher efficiency of public spending compared to traditional approaches based mostly on instruments of production support (e.g. market protection). It is also consistent with general trends in farm policy reforms in OECD countries, and is specifically true for the CAP (the future farm policy for Poland).
- Besides, recent studies by Berkum and Meijl (1998) concluded that comparative advantage is most probably the major force driving competitiveness in the agro-food sector (especially those sub-sectors which rely heavily on certain domestic resources, for example, dairy production relies on domestic green pastures and farm labour).

Appendix 2-1: Measures of competitiveness

1. Real Exchange Rate

(2-1) $RER = \frac{NER}{PPP} = NER \frac{p^*}{p}$

where: PPP is Purchasing Power Parity, NER is the nominal exchange rate expressed in units of domestic currency per one unit of foreign currency; p^* and p are the appropriate foreign and domestic price deflators.

(2-2) $RER = \frac{p^T}{p^{NT}}$

where: NER stands for nominal exchange rate, p^T is the price index of tradable commodities and p^{NT} of non-tradable commodities.

2. The Revealed Comparative Advantage

(2-3) RCA = $\left(\frac{Xin}{Xiw} \Big/ \frac{Xmn}{Xmw} \right) * 100$

where: Xin refers to the value of exports of commodity i from the country n, Xiw the value of exports of commodity i from all countries in the world, Xmn the value of exports of all goods m from the country n and Xmw value of exports of all goods from all countries. Values above 100 indicate a RCA and vice versa.

3. The Relative Export Advantage Index (XRCA)

(2-4) $XRCA_{ij}^{EU} = (X_{ij} / X_{im}) / (\sum_{k,k \neq i} X_{kj} / \sum_{k,k \neq i} X_{km})$

where: X refers to exports; i and k denote the product categories; j and m refers to countries of interest, EU (or World) is a benchmark. Values above unity suggest that the country has a competitive advantage in the considered product category, whereas values below 1 point to a competitive disadvantage.

4. The Relative Import Penetration Index (MRCA)

(2-5) $MRCA_{ij}^{EU} = (M_{ij} / M_{im}) / (\sum_{k,k\neq i} M_{kj} / \sum_{k,k\neq i} M_{km})$

Is very similar to the XRCA but relates to imports. However interpretation is vice versa; a value above unity is a sign of a competitive disadvantage, and values below unity are an indication of comparative advantage.

5. The Relative Trade Advantage Index

(2-6) $RTA_{ij}^{EU} = XRCA_{ij}^{EU} - MRCA_{ij}^{EU}$

where: all superscriptions are as above. The competitive advantage revealed by this indicator is implicitly weighted by the importance of the relative export and the relative import advantages. Hence, it is not dominated by extremely small export or import values of the commodity considered. A positive value indicates a competitive advantage and a negative, a competitive disadvantage.

6. The Intra-Industry Trade Index

(2-7) $IIT_{ij} = (1 - (abs(X_{ij} - M_{ij}) / (X_{ij} + M_{ij}))) * 100$

This indicator measures the intensity of imports and exports for the same good. It is bound between zero and 100. The closer the value is to 100 the more intensive is the trade.

7. The Trade Coverage

(2-8) $TC_i = \frac{X_{ij}}{M_{ij}}$

where: X_{ij} is export of commodity (or group of products) i to the reference country; M_{ij} import of commodity (or group of commodities) i from the reference country; i is commodity group; j is the reference country.

8. Competitive Position Indicator Ct

(2-9) $\mathrm{Ct} = \frac{Ex_t}{\mathrm{Im}_t} \Big/ \frac{Ex_0}{\mathrm{Im}_0}$,

where, Ex is export and Im is import in the base year 0 or certain year t.

9. The Price Ratio Algorithm

$$(2\text{-}10)\ PRA_{Ex/\mathrm{Im}} = \frac{\sum_i V_i^{C\_UEex}}{\sum_i Q_i^{C\_UEex}} \Bigg/ \frac{\sum_i V_i^{C\_UEim}}{\sum_i Q_i^{C\_UEim}}$$

Where $V_i^{C\_UEex}, Q_i^{C\_UEex}$ are the value and volume of exports from country C to UE (respectively) and $V_i^{C\_UEim}$ and $Q_i^{C\_UEim}$ are the value and volume of imports to country C from UE (respectively*)*

10. The Domestic Resource Cost and Private Costs Ratio

$$(2\text{-}11)\ DRC_i = \frac{\sum_{j=k+1}^{n} a_{ij} V_j}{P_i^r - \sum_{j=1}^{k} a_{ij} P_j^r}$$

where: *aij, k+1* to *n* is the technical coefficient for domestic resources and non-tradable inputs; *Vj* is the shadow price of domestic resources and non-tradable inputs; P_i^r is the border / reference price of traded output; *aij 1* to *k* is the technical coefficient for traded inputs. P_j^r is the border / reference price of traded inputs; *i* commodity and *j* input. DRC<1 indicates the existence of a comparative advantage and vice versa. If one expresses the DRC in private prices then a Private Cost Ratio (PCR) is estimated. PCR<1 indicates that an activity generates positive private profits.

11. The Rates of Bilateral Competitiveness

$$(2\text{-}12)\qquad RBC_i^{C,EU} = \frac{\sum_{j=1}^{k} a_{ij}^C V_j^C}{P_i^{EU} - \sum_{j=k+1}^{n} a_{ij}^C P_j^{EU}}$$

where: superscriptions are as above and in addition: *c* denotes the country of interest and EU the respective benchmark. RBC<1 indicates that the country of interest is profitable if operating under the benchmark's output and tradable input prices with domestic resource valued in terms of domestic opportunity costs.

12. The Net Economic Benefit

$$(2\text{-}13)\, NEB = P_i^r - \sum_{j=1}^{k} a_{ij} P_j^r - \sum_{j=k+1}^{n} V_j$$

where: superscriptions are as above. A positive NEB reflects efficient resource use, and negative, vice versa.

13. The Social Cost Benefit ratio

$$(2\text{-}14)\, SCB_i = \frac{\sum_{j=1}^{k} a_{ij} P_j^r + \sum_{j=k+1}^{n} a_{ij} V_j}{P_i^r}$$

where: the superscriptions are as above. The SCB offers a ranking of alternatives of production with regard to increasing social profitability; the higher the ranking the stronger the impact on social profitability.

14. The Competitiveness Coefficient

$$(2\text{-}15)\, CC_i = \frac{P_i^r - \sum_{j=1}^{k} a_{ij} P_j^r}{\sum_{j=k+1}^{n} a_{ij} V_j}$$

All superscriptions as above. It is the inverse of the DRC ratio (the higher values above 1 the higher comparative advantage).

3 Overview of Empirical Research on the Competitiveness of Polish Agriculture

This chapter synthesises the methodology and results from previous empirical research on the competitiveness of Polish agriculture vis-à-vis European Union (EU) and world markets. The ultimate aim of the chapter is to present how this dissertation could develop current knowledge and methodology in further exploration of the subject.

The literature on competitiveness of Polish agriculture, especially in the context of European Union entry is very rich. Over the last few years, many publications on the subject have been written within various projects (usually financed by the State Committee for Scientific Research (KBN) and the European Commission), with Polish academics often co-operating with academics from the European Union. Many papers on the issue have been presented at agricultural conferences and congresses in Poland (e.g. the congress of the Polish Association of Agriculture and Agrobusiness Economists (SERiA) and abroad (e.g. at congresses of the European Association of Agricultural Economists and International Association of Agricultural Economists). The most active in research and publishing on this subject in Poland have been: the Institute of Agricultural and Food Economics (IERiGŻ), Warsaw Agricultural University (SGGW), Agricultural University in Poznań, Warsaw University (UW) and some other universities in Poland, the Polish Academy of Science (IRWiR/PAN), the Foundation of Assistance Programmes for Agriculture (SAEPR/FAPA), the Foreign Trade Research Institute (IKCHZ), the World Bank mission in Poland and many NGOs.

This broad literature on the competitiveness of Polish agriculture can be divided into two broad categories: empirical and descriptive[7], with the latter far outweighing the former. The literature overview in this thesis deals exclusively with empirical studies, for the following reasons. First of all, this thesis also has an empirical character and therefore such an overview is the more desirable from the point of view of the ultimate aims of the research. Secondly, to offer quality insights into the analysis it would be impossible to analyse each publication written on that subject, especially those of a descriptive character. Thirdly, quantitative results are easier to compare, because the same or similar indicators are calculated and presented in different studies.

Moreover, it is possible to draw various common conclusions from a combination of both descriptive and empirical studies. Many studies indicate, for example, that: (i) the potential of Polish competitiveness results mainly from low production factor costs (mainly wages) relative to other sectors in the economy and relative to agricultural sectors in Poland's main trade partners, i.e. EU countries; (ii) Poland has

[7] The descriptive studies also include statistical analyses and are based on solid microeconomic data, but we call them descriptive because they do not explicitly measure competitiveness.

a revealed comparative advantage in the production of labour-intensive products; (iii) general speaking, larger farms are more competitive than small ones, (iv) the competitiveness of basic agricultural products is relatively higher than that of processed ones; (v) the competitiveness of agriculture is relatively low in the economy compared with other sectors; (vi) competitiveness is determined mainly by productivity and profitability. How these results were found is explored below.

Empirical studies on the competitiveness of Polish agriculture are most frequently based on the concept of c*omparative advantage,* though most are of a static character. Both approaches to comparative advantage, the Ricardian (ex-ante) comparative advantage approach and Balassa's (ex-post) revealed comparative advantage, have been applied. A comparison of results from those two approaches and even within them is not straightforward because the studies differ in too many aspects, for example they assess competitiveness based on a broad range of comparative advantage indicators, in different time spans, with different points of reference, different sets of products, at different levels of aggregation, etc.. Nevertheless, some very general similarities and lessons can be drawn. All the studies which we attempt to refer to here are summarised in Table 3-1 and basic assumptions about farm sizes and reference markets are summarised in Table 3-2.

3.1 Studies on potential (*ex-ante*) competitiveness

Among potential measures of comparative advantage, Domestic Resource Cost ratios (DRCs) have been the most frequently used. The main studies on Polish agriculture which have used this indicator are Gorton et al. (2000), Czyżewski, et al. (2000), Guba (2000), Guba (1999), Műnch (1997), Safin, and Rajtar (1997), and Safin (1995) (see Table 3-1).

Most of the aforementioned studies focused on primary agricultural products and only a few analysed processed products and food processing industries. The reference markets were taken to be either world markets or EU markets, with the former given precedence. As depicted in Figure A.3-1 in Appendix 3-1, studies of *non-processed products* indicate quite similar results when the same periods are covered. Generally speaking, they show that average arable production of primary *agricultural products* was more competitive than livestock production, especially during the period 1993-1997. Furthermore, small farms had a lower competitiveness than relatively large farms (DRCs for the small farms were usually above those of the large farms as indicated in Figure 3-1). This was true for wheat, rape seed, sugar beet, beef, milk and pig production (1996-1997) (note: the findings are fairly consistent despite the varying definitions of farm sizes and reference markets employed, presented in Table 3-2).

Another general conclusion is that most of the studies indicated a trend of decreasing competitiveness in the analysed period 1993-1998 and in the forecast for 2002. This concerned wheat production in both small and large farms, as well as sugar beet, pigs, beef, and milk production. Only rape seed in large farms, and apples in small farms, revealed the opposite tendency (although the forecast for apples was less optimistic).

Another conclusion from the studies on primary agricultural products is that competitiveness *vis-à-vis* EU markets was usually higher than *vis-à-vis* the world market in the case of products which are protected in the EU. Only for rape seed and apples in small farms was the reverse situation observed (Safin and Rajtar, 1997; Münch, 1997).

Referring to Poland's EU entry, Banse, et al. (2000) expanded their analysis with a forecast to 2005, employing different scenarios, i.e. the CAP with and without an inflow of foreign direct investment (FDI), with and without direct payment, etc. The forecast for fruit and vegetables was optimistic - they become competitive under all scenarios, though far more so under the 'accession plus FDI' scenario.[8] The forecast is also quite optimistic for cereals, which are expected to maintain or increase their competitiveness, and for oilseeds, which may gain competitiveness under the 'accession plus FDI' scenario.

Results from studies on *processed products* and *processing industries* are even more difficult to compare. Although fewer studies have been conducted (Guba, 2000; Banse et al., 2000; Safin and Rajtar, 1997), they have often covered different products or industries and these products were quite often at different stages of processing and different levels of aggregation. Therefore, conclusions on processed products are more circumspect and partial.

Regarding the production of meat and the meat processing industry, some products which were marginally competitive in respect to the EU were gradually losing their advantage, with the possible exception of pork (Safin and Rajtar, 1997; Banse et al., 2000) (see Appendix 3-1, Table A.3-1 and Table A. 3-3). Dairy products in general showed a lack of competitiveness, with the exception of skimmed milk powder (SMP) and ripening cheese (Table A. 3-2). Only SMP is likely to have maintained its competitiveness through to 2007. Milk processing industries per year may achieve competitiveness, but only if certain conditions are met, primarily technical change and restructuring (Guba, 2000). According to Banse et al. (2000), the dairy sector as a whole may become competitive, but only under a scenario of accession accompanied by inflows of FDI (Appendix 3-1, Table A. 3-3).

Among other groups of processed products and industries, sugar and potato processing are expected to show a lack of future competitiveness both before and after accession. Vegetable oil processing, fruit and vegetables perform better and are generally predicted to gain or sustain their competitiveness after accession.

[8] This scenario assumes an indirect effect on agricultural commodities through increased demand from processing industries which attract FDI.

In summary, several processed products and processing industries are expected to either decrease or lose competitiveness after accession, with the exception of certain products in particular conditions. Potentially, the most competitive appear to be vegetable oils, fruit and vegetables.

3.2 Studies on revealed (*ex-post*) competitiveness

A large number of measures have been used to study revealed comparative advantage. The main ones were carried out by Frohberg (2000), Misala (1997), Mroczek (1995) and Guzek (1993).

The most common measures of this type which have been employed are the Revealed Comparative Advantage (RCA) and the Trade Coverage (TC) indicators. A number of measures, derived from the basic ones, have also been applied. These include the Relative Comparative Export Advantage Index (XRCA), the Relative Import Penetration Index (MRCA), the Relative Trade Advantage Index (RTA), the Revealed Comparative Advantage Export Indicator (XCA), the Import Penetration Index (MP) and the Competitive Position Indicator (Ct). These measures were used by Frohberg (2000), Misala, (1997) and Mroczek (1995). Misala (1997) also analysed intra-industry trade with the EU. Guzek (1993) pioneered this approach in Polish studies by applying the PRA (Price-Ratio Algorithm) measure. Technical presentation of the main measures is included in the previous chapter, in Appendix 2-1.

Comparison of these studies is even more complex than those previously considered. This is because: (i) there are more measures applied in each study (from 3 to 7); (ii) there is a longer time span for analysis including forecasts (from 4 to 10 years) and (iii) of the large number of products considered in each study (from 21 to 92) at different levels of aggregation (e.g. CN-2 digit or CN-4 digit). For this reason only the results of some of the most comprehensive studies are presented below.

An early study by Guzek (1993) covered 65 agro-food products broken down into 12 sections of agriculture and processing, referred to six years as a base period (1986 – 1991) and included a 5-year forecast (1992 - 1996). Guzek (1993) concluded that Poland has a higher revealed comparative advantage in the production of raw materials and labour-intensive products compared to processed goods. Poland's comparative advantage in processed goods has been gradually declining (Appendix 3-1, Table A. 3-4). These results were confirmed by Mroczek (1995). He indicated that during the analysed period (1990-1993), Polish comparative advantage systematically declined *vis-à-vis* the EU with regard to agro-food products. He also confirmed that Polish comparative advantage was revealed mainly in labour-intensive products (Table A. 3-5).

Misala (1997) continued Mroczek's (1995) approach and calculated the same indicators of revealed comparative advantage for two-digit CN data for the years 1992-1995 (Appendix 2, Table 6). Misala classified the products into three groups:

declining RCA, changeable RCA and clearly growing RCA (Table A. 3-7 in Appendix 3-1). Misala's conclusions could be summarised into the following points:

- during the analysed period, the degree of comparative advantage was declining for a large number of products, especially those for which an important share of output was exported;

Polish exports were dominated by unprocessed food and agricultural products, the income elasticity of demand for which are low;

- in the group of products with declining RCAs were live animals, meat and edible meat offal, fruit and vegetables, fats and oils, fruit and vegetable juices and ethyl alcohol. In the group of products with increasing RCAs were mainly dairy products and frozen fruit and vegetables. The rest of the analysed products had changeable RCA indicators.

A similar approach, but based on slightly different coefficients of revealed comparative advantage, was applied by Guzek et al. (1999) for the years 1993-1997. The study included a forecast up to 2002. Out of the 92 products analysed, 43 per cent had a comparative advantage over the EU, out of which 18 per cent had a high comparative advantage. Among the most competitive products were thoroughbred horses (technical point here: do you mean purebred horses (of any breed) or thoroughbreds as in racehorses like Savannah?, vegetable seeds, various fresh fruit and vegetables, and various alcoholic beverages (beer, ethyl alcohol). Among the commodities that revealed a lack of comparative advantage were yoghurt, soya oil, tomato concentrate and herbs. The rest of the analysed products had changeable comparative advantage indictors (Appendix 3-1, Table A.3-8).

In the most recent study on ex-post competitiveness by Frohberg (2000) a broad set of measures was calculated, among them XRCA, MRCA and RTA. The study covered 21 agricultural products (including their processed derivatives) over a time span of 1995 to 1998. The study showed that confectionery, pastry and cattle had revealed comparative advantage in relation to the EU and the world market. However, wheat, rape seed oil(do you mean oil seed rape of oil from rapeseed?, barley and malt of barley and grapes were not competitive (Table A. 3-9 and Table A. 3-10 in Appendix 3-1).

Overall, the studies on revealed comparative advantage (RCA) confirmed that Poland has a low comparative advantage in processed products, which is consistent with results from studies on potential competitiveness.

3.3 Studies on determinants of competitiveness

It is worth mentioning one more group of empirical studies which focus on selected determinants of competitiveness such as factor productivity, profitability and efficiency. These generally aim at explaining overall performance of farms. Although they do not explicitly refer to (or measure) competitiveness they do contribute considerably to the overall understanding of the competitiveness of the Polish agricultural sector. The methodology applied in these studies and the main results are summarised in Table 3-3.

From studies on productivity it is clear that total factor productivity (TFP) of individual farms in Poland in 1991-1994 was declining (Brümmer, et al. 2002) and at the end of 1990s was on average rather low – most of the analysed farms were found to be unproductive by Davidova, et al., 2002. The reasons for this which were highlighted in such studies were either of a technical character, for example technological regress (Brümmer, et al. 2002), overcapitalisation of farms combined with low quality of capital (Davidova et al., 2002) or of other character, for example low quality of other production factors such as land and labour (where the latter is indicated by low education of farm owners) and lack of profitability (Davidova, et al. 2002).

Generally, TFP seems to be positively correlated with farm size (Davidova, et al., 2002 and Mech, 1999), although there are some contradictory findings concerning partial productivity in that respect. Some studies indicated that land and labour productivity increase with farm size (Lerman, 2002), while others show that land productivity decreases with farm size and only labour and capital productivities increase with it (Mech, 1999).

There is also a whole spectrum of opinion on efficiency, especially with respect to farm size. While some authors could not find a statistically significant relationship between efficiency and farms size (van Zyl, et al., 1996), some pointed to a negative relationship (Munroe, 2001), while others to a positive relationship (Lerman, 2002). Generally, technical efficiency was assessed as low and most farms as inefficient (Latruffe, et al. 2003, Lerman, 2002), although Lerman (2002) pointed out also that this is not the whole picture , as there is a small (10%) group of efficiency leaders. The situation in terms of scale efficiency appears to be somewhat better, with the average higher than 'pure' technical efficiency, and in both efficiencies livestock farms were found to be better on average than crop farms (Latruffe, et al. 2003). Among the key determinants hampering efficiency the authors pointed to poor management due to low education (Latruffe, et al. 2003, Munroe, 2001), the ageing of farmers (Munroe, 2001) and overcapitalisation (Latruffe, 2003), while family labour and specialisation were positively correlated with efficiency (Munroe, 2001; Latruffe, 2003). As for development of efficiency over time, Brümmer, et al. (2002) show some improvement in technical and scale efficiency in 1991-1994, but later studies by Latruffe, et al. (2003) show a declining trend – scores for efficiency are lower in 2000 than in 1996.

3.4 Limitations of the previous research

Most of the research on competitiveness is typically microeconomic. There has not been any research on competitiveness done in Poland to date using dynamic comparative advantage broken down into changes in factor productivity, relative prices and production techniques that takes into account macro- and microeconomic linkages. In addition, static measures of comparative advantage have tended to prevail over those which are dynamic (although they were usually calculated for several year periods). Besides, research on the productivity of the Polish agricultural sector has usually been covered by partial productivity indicators (productivity of labour and productivity of land in particular) and only exceptional studies have touched Total Factor Productivity. Furthermore, the TFP Malmquist index for Polish farms has never been broken down by the DEA method to take account of technological and efficiency changes in the sector. As far as this author is aware, the TFP index break down has been carried out in only one study for Poland (Brümmer, et al, 2002). Studies on efficiency, which is an important element of productivity, are relatively rare and there is still a need for a more comprehensive explanation of particular determinants of various types of (in)efficiency.

3.5 Conclusions

- Based on an overview of previous studies this thesis addresses some of the deficiencies in the current literature and seeks to popularise the discussion on agricultural sector issues in a macroeconomic context. By applying the dynamic comparative advantage (DCA) approach and its break down (into relative prices, productivity and factor proportions components) the thesis will illustrate the dynamic aspects of changes in competitiveness in this sector which has struggled under transition pressures. The importance of total factor productivity (TFP) in the overall process of adjustment will be shown, and the TFP determinants that are specific to Polish farms will be specified. In this way the study combines micro- and macroeconomic fundamentals.
- Time series analysis will help understanding of the dynamics of the process of competitiveness and its determinants, while spatial analysis will address the importance of farm characteristics in determining the competitiveness of the Polish farm sector. This will allow for an analysis of many ‘old’ (that is, presented in previous studies) and ‘new’ variables, which can be prospective determinants of TFP, including those which are most controversial, such as size. This will put debate on possible economies of scale in Polish farming and determinants which are the most important for productivity on the policy map.

Table 3-1 Some quantitative studies of comparative advantage of Polish agro-food products

Projects	Years covered	Commodities/aggregation	Measures used
Majewski and Dalton (eds.) (2000).			
Frohberg, K.	1995-1998	21 primary and processed products	XRCA, MRCA, RTA, XCA, MP, MRTA, IIT
Gorton, M. et al.	1996-1998	9 Products: wheat, rye, rape seed, potatoes, sugar beet, pigs, beef , milk Farms: small, medium, large	DRCs
Poganietz and Frohberg (eds.) (2000)			
Banse, et al.	1995 and 2005	24 primary and processed products (at two stages of processing)	DRCs, PRCs
Czyżewski, et al.	1993-1995	8 products/activities: wheat, sugar beet, rapeseed, potatoes, live pigs, beef cattle, dairy cows, apples Farms: small and large	DRCs, PRC
Guba (2000)	1997 and 2007	Milk processing industry	DRCs, PRCs
Guba (1999)	Base years 1993-1995	8 products/activities, small and large farms	DRCs, PRCs
Guzek, et al. (1999)	Base years 1993-1997 Forecast until 2002	92 products	r_i^t coefficient (PRA)
Tangerman and Műnch (eds.) (1997)	1990-1995 forecast for 2002		
Safin, M. and Rajtar, J. Műnch, W. Rajtar, J. Safin, M.		Agro-food various products, Primary products and processing Farm-gate level Processing	DRCs
Misala, J.	1992-1995	CN 2-digit and CN 4-digit	C, IIT,RCA
Safin (1995)	1990-1993	2 products: pigs and cattle	DRCs
Mroczek (1995)	1990-1993	2-digit CN	RCA, TC, IIT
Guzek (1993)	Base period 1986-1991 Forecast period 1992-1996	65 agro-food products broken down into 12 sections of agriculture and processing	PRA

Source: Author's own compilation (for full references see the Bibliography).

Table 3-2 Main assumptions employed in different studies

1. Farm size	Small farms 5-10 ha	Large farms
Gorton et.al (2000)	3-10 ha	5 largest farms in Poland
Guba (1999); Czyżewski at al. (2000)	about 10 ha	about 20 ha
Safin and Rajtar; Műnch (1997)	5-10 ha	10< ha
Safin (1995)	no distinction between sizes	
2. Reference market		
Gorton et.al (2000)	the world market	
Guba (1999; Czyżewski at al.(2000)	the world market	
Safin and Rajtar; Műnch (1997)	the world and the EU markets	
Safin M. (1995)	the world market	

Source: Author's compilation.

Table 3-3 Summary of studies on the performance of individual farms in Poland during transition

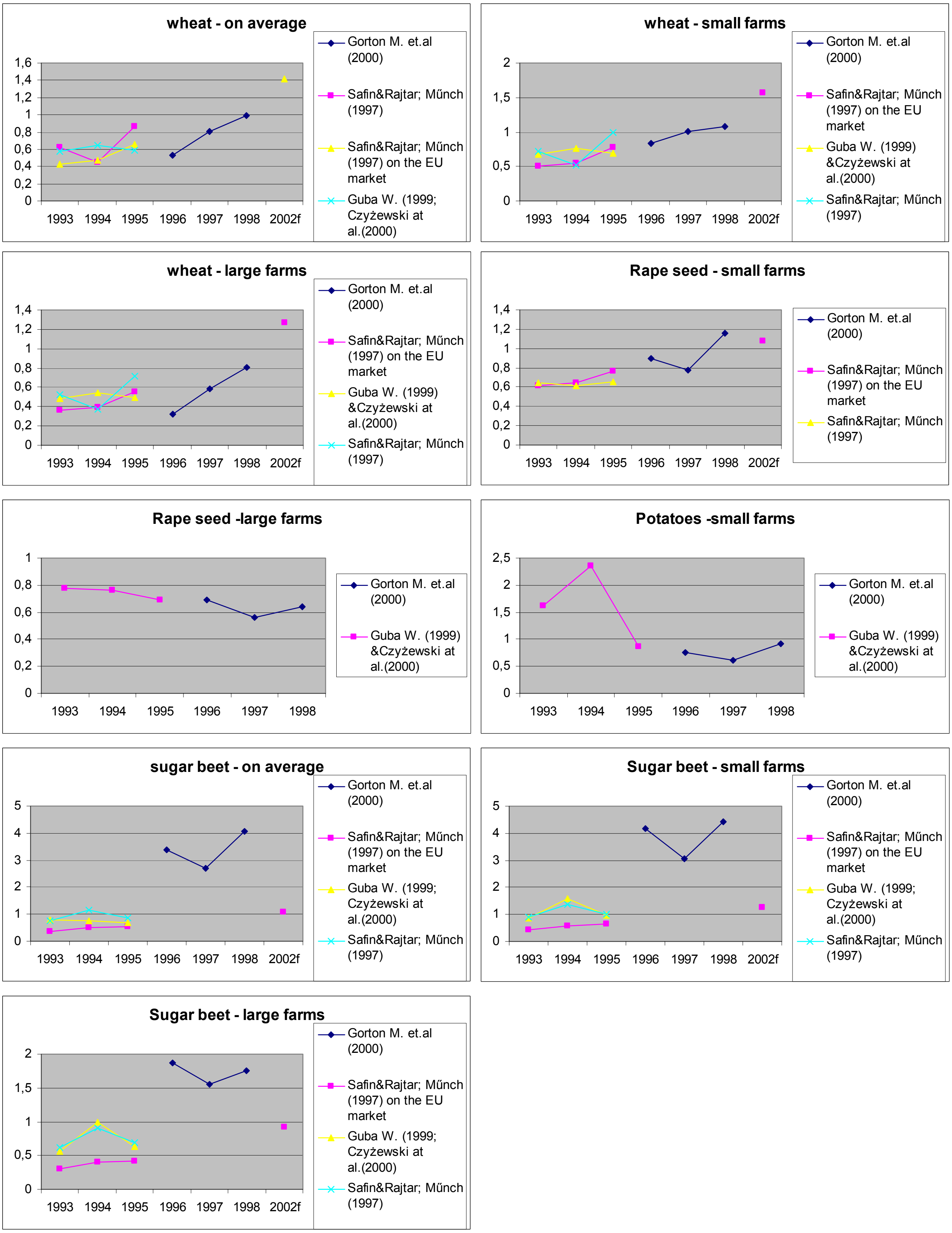
Study	Core analysis	Methodology	Period covered and data	Results
Latruffe et al. (2003)	Differences between crop and livestock farms in Technical and Scale Efficiencies	-Data Envelope Analysis - Confidence intervals from bootstrapping	1996 and 2000 IERiGŻ farm survey	- Livestock farms on average more technically and scale efficient than crop farms - Technical inefficiency is due to 'pure' technical rather than scale inefficiency - Generally all types of inefficiency are larger in 2000 than in 1996 for both crop and livestock farms - Low education of farmers and overcapitalisation hamper farm efficiency - Most of the crop farms and about half of livestock farm operating under increasing returns to scale
Lerman (2002)	Efficiency and partial productivity	- Data Envelope Analysis (DEA) -Productivity of land and labour	2000, Survey conducted by the World Bank	- Most farms very inefficient - Small group of leaders in efficiency - Larger farms on average more efficient - Land and Labour productivity increases with farm size

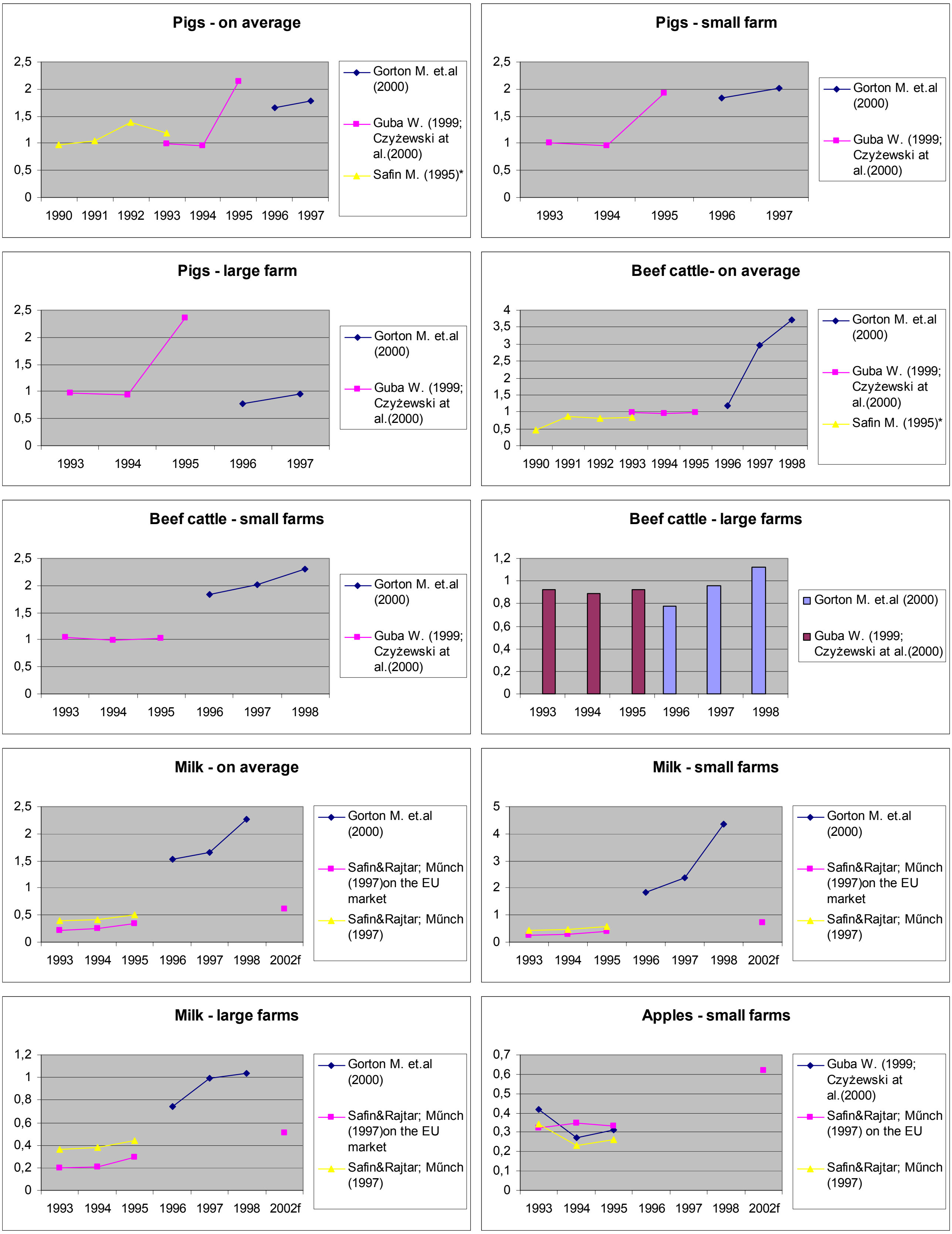
Brümmer et al. (2002)	Decomposition of productivity growth for individual farms	-Total Factor Productivity (TFP) - Malmquist index decomposition - Parametric approach, translog funcion	1991-1994 IERiGŻ farms survey	- Sharp decline in TFP - Technological regression - Small increase in technical efficiency and scale efficiency
Davidova et al. (2002)	Spatial analysis of Total Factor Productivity and profitability in Poland (+some other CEE and EU countries)	-Total Factor Productivity (TFP) - Tornqvist-Thail index - Three cost revenue ratios (one taking account of alternative costs)	1999, 2000 IERiGŻ farms survey	- Very low profitability of individual farm sector and most farms unprofitable (especially if own factors evaluated) - Generally low TFP, most farms unproductive - Low quality of education and land hamper productivity - Positive relationship between farm size and TFP and profitability
Munroe (2001)	Technical efficiency	Cobb-Douglas stochastic frontier	IERiGŻ farm survey (1996)	Farms above 15ha are less efficient. Positive correlation between specialisation and efficiency, negative with age.
Mech (1999)	Comparing productivity and gross margin between size groups of family farms	- Partial productivities- labour, land, capital. - TFP-Tornqvist index. - Gross margin index by farm sizes in relation to the country average.	1988-1994 IERiGŻ farm survey	- Land productivity decreases with size. - Labour productivity, increases with size. The smaller the farm, the higher the labour intensity. - Capital productivity increases with farm size - TFP increases with size; values larger than 1 in farms above 10 ha. - GM index increases with size, values larger than 1 in farms above 7 ha.
van Zyl et al. (1996)	Total factor productivity, and technical and scale efficiency for different size groups of family farms	- TFP-Tornqvist-Theil index at private prices and at opportunity costs - DEA	1993 IERiGŻ farm survey Two regions around the capital and Central-West	- Large farms (above 15 ha) are not more efficient than smaller farms -Differences in scale efficiency between large and small farms are insignificant -Total efficiency does not differ significantly between the two groups. - Smaller farms are more labour-intensive than larger

Source: Author's compilation based on the quoted studies

Appendix 3-1: Comparison of previous studies

Figure A. 3-1 Comparison of the DRCs of non-processed agricultural products from previous studies





Source: Author’s own compilation (for full references see Bibliography)

Table A. 3-1 Domestic Resource Cost for the first-stage processing level, 1992-1995 and projections for 2002

	Pig		Chicken		Wheat flour		Rape oil		Cheese		Sugar		Apple	
	World	EU	World	EU	World	EU	World	EU	World	EU	World	EU	World	EU
1990		0.93		0.13		1.59		0.76		0.66		2.3		0.43
1991		0.83		0.23		1.82		1.61		0.98		2.25		0.2
1992	2,26	0.51	0.66	0.28	0.98	1.23	0.23	0.85	1.51	1.5	1.36	1.82	0.22	0.2
1993	1,55	0.45	0.66	0.31	2.46	1.43	0.2	0.68	3.16	1.45	1.79	1.46	0.47	0.44
1994	1,60	0.37	0.67	0.37	1.67	0.96	0.2	1.04	2.8	1.78	2.89	1.33	0.69	1.18
1995	1,00	0.38	0.58	0.58	0.46	0.97	0.18	0.93	4.5	1.96	3.45	1.19	1.08	0.57
2002 mod. Reform		0.49		0.74		1.27		0.98		2.36		1.88		0.59
2002 Mac Sharry										3		2.49		
2002 mod. Reform		0.7		1.06		1.82		2.7		3.4		2.23		0.84
Sharry (revaluat.)										4.35		2.93		

* 2002 mod. Reform – assumption of moderate reform scenario, with no significant changes in prices and costs compared to one observed in 1998-1991; **2002 Mac Sharry- scenario based on Mac Sharry reforms' schedule

Source: Based on Safin and Rajtar (1997), Műnch (1997)

Table A. 3-2 Private (PCR) and social (DRC) profitability of dairy products under different scenarios, 1997, 2007

	1997		2007					
			Low Growth		Base		High Growth	
Without technical change	PCR	DRC	PCR	DRC	PCR	DRC	PCR	DRC
Milk processing industry	0.92	1.13	1.12	1.26	1.25	1.38	1.40	1.52
Skim milk powder	0.94	0.98	0.71	0.84	0.75	0.86	0.78	0.88
Ripening cheese	0.84	0.77	2.09	2.73	2.16	2.67	2.23	2.62
Butter	1.99	2.16	1.3	1.77	1.35	1.74	1.40	1.72
Yoghurts	0.67	1.15	0.98	1.04	1.12	1.18	1.29	1.34
With technical change								
Milk processing industry	0.92	1.13	0.82	0.86	0.92	0.96	1.01	1.05
Skim milk powder	0.94	0.98	0.67	0.71	0.69	0.73	0.71	0.75
Ripening cheese	0.84	0.77	1.24	1.28	1.33	1.36	1.42	1.46
Butter	1.99	2.16	1.18	1.24	1.21	1.26	1.24	1.29
Yoghurts	0.67	1.15	0.84	0.89	0.93	0.97	1.03	1.08

Source: Guba (2000)

Table A. 3-3 DRCs for agricultural and processed products under different scenarios, 1995, 2005

Specification	Competitiveness in "Accession"		Competitiveness in -Accession + FDI"		Specification	Competitiveness in "Accession"		Competitiveness in -Accession + FDI"	
	1995a	2005a	2005a	Change (%)b		1995a	2005a	2005a	Change (%)b
Cereals	0.95	0.98	0.72	26.7	Canning Industries	0.96	0.98	0.74	24.5
Oilsceds	1.05	1.02	0.78	22.9	Milling	1.02	1.04	0.82	21.1
Fruits	1.01	0.94	0.83	11.3	Potato Processing	1.05	1.19	1.1	7.5
Vegetables	1.03	0.96	0.65	32	Baking	0.98	1.08	0.74	31.2
Tee	1.1	1.21	1.05	13.1	Sugar Industries	1.08	1.15	1.07	7.2
Beef and Veal	1.11	1.33	0.93	29.8	Sweets and Confectionery	0.97	1.1	0.99	9.8
Pork	1.03	1.06	0.87	18	Vegetable Oil Processing	0.85	0.84	0.59	29.1
Poultry	1.08	1.2	0.85	29.1	Spirits	95	1	0.97	2.9
Other Meat	1.04	1.13	0.85	24.7	Wine	1.02	1.03	0.9	12.6
Meat Processine	0.94	1.25	1.01	19.3	Beer	1.02	0.94	0.67	28.7
Poultry Processing	0.91	1.3	1.16	11	Soft Drink Industries	0.98	1	0.68	32.1
Dairy	1.11	1.02	0.94	7.7	Tobacco	1.02	1.01	0.83	17.7

[a] Value above 1 indicates uncompetitiveness, [b] Change between introduction of CAP and introduction of CAP plus changes in FDI. A negative sign (-) indicates a loss of competitiveness.

Source: Based on Banse et al. (2000)

Table A. 3-4 Projected indicators of Poland's comparative advantage for 1992-1996 measured by Price-Ratio Algorithm (PRA) vis-à-vis the EU

Product	1992	1993	1994	1995	1996	Product	1992	1993	1994	1995	1996
Barley flakes	++	++	++	++	++	Spring wheat	+'-	+'-	+'-	+'-	+
Oats	++	++	++	++	++	Canned peas	+'-	+'-	+'-	+'-	+
Potatoes	++	++	++	++	++	Concentrated tomato juice	+'-	+'-	+'-	+'-	+
Peas	++	++	++	++	++	Slaughter calves	+'-	+'-	+'-	+'-	+'-
Hemp	++	++	++	++	++	Slaughter pigs	+'-	+'-	+'-	+'-	+'-
Fresh raspberries	++	++	++	++	++	Fresh butter	+'-	+'-	+'-	+'-	+'-
Frozen red currant	++	++	++	++	++	Flour	+'-	+'-	+'-	+'-	+'-
Carrots	++	++	++	++	++	Maize	+'-	+'-	+'-	+'-	+'-
Fresh tomatoes	++	++	++	++	++	Potato flour	+'-	+'-	+'-	+'-	+'-
Apple sauce	++	++	++	++	++	White sugar	+'-	+'-	+'-	+'-	+'-
Fresh plums	++	++	++	++	++	Plain chocolate	+'-	+'-	+'-	+'-	+'-
Eggs	+	++	++	++	++	Beans	+'-	+'-	+'-	+'-	+'-
Barley	+	++	++	++	++	Drawn chicken	+'-	+'-	+'-	+'-	+'-
Buckwheat	+	++	++	++	++	Cauliflower	+'-	+'-	+'-	+'-	+'-
Winter wheat	+	+	++	++	++	Slaughter cattle	+'-	+'-	+'-	+'-	+'-
Rape seeds	+	+	++	++	++	Raw flax	+'-	+'-	+'-	+'-	+'-
Fresh cherries	+	+	++	++	++	Frozen strawberries	+'-	+'-	+'-	+'-	+'-
Consumer apples	+	+	++	++	++	Frozen black currant	+'-	+'-	+'-	+'-	+'-
Sheep for slaughter	+	+	+	++	++	Frozen raspberries	+'-	+'-	+'-	+'-	+'-
Pure-bred horses	+	+	+	++	++	Fresh pears	+'-	+'-	+'-	+'-	+'-
Fresh strawberries	+	+	+	+	+	Groats of buckwheat	+'-	+'-	+'-	+'-	-
Fresh black currant	+	+	+	+	+	Frozen vegetable mixtures	+'-	+'-	+'-	+'-	-
Fresh cabbage	+	+	+	+	+	Milk powder	+'-	+'-	+'-	-	-
Light tobacco	+	+	+	+	+	Oats flakes	+'-	+'-	+'-	-	-
Roasted chicory	+	+	+'-	+'-	+'-	Flax seeds	+'-	+'-	+'-	-	-
Sausages of swine	+	+'-	+'-	+'-	+'-	Fresh red currant	+'-	+'-	+'-	-	-
Groats of barley	+	+'-	+'-	+'-	+'-	Fruit jams (60% sugar)	+'-	+'-	-	-	-
Fodder millet	+'-	+	+	+	+	Horses for slaughter	+'-	+'-	-	-	-
Mushrooms	+'-	+	+	+	+	Ripening cheese	+'-	+'-	-	-	-
Hop cones	+'-	+	+	+	+	Frozen cherries	-	-	-	-	+'-
Rye	+'-	+'-	+	+	+	Rape seed oil	-	-	-	-	-
Natural honey	+'-	+'-	+'-	+	+	Soya oil	-	-	-	-	-
Asparagus	+'-	+'-	+'-	+	+						

++ indicates the highest Comparative Advantage (CA) (PRA between 0.61-1.00); + indicates high CA (PRA between 0.33 and 0.60); +- indicates medium CA (PRA between 0.32 and –0.32); - indicates low CA (PRA between –0.33 and –1.00).

Source: Based on Guzek (1993: 25-27)

Table A. 3-5 RCA, IIT, TC, ratios in Poland's trade with the EU in 1990 and 1993

CN	RCA ratios		IIT[1] ratios		TC ratios	
Code	1990	1993	1990	1993	1990	1993
01 Live animals	27.33	15.89	0.03	0.10	59.76	19.99
02 Meat and edible meat offal	4.18	2.28	0.28	0.89	6.21	1.26
03 Fish and crustaceans	2.58	1.09	0.36	0.63	4.09	2.15
04 Dairy produce	2.52	0.92	0.70	0.45	1.88	0.29
05 Products of animal origin	2.67	2.19	0.59	0.92	2.41	0.86
06 Live trees and other plants	0.81	0.87	0.91	0.65	0.84	0.48
07 Vegetables, roots and tubers	5.72	1.81	0.04	0.84	51.97	1.37
08 Fruit and nuts	1.47	1.58	0.72	0.90	1.76	1.23
09 Coffee and tea	0.03	0.03	0.07	0.10	0.04	0.05
10 Cereals	0.06	0.11	0.01	0.02	0.00	0.01
11 Products of the milling industry	7.37	0.86	0.08	0.08	24.54	0.04
12 Oil seeds and oleaginous fruit	2.47	0.36	0.14	0.98	13.15	1.05
13 Lac, gums and resins	0.24	0.01	0.44	0.01	0.28	0.01
14 Vegetable plating materials	0.61	1.27	0.95	0.33	0.90	5.08
15 Fats and oils	0.53	0.47	0.45	0.30	0.29	0.17
16 Preparations of meat and of fish	3.25	2.11	0.67	0.39	1.98	4.18
17 Sugar and sugar confectionery	2.29	0.84	0.58	0.62	2.44	0.44
18 Cocoa and cocoa preparations	0.53	0.04	0.52	0.04	0.35	0.02
19 Preparat? of cereals, flour and	0.13	0.27	0.04	0.11	0.02	0.06
20 Preparat. of vegetables and fruit	2.56	2.90	0.50	0.52	3.03	2.82
21 Miscellaneous edible	0.21	0.11	0.08	0.02	0.04	0.01
22 Beverages and vinegar	1.39	0.44	0.25	0.33	0.15	0.20
23 Residues and wastes from food	0.43	0.25	0.73	0.29	1.74	0.17
24 Tobacco and tobacco substitutes	0.04	0.05	0.08	0.14	0.04	0.08
01-24	2.33	1.18	0.71	0.86	1.80	0.75

[1] Intra-industry trade ratios (indexes)

Source: Mroczek (1995:143)

Table A. 3-6 RCA, IIT, and Ct in Poland's trade with the EU by two-digit CN sections, 1992-1995

CN [9] Code	RCA Ratios				IIT ratios				Ct indicator*		
	1992	1993	1994	1995	1992	1993	1994	1995	1993	1994	1995
01	3.01	3.09	4.73	1.98	0.11	0.11	0.02	0.28	98.9	540.8	34.69
02	1.09	0.24	-0.17	0.50	0.55	0.99	0.84	0.83	39.28	27.54	54.01
03	0.06	-0.57	0.04	0.26	0.97	0.63	0.94	0.95	48.86	94.28	118.2
04	0.64	0.94	1.29	1.66	0.75	0.65	0.49	0.37	124.1	184.8	269.9
05	-0.08	-0.18	-0.22	-0.32	0.90	0.80	0.81	0.77	82.37	83.29	76.51
06	-0.58	-0.19	0.06	0.17	0.66	0.80	0.95	0.99	134.9	183.3	205.3
07	1.34	1.04	1.27	1.12	0.46	0.61	0.50	0.55	67.89	89.45	77.63
08	0.84	0.93	1.27	1.03	0.66	0.66	0.50	0.59	99.64	148.5	117.6
09	-1.83	-2.28	-2.70	-2.20	0.25	0.15	0.11	0.17	58.50	40.34	67.08
10	-3.02	-5.20	-3.74	-3.45	0.08	0.01	0.04	0.05	10.40	46.85	63.07
11	-1.11	-2.10	-0.55	-1.83	0.45	0.18	0.66	0.24	33.90	169.6	47.67
12	0.63	0.39	0.12	1.15	0.75	0.91	0.98	0.54	71.69	57.74	163.5
13	-3.27	-4.85	-4.67	-4.73	0.06	0.01	0.02	0.02	18.79	23.74	22.62
14	1.83	2.68	2.46	2.60	0.31	0.16	0.18	0.16	214.2	181.7	210.0
15	-1.51	-1.80	-2.15	-1.95	0.33	0.23	0.18	0.22	67.98	50.47	62.24
16	1.63	1.66	1.87	1.57	0.36	0.38	0.31	0.39	94.46	121.8	91.79
17	-0.73	-0.15	-0.10	-0.97	0.59	0.82	0.87	0.49	163.7	182.3	76.88
18	-3.02	-3.37	-3.04	-1.68	0.08	0.05	0.08	0.27	64.42	94.94	371.3
19	-3.23	-1.96	-1.67	-1.50	0.07	0.20	0.27	0.32	327.5	459.8	552.2
20	1.87	1.47	1.13	1.47	0.30	0.44	0.55	0.42	61.43	45.72	65.30
21	-1.86	-2.33	-2.48	-2.48	0.24	0.15	0.13	0.13	57.58	51.95	52.30
22	-1.02	-0.81	-0.85	-1.18	0.48	0.53	0.53	0.41	112.5	114.0	82.45
23	-2.83	-1.79	-1.35	-1.88	0.10	0.24	0.36	0.23	258.0	424.3	250.6
24	-1.29	-1.50	-0.52	-2.13	0.39	0.30	0.67	0.18	73.91	207.9	41.98
0-24	0.18	0.03	0.17	0.09	0.41	0.42	0.46	0.40	78.55	95.30	88.97

* 1992 = 100

Source: Misala (1997: 22,24,29)

[9] The same codes are used as in Table A.3-5.

Table A. 3-7 Groups of agro-food products according to RCA in Poland's trade with the EU by CN sections, 1992-1995

CN code	Declining RCA :	CN code	Changeable RCA	CN code	Increasing RCA
101	Horses, asses, mules	208	Other meat and edible meat offal	302	Fish. fresh or chilled
104	Live sheep and goats	301	Live fish	305	Fish, dried and salted
106	Other live animals	709	Leguminous vegetables; cucumbers	402	Milk and cream
204	Meat of sheep or goats	810	Other fruit, fresh	405	Butter and other fats derived from milk
207	Meat and edible offal of the poultry	1205	Rape or colza seeds	410	Miscellaneous edible products of animal origin
307	Molluscs; aquatic invertebrates	1210	Hop cones	508	Coral and similar materials
409	Natural honey	1212	Locust beans, algae	602	Live plants
505	Skins and other parts of birds	1521	Vegetable waxes	710	Frozen vegetables
511	Animal products not elsewhere specified	1602	Prepared or preserved meat	711	Inedible vegetables, provisionally preserved
604	Foliage, branches and other parts of plants	1604	Prepared or preserved fish	714	Manioc, arrowroot, salep
703	Onions, garlic and other alliaceous vegetables	2007	Jams, fruit jellies	811	Fruit, containing added sugar
704	Cabbage, cauliflower, kale. Kohlrabi	2007	Jams, fruit jellies	1008	Buckwheat and millet seeds
708	Leguminous vegetables			1105	Flour, meal, flakes
712	Dried vegetables			1211	Plants and parts thereof used in perfumery
713	Dried leguminous vegetables			1213	Cereal straw and husks
812	Fruit provisionally preserved			1214	Fodder products
909	Seeds of anise, fennel			1401	Vegetable materials for plaiting
1501	Lard and other pig fat			1404	Vegetable products not elsewhere specified
1506	Animal fats and oils			1601	Sausages
1518	Inedible fats and oils			1701	Molasses from the extraction of sugar
1605	Crustaceans and molluscs			2003	Mushrooms and truffles
2009	Fruit and vegetable juices			2303	Wastes of sugar manufacture
2101	Extracts and essences of coffee, tea, etc.			2306	Oil-cake
2207	Ethyl alcohol of strength > 80%			2308	Vegetable waste
2208	Ethyl alcohol of strength < 80%				

Source: Misala (1997)

Table A. 3-8 Comparative advantage (measured by PRA) of Poland *vis-à-vis* the EU in descending order for selected years and products

Specification	1993	1995	1997	1998f	2002f
Pure-bred horses	++	++	++	++	++
Vegetable seeds	++	++	++	++	++
Fresh cabbage and chicory	++	++	++	++	++
Beer	++	++	++	++	++
Fresh red currant	++	++	++	++	++
Fresh raspberries	+-	+-	++	+-	++
Consumer apples	++	+	++	++	++
Ethyl alcohol	++	++	++	++	++
Fresh plums	+	+	++	+	++
Fresh strawberries	+	++	+	+	+
Fresh cherries	++	++	+	++	+
Potato flour and croup	+-	+-	+	+-	+
Slaughter cattle and calves	+	+	+	+	+
Frozen vegetable mixtures	+	+-	+-	+-	+-
Frozen cherries	+	+-	+-	+	+-
Ripening cheese	+-	+-	+-	+-	+-
White sugar	+-	+-	+-	+-	+-
Rye	+-	+-	+-	+-	+-
Fresh beef carcasses	+-	+-	+-	+-	+-
Potatoes	+-	+-	+-	+-	+-
Frozen raspberries	-	+-	+-	-	+-
Fruit jams	+	+-	+-	+	+-
Fresh butter	+-	+-	+-	+-	+-
Cheese (hard)	+-	+-	+-	+-	+-
Milk powder	+-	+-	+-	+-	+-
Sheep for slaughter	+-	+-	+-	+-	+-
Slaughter pigs	+-	+-	+-	+-	+-
Wheat	+-	+-	+-	+-	+-
Barley	+-	+-	+-	+-	+-
Sausages	+-	+-	+-	+-	+-
Margarine	+-	+-	+-	+-	+-
Flower of wheat	+-	+-	+-	-	+-
Rape seeds	+-	+-	+-	-	+-
Yoghurt	+-	+-	-	-	-
Soya oil	-	-	-	-	-
Cotton	-	-	-	-	-
Tomato concentrate	-	-	-	-	-
Herbs	+-	-	-	-	-

++ indicates the highest Comparative Advantage (between 0.61-1.00);
+ indicates high CA (between 0.33 and 0.60);
+- indicates medium (between 0.32 and –0.332);
- indicates low CA (between –0.33 and –1.00).

Source: Own presentation based on Guzek et al.(1999: 36-37)

Table A. 3-9 RCA results for crops and their processed products on the EU and world markets, 1995 - 1998

	1995	1996	1997	1998		1995	1996	1997	1998
Sugar Confectionery	+	+	+	+	Beer of Barley (EU)	+'-	+'-	+'-	+'-
	+	+	+	+	Beer of Barley (W)	+'-	+'-	+'-	+'-
Sugar (EU)	+	+	+	+	Oil of Rape seed (EU)	+'-	-	-	-
Sugar (W)	+'-	+'-	+'-	+'-	Oil of Rape seed (W)	+'-	-	-	-
Rapeseed (EU)	+	-	-	+	Wheat (EU)	-	-	-	-
Rapeseed (W)	+	-	-	+	Wheat (World)	-	-	+'-	+'-
Pastry, bread, and wafers (EU)	+'-	+	+	+	Grapes (EU)	+'-	-	-	-
Pastry, bread, and wafers (W)	+	+	+	+	Grapes (W)	-	-	-	-
Flour of wheat (EU)	+'-	+'-	+'-	+'-	Barley (EU)	-	-	-	-
Flour of wheat (W)	+'-	+'-	+'-	+'-	Barley (W)	-	-	+'-	-
Wine (EU)	+'-	+'-	+'-	+'-	Malt of Barley (EU)	-	-	-	-
Wine (W)	+'-	+'-	+'-	+'-	Malt of Barley (w)	-	-	-	-

* the ‘+’ sign indicates a high competitiveness. It is given here when the RTA is positive and the XRCA is above unity. The opposite sign, a ‘-‘ is shown in those cases in which the RTA is negative and the MRCA is above unity. This is to indicate lack of competitiveness. For those commodities and years, which depict a ‘+ -‘ the results are inconclusive.

Source: Based on Frohberg (2000)

Table A. 3-10 RCA results for livestock products on the EU and world markets, 1995 - 1998

	1995	1996	1997	1998		1995	1996	1997	1998
Cattle (EU)	+	+	+	+	Meat preparations Pigs and Sausages (EU)	-	-	-	-
Cattle (W)	+	+	+	+	Meat preparations Pigs and Sausages (W)	+	+	+	+
Beef and Veal, with and without bones (EU)	+'-	+'-	+'-	+	Butter of cow milk (EU)	+'-	+'-	+'-	+'-
Beef and Veal, with and without bones (W)	+'-	+'-	+'-	+	Butter of cow milk (W)	+	+	+'-	+'-
Beef Dried, Salt,Smoked (EU)	+'-	+'-	+'-	+	Cow Milk, Whole, Fresh (EU)	+'-	+'-	+'-	+'-
Beef Dried, Salt,Smoked (W)	+'-	+'-	+'-	+	Cow Milk, Whole, Fresh (W)	+'-	+'-	+'-	+'-
Pigs (EU)	+'-	+'-	+'-	+'-	Cheese from skim and whole cow milk (EU)	+'-	+'-	+'-	+'-
Pigs (W)	+'-	+'-	+'-	+'-	Cheese from skim and whole cow milk (W)	+'-	+'-	+	+
Pigmeat and Pork (EU)	-	+'-	+'-	+'-					
Pigmeat and Pork (W)	-	+	+	+'-					

* the ‘+’ sign indicates a high competitiveness. It is given when the RTA is positive and the XRCA is above unity. The opposite sign, a ‘-‘ is shown in those cases in which the RTA is negative and the MRCA is above unity. This is to indicate lack of competitiveness. For those commodities and years, which depict a ‘+ -‘ the results are inconclusive.

Source: Based on Frohberg (2000)

4 Theoretical Framework for Assessing Changes in Competitiveness

This chapter provides a combined theoretical formalisation of the relationships between competitiveness, productivity and macroeconomic variables. It provides a detailed description of the methodologies which will be applied later in the empirical part of the thesis in order to verify the research hypotheses.

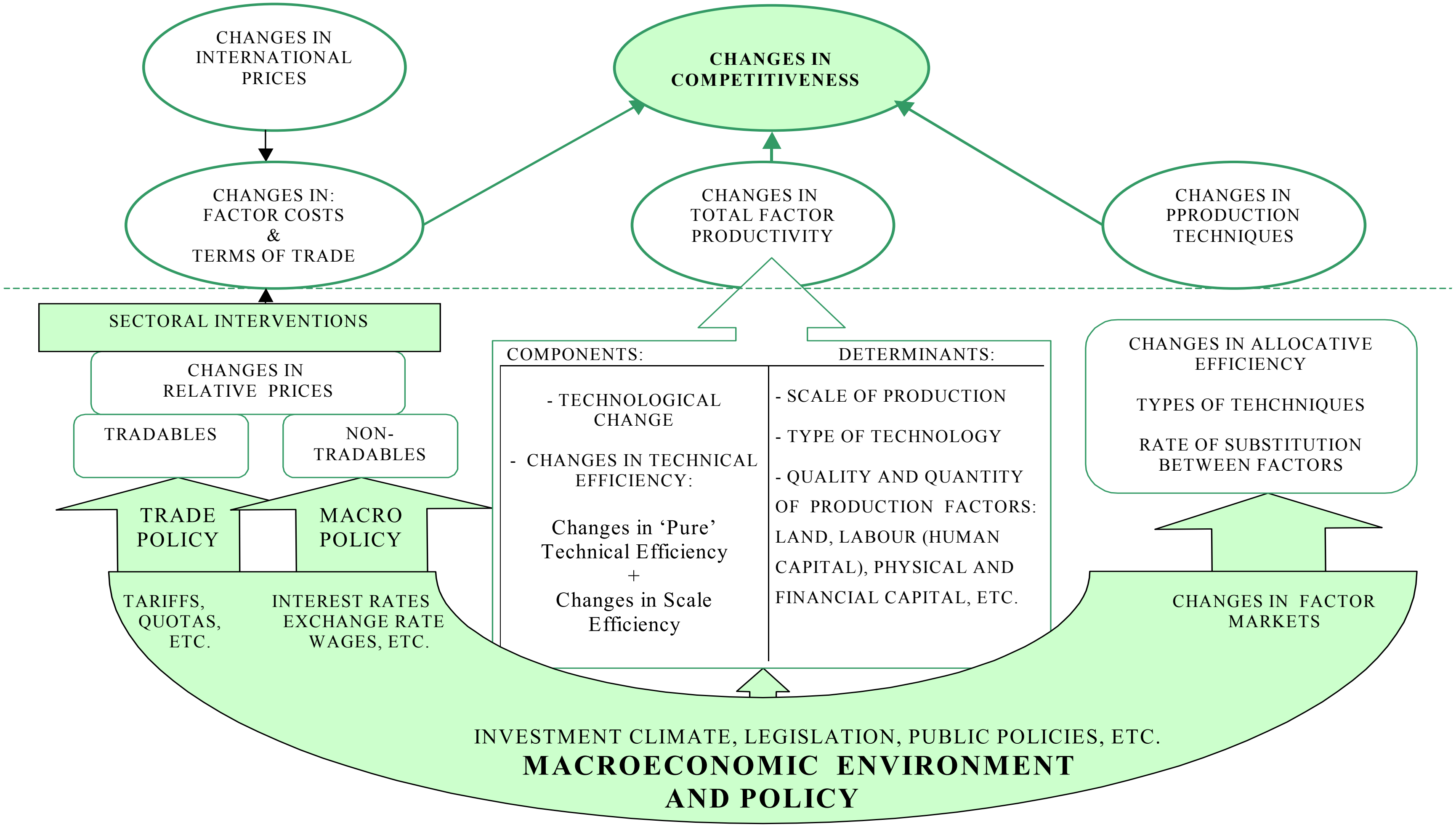
4.1 Theoretical model

The analysis of changes in the competitiveness of the agricultural sector in this thesis is undertaken according to a theoretical model not based on any one theory or method but a combination of theories and methods. This eclectic approach towards competitiveness was suggested by Berkum and Meijl (1999) and Abbott and Bredahl (1994) (see Chapter 2) and other agricultural economists. This author's wish to analyse competitiveness in a broad context linking macro- and microeconomic analysis underpins the choice of such an approach in this work. Analysing the competitiveness of agriculture in a macroeconomic context, especially in transition countries, has been popularised by many non-Polish economists (to name only a few: M. Banse, K. Macours, W. Münch, S. Tangerman, J. Swinnen) and Polish economists (to name only a few: W. Guba, W. Orłowski, W. Piskorz, M. Safin, J. Wilkin, A. Woś).

The model expounded here is, therefore, a combination of methods which have their roots in two macroeconomic theories: trade theory and growth theory, as well as the microeconomic theory of the firm. From the first two, the ideas of dynamic comparative advantage and endogenous growth are borrowed, and from the third, the production function. Various methods well defined in the literature were also chosen. These, combined with some general economic knowledge, allowed for a formalisation of a logical model with two goals: the introduction of discipline (structure) into the analyses and tools to enable the formulation of testable hypotheses. As such, the work is not a single econometric model, but a combination of econometrical and statistical methods which lead to a verification of the hypotheses and formalise the framework within which competitiveness is defined. The model is depicted in Figure 4-1.

The upper part of the model is based on a methodology developed by Nishimizu and Page (1986), called the decomposition of dynamic comparative advantage. The changes in competitiveness, measured for example by domestic resource costs (DRC), can be broken down into changes in: relative prices (factor costs and terms of trade), changes in total factor productivity, and changes in techniques of production (defined as changes in factor proportions). The formal derivation of these elements is presented later in this chapter. The logic of the method is as follows: in a small, open economy agricultural prices are determined by changes in international prices on

Figure 4-1Theoretical Model for the Mixed (Micro- and Macro-) Dynamic Approach to Competitiveness



Source: Author's own conception based mainly on Nishimizu and Page (1996), Quiroz and Valdes (1993), Färe et al. (1994).

foreign markets. This in turn influences relative domestic agricultural prices, i.e. relative factor and output-input prices. If output prices (tradables) decline due to pressure from outside and input prices (a mixture of tradables and non-tradables) do not follow, then producers are under cost pressure, which squeezes the profitability of their production. Importantly, producers do not have much influence on the relative prices (the prices are exogenous from their point of view). However, according to the model, producers may respond to this outside pressure by increasing their total factor productivity (e.g. by increasing their efficiency) and techniques of production (i.e. replacing expensive factors with cheaper ones, given the changes in relative prices) because they are endogenous from the point of view of producers. Generally, changes in factor proportions are limited, so the main offsetting power in the hands of producers, to maintain or improve competitiveness, lies in improving factor productivity.

The left-hand side of the model is based on a framework developed by Quiroz and Valdes (1993) and shows that relative prices are influenced by domestic policies both directly (by sector-specific interventions and trade policy instruments) and indirectly (by macroeconomic policy). The authors show that indirect or economy-wide effects result from the impact of macroeconomic policies on the real exchange rate and, thereby, on the relative price between tradables and non-tradables. Sometimes, indirect interventions (macroeconomic) are stronger than the sector-specific ones because they directly influence input prices in the economy such as labour, capital and land costs. This method (formally presented later in this work) disentangles the effects of exogenous factors (border prices) from the effects of real exchange rate evolution (due to e.g. the Harrod-Balassa-Samuelson effect) and of domestic price policy. This approach helps to understand the extent to which economic performance determines agricultural competitiveness.

The central part of the model explains the importance of total factor productivity for competitiveness. It deals, as such, with determinants of TFP and decomposition of TFP changes. The components of TFP changes are calculated based on a methodology suggested first by Färe et al. (1994). Using the Malmquist index derived from the non-parametric approach we can distinguish the importance of technological progress, 'pure' technical efficiency, and scale efficiency in productivity changes. Furthermore, an investigation of TFP includes analysis of TFP determinants by means of spatial and pooled analysis which allows for direct comparisons of TFPs among individual farms. This time productivity is measured using the Tornqvist index and the comparisons are made with the use of multivariate statistical methods such as factor and cluster analysis, ANOVA and a pooled regression analysis.

The right-hand part of the model concerns changes in techniques of production, narrowly defined as proportions in production factors dictated by their prices. In the original approach developed by Nishimizu and Page (1986) this element was residual, while in this thesis's theoretical model competitiveness is residual, and as such, factor proportions should be endogenous. However, in the course of this research, including verification of the other elements of the model, it turned out that the need to assess such changes in factor proportions was not necessary because they would be insufficient to for improve competitiveness anyway (this is explained in Chapter 5 Section 5.3). Overall, we should bear in mind that this element has very limited influence on competitiveness, especially in the agricultural sector where the proportion of production factors are subordinated to strict production requirements[10]. This part of our model then has a largely descriptive character.

The last, bottom part of the model is also descriptive. Its ultimate goal is to show the relationships between the development of the whole economy and its influence on the agricultural sector. Both the direct and indirect influence of government policies on agriculture are discussed and the most characteristic elements of the transition process are underlined (those concerned with the convergence of the Polish economy to the EU, restructuring the economy, liberalisation, etc.).

4.2 Macroeconomic pressure and the competitiveness of the agricultural sector

The macroeconomic framework (the bottom part of Figure 4-1) is important in the model because the dynamic changes in the economy and economy-wide policies during the 1990s affected distribution of resources between the economy's sectors. Therefore, understanding the macro-micro linkages is crucial for a proper evaluation of agricultural performance and competitiveness.

According to Schiff and Valdes (1998), governments can affect agriculture in two ways: (i) directly, via sector-specific measures including tariffs, input and credit subsidies, price controls, quantitative restrictions, government expenditures and taxes; (ii) indirectly (in unintended ways), via policies concerning industrial protection, exchange rates and interest rates, other fiscal and monetary policies, which can strongly influence the incentives for agriculture vis-à-vis other sectors. Economy-wide policies can also sometimes more strongly influence agriculture's ability to compete for resources (domestically and globally) than sector-specific ones. Of interest to this investigation (within the proposed analytical framework) is which of the two effects was stronger in the case of Poland.

One might expect the Polish economic transition in the 1990s to have significantly influenced agricultural price incentives, terms of trade and hence farmers' real incomes, production and competitiveness, because it developed quickly and changed the fundamental relations between sectors of the economy. For example, the most influential macroeconomic policies in Poland at the beginning of the 1990s were: liberalisation of prices (of goods and services) and external trade, monetary policy aimed at reducing hyper-inflation (with exchange rate as a nominal anchor),

[10] Note that this element was also negligible in the study by Nishimizu and Page (1986), where the changes in factor proportions did not exceed 0.75% annually.

expansionary fiscal policy (and need for financing an unsustainable budget deficit), restructuring of the economy through privatisation aimed at more efficient allocation of production factors and better functioning of markets (which resulted in structural unemployment), etc.

However, not only the policies but also the 'developing' nature of the Polish economy, which was converging with the more developed economies, determined various key tendencies influencing the competitiveness of sectors of the economy: for example, higher real interest rates than in 'developed countries' (which meant higher marginal costs of capital) and real appreciation of exchange rate (which meant competitive pressure vis-à-vis Poland's trade partners). In addition, the process of Polish accession to the EU has required commitments aimed at deepening economic integration, which have also triggered certain economic pressure (for example, contributed to attracting long-term and short-term capital, which has in turn reinforced the tendency to appreciation of the real exchange rate), etc.

Although the majority of the above mentioned macroeconomic examples were mostly of a transient nature, their strong influence was due to an accumulation of their effects in a relatively short period of time, and this imposed a significant adjustment challenge on the whole economy, including the agricultural sector, discussed below.

The relationships between the various macroeconomic variables during the analysed period were of course extremely complex and the debate on causalities between them continues (for example, theories explaining the real exchange rate appreciation of the Polish zloty, etc). As such, this author has chosen not to engage in any analytical overview of them for reasons of limited time and space in this section of this thesis. Instead, the thesis focuses on a few most evident macroeconomic facts and discusses their hypothetical influence on the competitiveness of the Polish agricultural sector before moving on to empirical findings (in the next chapter).

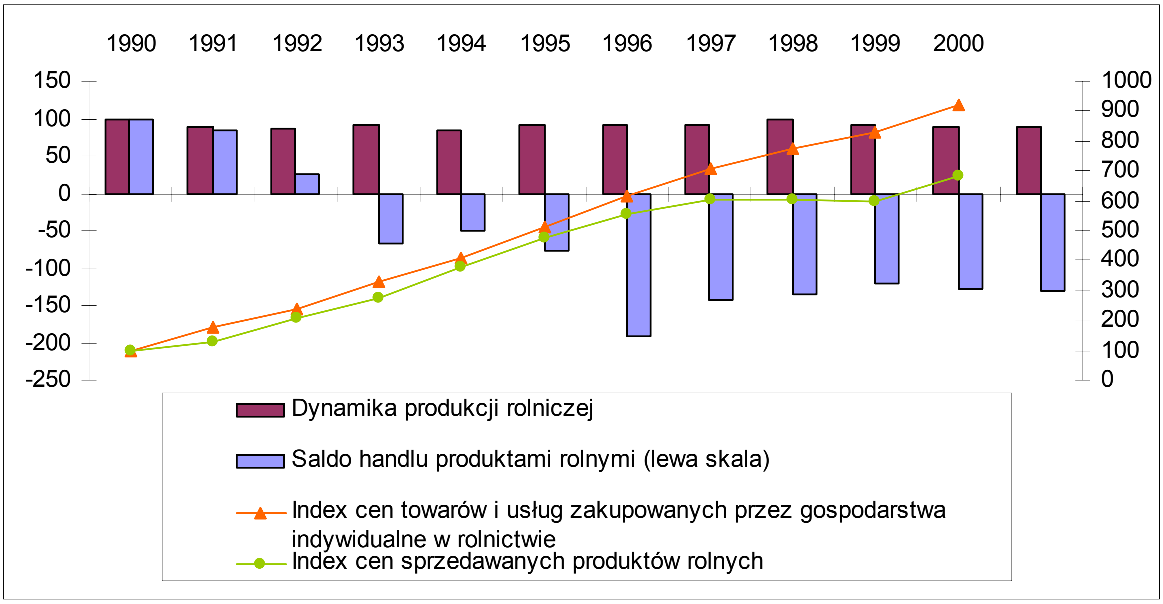
4.2.1 Real appreciation of domestic currency

At the core of an economy's performance is its real exchange rate (RER), as this reflects the competitiveness of its tradable sectors (import substitutes and exportables). Poland, as well as other CEE countries in the region, has experienced real appreciation, or in other words, a strong increase in the real cost of its currency vis-à-vis foreign currencies (details are presented in Chapter 5). The magnitude of the effect is such that it resembles a Dutch disease phenomenon, with unfavourable implications for the competitiveness of the domestic tradable sectors (Guba and Zawalińska, 2002).

Agriculture has been in a particularly unfavourable position because most of its inputs are non-tradables (such as land and family labour), while outputs are tradables. Therefore, the considerable liberalisation of agricultural trade (especially at the beginning of the 1990s), which coincided with appreciation of the real exchange rate, caused a high increase in costs of inputs (non-tradable) and relatively slower growth in output prices (tradable), which resulted in a gradual deterioration of relative output-input prices and hence agricultural terms of trade.

During 1996-1999, the gap increased considerably, an effect of widening the ‘price scissors’ or cost-price squeeze (see Figure 4-2). This put pressure on the profitability of agricultural production and as a consequence agricultural production fell as well. Although it slightly recovered later it never regained its pre-transition level. Furthermore, since 1993, Poland has been a net importer of agricultural products. The decline in the profitability of agricultural production put significant pressure on the competitiveness of the sector, given that no unprofitable production can be competitive in the longer run.

Figure 4-2: Dynamics of Trade and Relative Prices in Agricultural Sector (1990=100)



Source: GUS (2001a, b)

4.2.2 Real interest rates and credits

There is a strong link between capital markets and agriculture. As Mundlak (1997) shows, agriculture is generally a capital-intensive activity and is, therefore, more sensitive to changing costs of capital (changes in interest rates) and less sensitive to changes in costs of labour (wages) than other industry sectors. However, even if agriculture was more labour-intensive in Poland it tends to rely on family labour (which is not usually directly paid in the family type of farming). In contrast, capital input costs are unavoidable (that is, they must be incurred) and are set by both policy and markets. Agricultural production is, therefore, more sensitive to market signals in the case of capital, than labour. Thus, considerable increases in interest rates in Poland (especially at the beginning of economic reforms after the period of substantial RER appreciation), as well as its general persistence at a relatively high level (partially due to the need to finance high fiscal deficits and fight inflation within an inflation-targeting policy after 1998) probably contributed to the decline in agricultural investments. In spite of opening the capital account, domestic real interest rates remained far higher than international interest rates for a period of several years.

Besides, prior to the outset of economic reform in Poland, the domestic agricultural sector benefited from far more subsidised credits than it has since (Woś, 2000b). When subsidies were reduced or removed, the farm sector faced higher, largely market-determined, interest rates.

Another aspect is that after the international financial turmoil of the late 1990s (e.g. the devaluation of the Czech koruna and the Asian crises in 1997) domestic banks tended to favour lower risk investments, thus putting agriculture in a rather disadvantageous competitive position on the capital market *vis–á-vis* other sectors given the widespread perception that it is more risky due to highly volatile production and unstable international product markets.

Another harmful effect of high interest rates on the sector has been indirect. High rates attracted short-term capital, thus contributing to a real appreciation of the Polish zloty during most of the 1990s, with all the negative consequences of this on the sector (as discussed above).

4.2.3 Economic structural adjustment

The initial economic transformation programme set for Poland in 1989 provided the foundations for a modern democracy and stable market institutions. Policy and institutional reforms (from trade and price liberalisation to privatisation, tax reform and fiscal decentralisation) fuelled economic growth (GDP growth was highest during 1994-1998, averaging 5%) (GUS, 2001c), but while most sectors developed or at least changed during this period, rural development lagged behind (EBRD, 2000).

Structural adjustment programmes affected agriculture in a number of ways, outlined below.

Liberalisation of trade theoretically should improve agricultural incentives in two ways: via lower industrial (input) prices and via depreciation in the RER (Schiff and Valdes, 1998). However, in Poland the initial trade liberalisation coincided with low international prices, which immediately and considerably hampered agricultural producer prices, and the RER in fact appreciated, which thus amplified the initial shock of quick liberalisation.

Reforming the fiscal imbalances, another component of the adjustment program, involved reductions in many subsidies in all sectors, including agriculture, where they were substantial. As Schiff and Valdes (1998) show, the impact of such reductions on agricultural relative prices (to other sectors) is ambiguous and depends on the initial distribution of subsidies across sectors.

Privatisation triggered two phenomena in the labour market: increasing real wages (partly explained by improved labour productivity) and a tendency towards high unemployment (resulting from overall restructuring of state-owned companies). These in turn have affected agriculture in Poland in the following ways. Firstly, high wages usually translate into higher processing and marketing margins in the food chain, which tend to increase processed products prices and decrease farm output prices (given the fragmentation and low bargaining position of farmers). Secondly, increasing wages (in part attributed to an increase in productivity) may indirectly (according to the Harrod-Balassa-Samuelson theory) enhance further real exchange rate appreciation, with all the aforementioned consequences for the sector. Even if one could argue that an increase in opportunity costs of farm labour (wages in urban areas) is not proportional to an increase in overall wages, such an increase widens the farm to non-farm income gap, and, thus, increases pressure on the sector.

High unemployment, especially of a structural character, has also resulted in a visible migration from urban to rural areas. The agricultural sector in Poland has became a buffer for those unemployed in cities, and therefore, unlike in other CEECs, the agricultural labour force remains at a high, two-digit, unemployment level. This situation hampers the outflow of an already excessive labour force (even before the transition) from the agricultural sector and may have contributed to a slowdown in agrarian restructuring, modernisation and factor productivity improvement. Despite efficiency losses in agriculture, keeping excess rural labour on farms was widely seen as a politically, even a socially, preferable method of dealing with the unemployment problem, at least in the short to medium term (agriculture serves as a kind of safety-net). This, however, may in turn produce a kind of inefficiency trap for agriculture, since the beneficial macroeconomic outcomes of transition would lead to an aggravation of the relative efficiency of the sector, given further currency appreciation and maintained high interest rates. This would also just put the problem off for the longer-term.

This overview of linkages between the economy and agricultural sector in Poland is important from a policy-making point of view, in particular, given that the sector's deteriorating performance has tended to trigger demands from some quarters for more restrictive trade policy and larger income support for farmers. The more 'deterministic' macroeconomic nature of the problem (specific macroeconomic conditions), has tended to be somewhat marginalised in this debate. Little attention is also usually drawn to the low productivity of the sector vis-à-vis other sectors in the economy (its relative backwardness is most often only mentioned vis-à-vis the agricultural sectors of Poland's trading partners). It is worth stressing, however, precisely because it is the sector's relative, rather than absolute, lagging behind that is the main problem, given that in practice it is comparative advantage that matters, not absolute advantage (Orłowski, 2001).

4.3 Decomposition of comparative advantage

The formal relationship between competitiveness and its technical and price components is based on the concept of dynamic comparative advantage proposed by Nishimizu and Page (1986) (see the upper part of the model depicted in Figure 4-1). They proposed a decomposition of changes of the widely used measure of competitiveness, Domestic Resource Cost (described in Chapter 2), into three elements: (i) changes in international prices ('factor cost effect' and 'terms of trade effect'), (ii) changes in production techniques (changes in factor proportions); (iii) total factor productivity (TFP) changes.

The formal decomposition of the DRC measure is presented in Box 4-1. This thesis focuses on components of the measure (the right-hand side of Equation 3 in the Box 4-1) and does not calculate DRC directly, but treats it as a 'residual'. Hence, the key focus is on the three aforementioned components which make-up the measure of competitiveness.

The first component, *international prices*, influences competitiveness in a small open economy through its influence on relative prices: between factor relative prices and output-input prices. Generally speaking, if international prices put pressure on domestic factor costs they may negatively contribute to domestic competitiveness (if the factor proportions would not adjust toward more optimal solution). Similarly, if the ratio of output to input prices decreases due to international pressure, this implies a deterioration in the sector's terms of trade (ToT) and also negatively influences the competitiveness of the sector.

Box 4-1 Decomposition of Domestic Resource Costs by Nishimizu and Page (1986)

From the definition of DRC, and assuming two factors of production, we can express this as a ratio of domestic factor costs at shadow prices to value added at world prices (see also Tsakok,1990):

$$(1)\ DRC = \frac{wL + rK}{pV};$$

where w is a vector of shadow wage rates, r is a vector of shadow rental costs of capital, L and K are vectors of labour and capital input requirements, respectively; p is defined as the world price and V as value added (both shadow prices can be directly expressed in terms of foreign exchange – following the convention set by Little and Mirrlees,1974[1].
Assuming value added is a well-behaved function of primary inputs and time $V= f(K, L,T)$ then:

$$(2)\ \frac{dV}{V} = a_L \frac{dL}{L} + a_K \frac{dK}{K} + a_T dT\ ;$$

where the weights a_L and a_K are the value added elasticises of labour and capital, respectively, and a_T dT is the rate of change of TFP. Then proportionate change in the DRC ration can be expressed as:

$$\textbf{(3)}\qquad \frac{dDRC}{DRC} = s_L \frac{dw}{w} + s_K \frac{dr}{r} - \frac{dp}{p} + (s_L - a_L)\frac{dL}{L} + (s_K - a_K)\frac{dK}{K} - a_T dT$$

Competitiveness **Factor cost effect** **ToT effect** **Changes in techniques** **TFP effect**

where: $s_L = \frac{wL}{wL + rK}$ and $s_K = \frac{wK}{wL + rK}$ are the shares at shadow prices of labour costs and capital costs in total primary factor costs. If another measure of competitiveness is used (e.g. PRC – private resource costs) the shares of labour and capital costs are measured in market prices not in shadow prices.

In static analysis, a sector has a comparative advantage if the left-hand side measure of competitiveness (e.g. DRC) is less than or equal to one. In dynamic analysis, if the measure increases it means losing comparative advantage. Hence, all the effects which enter equation 3 with a positive sign, hamper competitiveness if they increase, and improve competitiveness if they decline. The opposite is true for effects which enter with a negative sign. For example an increase in TFP, which when it has a negative sign causes decline in the measure of competitiveness (DRC) and, hence, contributes positively to its growth.

In contrast, any improvement in the ToT, for example a rise in the world prices of output relative to world prices of intermediate inputs, means improvement in competitiveness.

The combined impact of the factor cost effect and terms of trade effect on comparative advantage (DRC) is termed the *price competitiveness effect*, though is referred to here as the *relative prices effect*. The main question, however, is the extent to which international prices can change (penetrate) the domestic factor and output markets, and influence the sector's competitiveness. To answer this question we will apply a methodology proposed by Quiroz and Valdes (1993) (detailed later in this chapter).

The second component, *changes in production techniques*, is defined as changes in factor proportions. Any increase in the efficiency of factor proportions (i.e. allocative efficiency) positively contributes to changes in competitiveness. If inefficiency exists, and moves towards or away from the optimum factor proportions, it increases or reduces competitiveness. If, however, the proportions are optimal, then this component no longer has any influence on competitiveness. The power of this effect is quite limited though, because certain types of production require certain techniques to be applied (e.g. labour intensive potato production can hardly become capital-intensive even if capital becomes significantly cheaper). This is borne out by empirical studies, as e.g. in the article referred to earlier, by Nishimizu and Page (1986). This thesis analyses this component in a descriptive way, as we do not have detailed price information allowing for a calculation of allocative efficiency.

The third component, *total factor productivity* (TFP), may have a much stronger influence on competitiveness than the second component, as it is determined by many factors (as we will see later in this chapter). Therefore, in the case that the first component (relative prices effect) causes negative pressures on competitiveness (when they deteriorate), the TFP improvements can offset this pressure and even overweigh it, leading to an increase in comparative advantage. We can also look at these relations in one more, different, way. Considerable deterioration in TFP will unnecessarily lead to a decrease in the competitiveness of the sector unless relative prices change favourably (e.g. due to policy interventions or favourable development of prices on foreign markets).

4.4 International prices

The approach used in this work, an analysis of price transmission from international agricultural markets to the domestic agricultural sector (illustrated as the left-hand side of the model in Figure 4-1), is based on the approach first developed by Quiroz and Valdes (1993). Its popularity lies in its simplicity, but also that it allows for an understanding of the basic mechanisms shaping relative prices in the sector. The method disentangles exogenous (economy-wide) effects with some influence on relative prices from sector-specific effects (sectoral interventions).

The basic framework for transmission mechanisms is the following[11]. By definition, the domestic price of good *i* at time *t* is equal to:

(4-1) $P_{it} = P_{it}^{w} * E_{t}(1+T_{it})$

where, P_{it} is the nominal domestic price (and $p_{it} = P_{it}/CPI$ is a real domestic price), P_{it}^{w} is the border price, E_t is the nominal exchange rate, and $(1+T_{it})$ is the tariff equivalent for good *i*. This tariff equivalent does not conceptually coincide with the explicit nominal import duty (or export tax) that the government may impose. Rather, it covers trade taxes as well as market structure in this particular activity.

After some simple replacements in Equation (4-1), we can show that the evolution of domestic real agricultural prices can be decomposed into the following components: (i) border prices (ii) exchange rate, and (iii) trade interventions, where the latter is computed as a residual. The formal notation of the relation is as in the Equation (4-2):

(4-2) $p_{it} = (P_{it}^{w} / CPI^{w}) * RER_{t} * (P_{it} / P_{it}^{w} * E_{t})$

where, P_{it}^{w} is deflated by international inflation (measured by CPI), *RER* is defined as the relative price of tradables to non-tradables $(E_t * CPI^{w} / CPI)$ at time *t*[12], and CPI is used as a proxy for home goods. After taking natural logs on both sides of the equation, and taking first order differences where operator Δ denotes first differences, the above equation yields:

(4-3) $\Delta \ln p_{it} = \Delta \ln p^{w}_{it} + \Delta \ln RER_{t} + \Delta \ln (1+T_{it})$

We will use the Equation 4-3 in this form in the empirical part of the thesis. Note, that such variables as p_{it} (real domestic prices), p_{it}^{w} (border prices), and *RER* (real exchange rate) are directly calculated in the thesis from the raw data, while $(1+T_{it})$ (policy intervention) is a residual[13]. This equation allows for assessing the extent to which real domestic prices have been influenced by international prices versus the exchange rate, and by how far domestic sectoral policy interventions have been able to offset the influence of both on real prices. At the end, the assessment of changes in relative prices will be carried out, as well.

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[11] The methodology and description is based on Quiroz and Valdes (1996).

[12] *RER* here is the actual real exchange rate and not necessarily the equilibrium real exchange rate.

[13] As a residual, this term also includes the interaction effect between the first three variables. When changes in prices and *RER* are small, these interaction effects tend to be negligible. However, when variations are large, this residual captures both intervention and domestic price policy as well as the interaction effects. Nevertheless, it is still useful as a rough estimate of the size and direction of change in price policies.

4.5 Total factor productivity: determinants and changes

In the central part of this theoretical model (see Figure 4-1) we focus on total factor productivity. As explained in previous sections, productivity is a very important component of competitiveness and the only one which depends on producers (endogenous from their point of view). Therefore, much attention is devoted to it, analysing both its static components and changes over time and applying different methodologies in order to understand the concept thoroughly.

4.5.1 The concept of productivity

Firstly, a precise outline of what is meant by productivity and total factor productivity is needed here. The OECD (1955:21) quotes Larousse's etymological dictionary, in which one discovers that the term appeared for the first time in an article by Francois Quesnay, head of the French School of Physiocrats, in 1766. For a long time its meaning remained vague. Littré (1883)[14] defined it as the *'faculty to produce'*, which is still found in Larousse 1946-1949 edition, and cited (as above) by the OECD (1955:21). By the beginning of the 20th century, however, economists had already given a more precise meaning to the word 'productivity', as *'the relationship (measurable) between product and factors'* (OECD, 1960:21). In fact, the OECD itself contributed significantly into investigating and defining the concept. In 1950, the Organisation for European Economic Co-operation (at that time OEEC), started thoroughly studying the problem, under the supervision of Professor Jean Fourastié, which led to the publication "Terminology of Productivity". In this paper the first concept of a *specific factor (partial) productivity* was defined as *'the quotient obtained by dividing output by one of the factors of production'* (OECD, 1960:22). The source also differentiated between two approaches to factor productivity. Firstly, it can be defined generally as 'production per factor unit' and is usually applied to fixed factors like agricultural land (production per land) or to fixed assets (production per machine, etc.). Secondly, a reversed approach is 'consumption per unit produced', which is more common in measuring the economic use of variable factors such as labour, raw materials etc.[15]

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[14] For the detailed reference please see OECD (1955).

[15] OECD (1955) provides a very interesting overview of productivity concepts, e.g. it also specifies kinds of productivities which are much less popular, such as net productivity of a factor, and integral productivity, and also discusses their different applications. It also discusses alternative measures of inputs and outputs.

Box 4-2 Concept of partial factor productivity

It is worth explaining why this analysis refers to total factor productivity, while the concept of partial productivity is also quite popular. This is because partial factor productivity is widely criticised by economists due to the fact that it can potentially lead to misleading results (Diewert and Lawrence, 1999; Pesaran and Schmidt, 1999). For example, relying only on a labour (partial) productivity measure we can see an increase in productivity if labour decreases even if it is only due to its replacement by capital. The increase of productivity would result even if capital intensive techniques were more costly (and consequently the techniques should be avoided). Thus, taking into account only labour as an input, in the case of capital substituting for labour, we would have an increase in productivity. But if all inputs are taken into account, overall productivity would increase far less rapidly or might even go backwards. To avoid this problem, it is necessary to include all outputs produced and the quantity of all inputs. However, the partial productivity measures can still be used, although as an auxiliary variable.

Thus, the most comprehensive measure of productivity is a *total factor productivity* (TFP)[16].

The concept of TFP, introduced into the economic literature by Tinbergen (1942) and Stigler (1947) (see Pesaran and Schmidt, 1999 for precise references), is most broadly defined as *‘ a comparison between the quantity of goods and services produced and the quantity of resources employed in turning out these goods or services*’ (Fabricant, 1949:3[17]). Productivity, more precisely defined as the ratio of output to a function of the inputs, is captured by the residual in a regression of log output on an appropriate function of inputs (Pesaran and Schmidt, 1999). A framework for empirical approaches to measuring TFP was provided in Solow’s (1957) famous study, where he assumed Cobb-Douglas technology. Later contributions, such as e.g. Griliches (1963), Jorgenson (1955), used more flexible functional forms of production, such as translog (for more precise references please see Pesaran and Schmidt, 1999).

Last but not least, productivity growth is one of the most important sources of a rise in output and income per person employed (CNS, 1979), and productivity differences are useful for analysis of determinants of economic performance. Therefore, this thesis considers both: changes of productivity over time (needed for dynamic

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[16] There is also another similar concept of ‘multifactor’ productivity, which refers to studies taking a selected set of most common inputs, such as labour and capital. Taking account for this incompleteness of input coverage they name the measure ‘multifactor’ instead of ‘total’ factor productivity, as the latter attempts to include all possible factors of production.

[17] For detailed references see OECD (1955).

comparative advantage decomposition) and productivity differences between farms (to discover the determinants of productivity).

4.5.2 Measurement of productivity

The conceptual framework for the measurement of productivity is found in the theory of production. This theory is most directly relevant to individual firms or other producing units, though it may also be used, with appropriate modifications, to analyse the productivity of industries or for the aggregation of industries that comprise an entire business economy (CSN, 1979). Generally speaking, there are four different approaches to measuring productivity: (i) econometric approaches to TFP; (ii) the Divisia approach (general index number approach); (iii) the 'exact' index number approach[18]; (iv) non-parametric approaches (Diewert, 1980). Each of the methods involves an approximation error due to deficiency of data ability to fully determine the true production-possibilities (Diewert, 1980) and also has different advantages and disadvantages. As such, researchers choose their own approaches based on the needs of their studies (see Box 4-3).

Box 4-3 Advantages and disadvantages of different approaches to TFP

The primary advantage of the econometric approach is that it generates estimators for underlying true production functions (i.e. is based on econometric estimation of the production technology), but a disadvantage is that it becomes unworkable for large number of inputs and outputs. The index number approaches (such as Divisia and the 'exact' index number approach) have the advantage that they can be implemented even if the number of inputs and outputs is large. Its main disadvantage is that it does not lead to a definite formula for the shift in technology, since there are many ways of approximating continuous time derivatives by discrete differences. The primary disadvantage of 'exact' number approach is that a very specific functional form for the underlying cost function must be assumed. (Diewert, 1980). The non-parametric method has the advantage that it does not require assumptions on functional form because it relies on a true production function. Secondly, it does not rely on an equilibrium assumption, or that TFP can be explicitly decomposed into a measure of efficiency change (Kruger, 2001)[1], and the rate of technological progress. On the other hand, this approach is computationally more complex since it demands *t* (number of time periods) linear programming problems to be solved, and the measures of the shifts in technology that it generates are only lower bounds to the true shifts (Diewert, 1980).

[18] Approaches (ii) and (iii) combined are called the Index Number Approach

Based on data availability, the thesis's research goals and its author's computational (or do you mean computer?) skills the two methods and two measures of TFP are implemented in this study. For calculation of the relative differences in TFP performance among farms, the 'exact' Tornqvist-Thail index is applied, because it allows for spatial comparisons based on data including many inputs and outputs (different agricultural products), it is relatively (compared to other methods) simple to compute and is well grounded in the literature. For calculation of TFP changes over time, the Malmquist index has been chosen as more appropriate (it allows for decomposition of productivity growth into efficiency changes and technological progress), and is also well defined in the literature and provided in econometric software.

4.5.2.1 The index number approach and Tornqvist-Thail index

As previously stated, the major advantage of the index number procedures[19] is that they do not require any estimation of the parameters of production technology. Instead, by assuming cost-minimising and/or profit-maximising behaviour of the firm, these parameters become embedded in observed expenditure and revenue information (Diewert, 1980)[20].

One of the most frequently used TFP indexes in spatial analysis is the Tornqvist-Thail index, which is useful for comparison of productivity between firms. As an example it can be used for two firms (the following derivation is based on Hughes (2000), Capalbo and Antle (1988), Diewert and Lawrence (1999)).

Let's assume that two firms, *i* and *b*, are producing single outputs with multiple inputs. Then, generally, their production functions can be expressed as follows:

(4-1) $Q = f(X_1, X_2, X_3, ...X_m)$

where, *Q* is quantity of the single output, and each *X* is an input with a total of *m* inputs.

Then, we can suppose that there are two sets of input and output observations for each firm; for *b* expressed as: $(Q_b, X_{1b}, ..., X_{mb})$ and for firm *i*: $(Q_i, X_{1i}, ..., X_{mi})$. To make the analysis simpler, we also assume that the production function from Equation (4-1) is exact for firm *b* while firm *i* may have a portion of output which is unexplained by

[19] As Pesaran and Schmidt (1999) show, an important application of the index number theory has been in the growth accounting literature, such as Solow (1957), Denison (1967) and (1969), Kendrick (1961), Jorgenson and Griliches (1967), and surveyed in Nadiri (1970). For all the references see Pesaran and Schmidt (1999).

[20] We do not test this assumption here. However, because the farms in our sample are more market orientated we believe their behaviour is close to the idea of profit maximization / costminimization behaviour.

the production function evaluated with its inputs and it is attributed as having different productivity to b. Thus the appropriate production functions are expressed as follows:

(4-2) $Q_b = f(X_1^b, X_2^b, ..., X_m^b)$

(4-3) $Q_i = f(X_1^i, X_2^i, ..., X_m^i) + t$

Then, the Equation (4-1) can be approximated as a linear function (using a Taylor series expansion around observed points) using observations from either firm and based on the marginal productivities of all the inputs. Using the observations from firm i we obtain:

(4-4) $\hat{Q} = (Q^i - t) + \sum_{k=1}^{m} f_k^{'}(X_k^i)(X_k - X_k^i) + e^i$

where e is the approximation error. This is the first order Taylor series expansion of Equation (4-1) and because the firm i is incorporated, it also includes differences in output not attributable to input use, t.

First, including the observations from firm b into approximation given in Equation (4-4), we come up with an approximation of b's production function as follows:

(4-5) $\hat{Q}^b = (Q^i - t) + \sum_{k=1}^{m} f_k^{'}(X_k^i)(X_k^b - X_k^i)$

Analogously we come up with approximation of i's production function incorporating firm i's observations, as follows:

(4-6) $(\hat{Q}^i - \hat{t}) = Q^b + \sum_{k=1}^{m} f_k^{'}(X_k^b)(X_k^i - X_k^b)$

Equations (4-5) and (4-6) approximate respectively production functions (4-2) and (4-3).

Next, by subtracting Equation (4-6) from Equation (4-5) we come up with a desired form of equation:

(4-7) $\hat{Q}^b - (\hat{Q}^i - \hat{t}) = (Q^i - t) - Q^b + \sum_{k=1}^{m} f_k^{'}(X_k^i)(X_k^b - X_k^i) - \sum_{k=1}^{m} f_k^{'}(X_k^b)(X_k^i - X_k^b)$

which can be re-written with approximation errors as follows:

(4-8) $2[Q^b - (Q^i - t)] = \sum_{k=1}^{m} f_k^{'}(X_k^b) + f_k^{'}(X_k^i)(X_k^b - X_k^i) + e^i - e^b$

At this stage, a major assumption of marginal productivity[21] should be recapped and included, in order to calculate 'exact' TFP measure. The assumption says that the marginal physical product of each input *k* equals the cost of input *k* as the share ($0<s\leq1$) of total input costs:

(4-9) $f_k^{'}(X_k) = \frac{P_{X_k} X_k}{\sum_{k=1}^{m} P_{X_k} X_k} = S_k$ **,** (for all *k=1, 2, ..., m*)

where P_x is the price of an input *k* and S_k is the share of input *k* in total input costs. The Equation (4-9) is true only under certain assumptions. First, that each firm behaves as a profit maximiser in choosing the amount of each input. This is equivalent to setting the marginal physical product of each input equal to the input-output price ratio, as in the equation below:

(4-10) $f_k^{'}(X_k) = \frac{P_{X_k}}{P_Q}$

where P_Q is the price of the output.

The second assumption, which is much stronger, says that the long-term equilibrium behaviour of each firm is such that no super normal profits are made, thus:

(4-11) $P_Q Q = \sum_{k=1}^{m} P_{X_k} X_k$

An additional property which must be applied in order to create a correct aggregation procedure is that the cross input elasticities have to be equal between the compared firms. For this to be true, the change in cost share with respect to the change in input use (cost share derivatives) must be the same for both firms (Hughes (2000), after Denny and Fuss (1983:320, 322). This is referred as the constant share elasticity (CSE) property[22]:

[21] This assumption (which entails constant returns to scale) as well as the previously assumed situation that two firms have the same underlying production function (except for a shifter *t*) led to criticism of the Tornqvist measure, since they are unlikely to hold in reality. However, this problem was addressed by economists and the assumptions relaxed, giving the index renewed validity. For more details on this see Caves, Christensen, and Diewert (1982), Diewert (1976), summarised in Hughes (2000).

[22] As Hughes (2000) shows, this property holds for a homogenous Translog production function and can be used for demonstrating that the Tornqvist-Thail index in its logged version is an 'exact' index for a Translog production function.

$$\textbf{(4-12)} \qquad \frac{\partial(f_k^{i}{}'(X_k^i))}{\partial X_l^i} = \frac{\partial(f_k^{b}{}'(X_k^i))}{\partial X_l^b} = \frac{\partial S^i}{\partial X_l^i} = \frac{\partial S^b}{\partial X_l^b} \text{ for all } k, l = 1, \ldots, m$$

Equations (4-10) and (4-11) can be substituted into Equation (4-8) so that the marginal productivity assumption (4-9) holds and Equation (4-8) becomes:

$$\textbf{(4-13)}\ t = (Q^i - Q^b) - \frac{1}{2}\sum_{k=1}^{m}(S_k^i + S_k^b)(X_k^i - X_k^b)$$

and it is a single output version of the Tornqvist-Thail interspatial TFP difference index. As introduced earlier, *t* here is the portion of output of firm *i* which is unexplained by the production function and is attributable to having different productivity to *b* either due to differences in technology or difference in the technical efficiency of use of technology.

If we want to extend the model to the multi-output translog production function, then we have to include the aggregation of outputs based on revenue shares, analogically to those for inputs (which were based on cost shares). Then for the multi-output case with *n* outputs we obtain:

$$\textbf{(4-14)}\ t_i = \frac{1}{2}\sum_{j=1}^{n}(R_j^i + R_j^b)\ln(Q_j^i - Q_j^b) - \frac{1}{2}\sum_{k=1}^{m}(S_k^i + S_k^b)\ln(X_k^i - X_k^b)$$

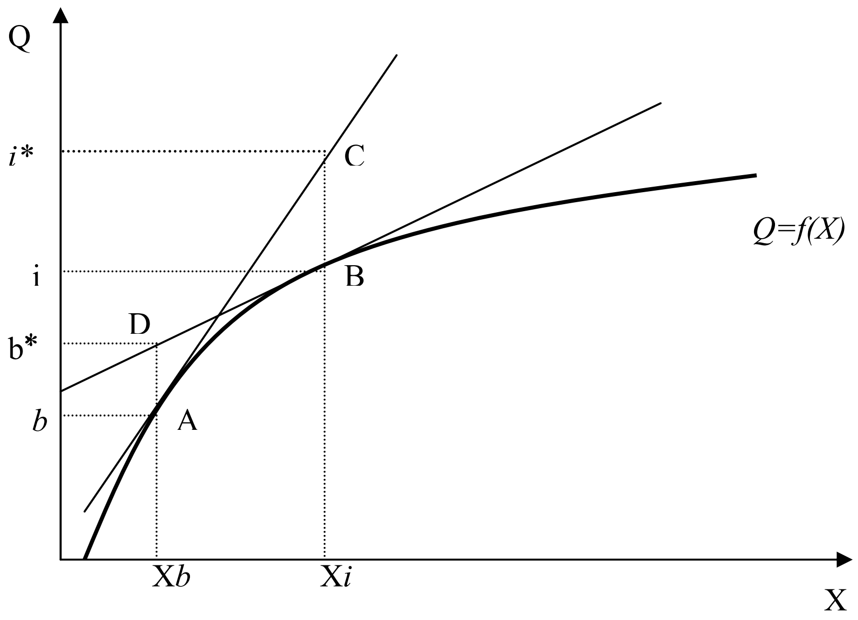
where *R* is the share of the *j*'th output revenues in total revenue for each firm and *S* is the share of *k*'th input in total cost for each firm.

This logarithmic version of the index will be used in the empirical part of the thesis, devoted to determinants between of productivity differences among Polish farms (see Section 6.4.1 and Section 6.5).

The Tornqvist productivity index has a graphical presentation. The one presented here is based on Denny and Fuss (1982) and presented in Hughes (2000). This Tornqvist methodology is an exact approximation of a quadratic function derived in Equation (4-13).

First, let's consider the case where the two firms in question have the same productivity (productivity difference t=0) as depicted in Figure 4-3. Those two firms have output values marked as *i* and *b* and input values as *Xi* and *Xb* respectively. The production function is in its simplest form: *Q=f(X)*. Then, we can see that if firm *i* uses the inputs of firm *b*, it would produce at level C, an amount of output equal *i**. At the same time, if firm *b* uses the inputs of firm *i*, it would produce at point D, amount of output equal *b**. Despite the fact that these estimates are only linear approximations of the real output values, the difference between them (*i** - *b**) is exactly the same as the real difference (*i* - *b*) if the underlying function is quadratic, or using logged variables, translog. The Tornqvist-Thail index *t* measures any difference between the two differences (in output approximated using the input data, and real data), which in this case is zero: $t = [(i - b) - (i^* - b^*)] = 0$.

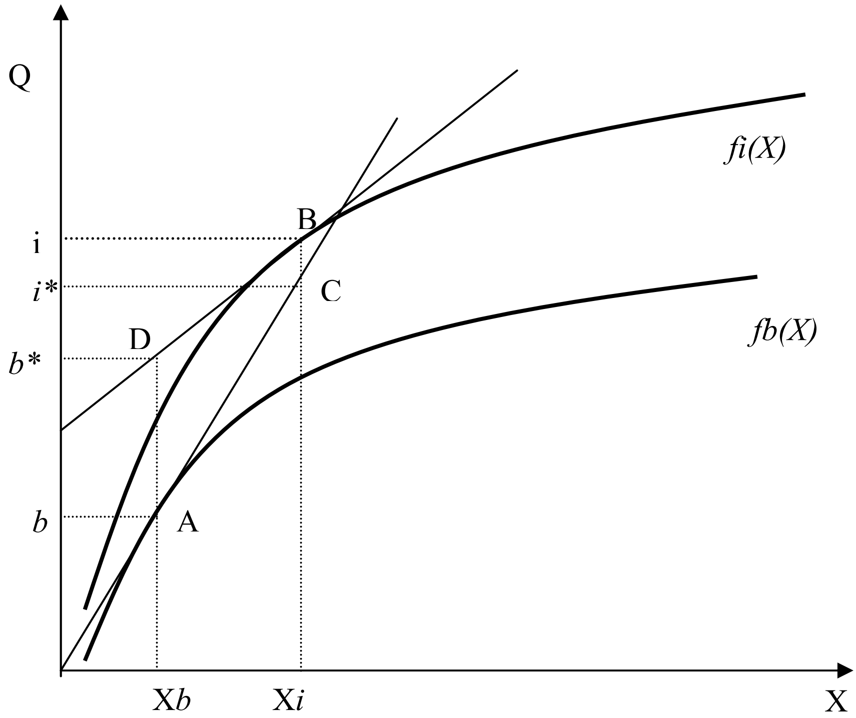
Figure 4-3 Estimation of identical productivities between firms based on the Tornqvist-Thail index



Source: Hughes (2000)

In the second case, the two firms have different production functions, so that firm *i* is more productive than firm *b*, as depicted in Figure 4-4. If we estimate firm *i*'s output using the observation of firm b, we obtain point C, which however, underestimates the real output of firm *i*, since *i* is in reality more productive. Similarly, if we estimate firm *b*'s output using firm *i*'s observations we would get *b's* output at point D, which in fact overestimates the real output of firm *b*. In this case, the estimation errors do not cancel each other out when the difference of i^* and b^* is taken into account, and the productivity measure *t* is positive: $t=[(i - b) - (i^* - b^*)]>0$. This indicates the higher productivity of firm *i*.

Figure 4-4 Estimation of different productivities between firms based on the Tornqvist-Thail index



Source: Hughes (2000)

4.5.2.2 The non-parametric approach to TFP changes and the Malmquist index

Färe et al. (1994) listed several traditional methods to calculate the Malmquist productivity index, though most of them require specification of a functional form for technology. However, the *Data Envelopment Analysis (DEA)* approach, proposed by Charnes et al. (1978), allows for constructing a 'best-practise' frontier without specifying production technology. In opposition to traditional techniques that look for the average path through the middle point of a series of data, DEA takes the best frontier based on empirical data.

Therefore, the non-parametric Malmiquist index has certain advantages over the parametric indices (such as Tornqvist and Fisher), and is especially useful in computing productivity changes based on panel data. These advantages are the following: i) the index does not require an assumption that all firms are cost minimisers or profit maximisers; ii) price data are not required; iii) obtained changes in TFP may be decomposed into technological change and efficiency changes where the former can be further decomposed into pure technical efficiency and scale efficiency changes. Overall, a richer set of information can be obtained from the Malmquist index with smaller data requirements than in other methods.

The best reference for the formal decomposition of the Malmquist TFP growth index is that of Färe et al. (1994). The paper takes the Malmquist index of TFP growth defined in Caves, Christensen and Diewert (1982) and illustrates how the component distance functions can be estimated using a DEA-like method. The paper also shows how the index can be further decomposed. That approach is followed in this work.

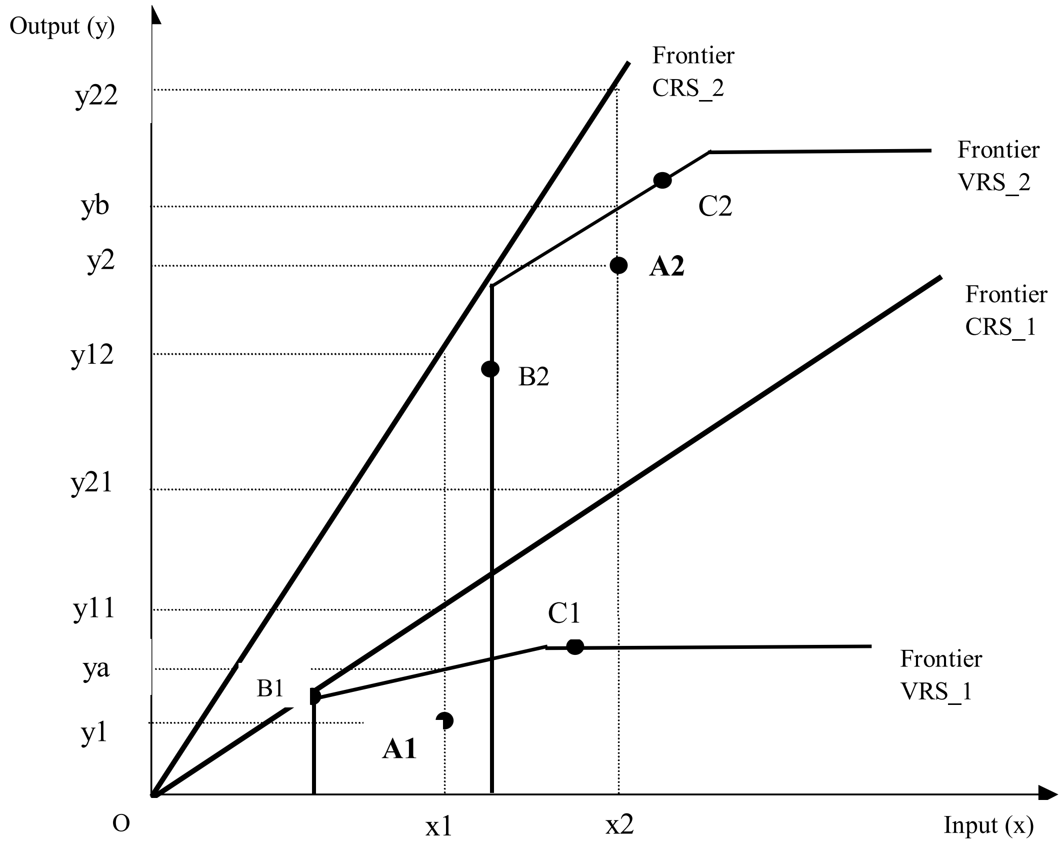
The Malmquist index of TFP change is defined using the distance functions. It compares two data points by calculating the ratio of the distances of each data point relative to a common technology. Distance functions allow one to describe multi-input, multi-output production technology without the need to specify behavioural objectives. There are two kinds of distance functions: the input distance function (which characterises the production technology by looking at a minimal proportional contraction of the input vector given an output vector) and the output distance function (which considers a maximal proportional expansion of the output vector, given an input vector).

Following Färe et al. (1994), the Malmquist output-orientated TFP index for this firm would be given by the following equation:

(4-15) $$M_0(y1, x1, y2, x2) = \left[\frac{d_0^1(y2, x2)}{d_0^1(y1, x1)} * \frac{d_0^2(y2, x2)}{d_0^2(y1, x1)} \right]^{1/2},$$

the notation $d_0^1(y2, x2)$ represents the distance from the observation in period 2 to the technology of this firm in period 1. If the value of M_0 is greater than one, it indicates the positive productivity change from period 1 to 2, while a value of less than one indicates TFP decline and a value equal to 1 indicates no change in TFP between the two periods. This can be illustrated as in Figure 4-5 on the example of firm A, operating in period 1 and 2.

Figure 4-5 Output-Orientated Malmquist TFP change index and its components



Source: Based on Fulginiti and Perrin (1997)

The Malmquist productivity index can multiplicatively be decomposed into two parts: one showing the catching-up effect (change in technical efficiency) and the other showing the frontier function shift effect (technical change). After a simple rewriting of Equation (4-15), this can be expressed as follows:

(4-16) $$M_0(y1,x1,y2,x2)=\frac{d_0^2(y2,x2)}{d_0^1(y1,x1)}\left[\frac{d_0^1(y2,x2)}{d_0^2(y2,x2)}*\frac{d_0^1(y1,x1)}{d_0^2(y1,x1)}\right]^{1/2},$$

where the ratio outside the square brackets measures the change in technical efficiency (i.e. the change in the distance of observed production from maximum feasible production) between years 1 and 2, while the bracketed term measures the shift in technology between the two periods evaluated at the time 1 and 2. An interpretation of the Malmquist indexes provided by Färe et al. (1994), is that if it is greater than one it indicates growth in productivity, and the opposite if the Malmquist indexes is less than one. In addition, improvements in any of the two components of the Mamquist productivity index (technical change and technical efficiency change) are also associated with values greater than one, and declines are associated with the opposite.

The Malmquist index derived in Equation (4-16) is applicable to either parametric or non-parametric representations of technology. Caves et al. (1982) showed that under certain conditions[23] Equation (4-15) can be computed as the ratio of the Tornqvist index of outputs and inputs. Färe and Grosskopf (1992) showed that the index may also be calculated as a ratio of Fisher ideal indexes. Another alternative is to estimate the frontiers parametrically by means of econometric estimation and then to use them to obtain the Malmquist index for each observation.

The Malmquist index, including its components, is depicted in Figure 4-5, in the case where technical advance has occurred (upward shift in technology). Then, for the case of scalar output and input, and CRS technology we have the following relationships for firm A operating in two periods 1 and 2:

The Malmquist TFP change index = Technical Efficiency change*Technological change:

(4-17) Malmquist productivity change index = $\dfrac{Oy2/Oy22}{Oy1/Oy11}\left[\dfrac{Oy2/Oy21}{Oy2/Oy22} * \dfrac{Oy1/Oy11}{Oy1/Oy12}\right]^{1/2}$,

and after some simplifications we can show that:

(4-18) Technical Efficiency change = $\dfrac{Oy2/Oy22}{Oy1/Oy11}$, while

(4-19)Technology change = $\left[\dfrac{Oy22}{Oy21} * \dfrac{Oy12}{Oy11}\right]^{1/2}$.

Färe et al. (1994) introduced an additional decomposition of the efficiency component of the Malmquist index that allows identification of change in scale efficiency and ‘pure’ technical efficiency. The former is the change in productivity resulting from a scale change that brings the economy closer to, or farther away from, the optimum scale of output as identified by a variable returns-to-scale technology. In the single-input-output case, the optimum scale can be defined as the scale of operation consistent with the highest average product. So the efficiency change under CRS technology can be decomposed as follows:

[23] The underlying technology must be translog and all second-order terms must be identical over time. It also requires technical and allocative efficiency.

(4-20) CRS Technical Efficiency = [Pure efficiency change] * [Scale efficiency change]

where:

(4-21) Technical Efficiency (CRS)

$$= \frac{d_0^2(y2,x2)CRS}{d_0^1(y1,x1)CRS} = \frac{d_0^2(y2,x2)VRS}{d_0^1(y1,x1)VRS}\left[\frac{d_0^1(y1,x1)VRS}{d_0^1(y1,x1)CRS} * \frac{d_0^2(y2,x2)CRS}{d_0^2(y2,x2)VRS}\right],$$

where CRS (VRS) indicates the distance measured under the assumption of constant (variable) returns to scale. The pure efficiency change (the first term on the right) measures change in technical efficiency under the assumption of variable returns to scale technology. In terms of distances in output orientated approach it is depicted in Figure 4-5 as:

(4-22)'Pure' technical efficiency change $= \dfrac{Oy2 / Oyb}{Oy1 / Oya}$

Scale efficiency in a given period captures the deviation between the variable return technology and the constant returns technology at observed inputs. The scale change portion of efficiency (term in brackets on the right-hand side of Equation (4-21) measures changes in efficiency due to a movement towards or away from the point of optimum scale, in Figure 4-5 it is:

(4-23)Scale efficiency change= $\dfrac{Oy1 / Oya}{Oy1 / Oy11} * \dfrac{Oy2 / Oy22}{Oy2 / Oyb} = \dfrac{Oy11}{Oya} * \dfrac{Oyb}{Oy22} = \dfrac{Oyb / Oya}{Oy22 / Oy11}$

Improvements in the indexes are denoted by values exceeding unity.

In the example depicted in Figure 4-5 we have 3 firms operating in the market and each of them produces one output (y) using one input (x) and operates in two periods, where period 2 indicates higher technological level than period 1. Firm A is technically inefficient in both periods and under both assumptions of CRS and VRS, as well scale inefficient. Of all the firms, the best performing is B in period 1 (it produces the highest output for the given input). It is technically efficient under both CRS and VRS technologies as (it lies on the CRS and VRS frontier) all other firms are not efficient under CRS in any period. However, the technical efficiency of B under CRS decreases between the periods (the firm becomes inefficient in the second period under CRS), but at the same time becomes scale efficient. Firm C in both periods is technically efficient under assumption of VRS at the same time firm C in period 2, which is scale inefficient is however technically efficient under VRS. All the levels of (in)efficiencies are given by the ratios incorporated into equations on efficiency changes presented above. For example, for firm A in period 1 it would be:

(4-24) Technical efficiency TE_CRS= $\frac{Oy1}{Oy11}$**, Technical efficiency TE_VRS=** $\frac{Oy1}{Oya}$

Scale efficiency VRS= $\frac{Oya}{Oy11}$**, Pure Technical efficiency VRS=** $\frac{Oy1}{Oya}$

In each case, a value of 1 indicates the existence of efficiency and any value smaller than 1 indicates inefficiency. For all other firms the measures of efficiency are defined analogically.

4.5.2.3 Numerical example of TFP decomposition

In order to illustrate the expressions above, one can analyse a simple numerical example. Figure 4-6 shows five firms (A, B, C, D, E) operating in two periods (1 and 2), each producing one output with use of one input, as presented in Table 4-1. If one assumes that the firms attempt to expand production with the use of available inputs, one can apply the output orientated DEA approach[24] (the DEA method is precisely described in Box 4-4 later in this chapter).

Firstly, in order to calculate the *change in technology* (TechCH) in this sector, one needs to identify the best firms i.e. those with the highest output-input ratios in both periods, hence, those which make up the 'best practice' production frontiers relative to CRS in both years. Only firm B fulfils this condition (see Figure 4-6 and Table 4-1) and hence it determines the technological progress for the whole group. Its technology (Tech), (i.e. output-input ratio) in year 1 equals 1, and in year 2, equals 1.33 (or, 3/4). The index of technological change (TechCH) then equals: Tech2/Tech1=1.33/1 = 1.33 (or 33%). This means that technology, as defined above, improved by 33%. We can also calculate the change according to the Equation (4-19) as follows: TechCH= $[4/3*4/3]^{1/2}$ =4/3=1.33, (or 33%). For all other firms in our numerical example the technological progress is the same.

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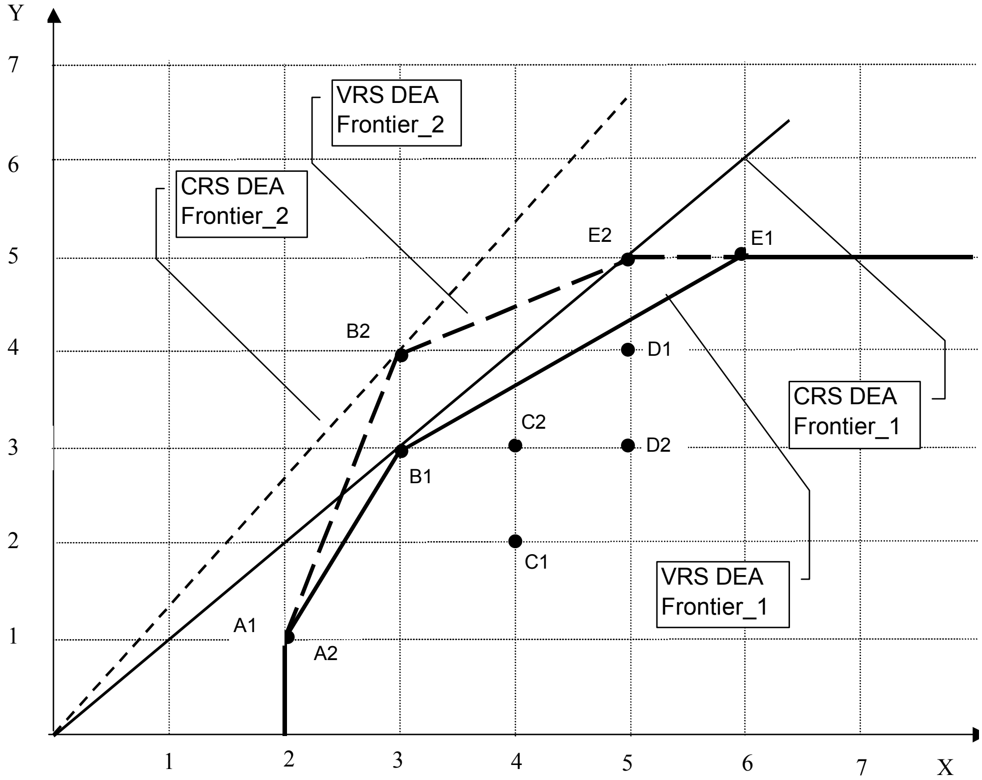
[24] Note, there is no assumption of profit maximisation or cost minimisation behaviour, only the logic of efficiency decisions. If the logic is to maintain production with a minimum use of inputs as e.g. in the case of many public services, one assumes input orientated DEA, while if the logic is towards maximising output within available inputs one assumes output orientated DEA. The latter approach is used here most often, as it seems more appropriate in case of Polish farms.

Figure 4-6 TFP Decomposition of the Malmquist index (DEA Output Orientated Numerical Example)



Source: Based on example in Coelli et al. (1998)

In order to calculate *changes in technical efficiency (TEff)* in our sector, one must first calculate technical efficiency of each firm relative to the CRS frontier (TE_CRS) in each period of time. This is simply the relative vertical distance of each firm from the production frontier under CRS in each year (compare Equation (4-24, Figure 4-6 and Table 4-2). For example, for firm A it is: in year 1, TE_CRS1=(1 / 2)=0.5, and in year 2, TE_CRS2=1 /2.66=0.375.

Table 4-1 Outputs and Inputs for Numerical Example

Firms	A	B	C	D	E
			Year 1		
Output	1	3	2	4	5
Input	2	3	4	5	6
			Year 2		
Output	1	4	3	3	5
Input	2	3	4	5	5

Source: Based on example in Coelli et al. (1998)

Table 4-2 Technical Efficiencies in Example

Firms	A	B	C	D	E
			Year 1		
TE_CRS	0.500	1.000	0.500	0.800	0.833
TE_VRS	1.000	1.000	0.545	0.923	1.000
			Year 2		
TE_CRS	0.375	1.000	0.562	0.450	0.750
TE_VRS	1.000	1.000	0.667	0.600	1.000

Source: Author's own calculations

The changes in technical efficiency (TEff) can be calculated as ratios of technical efficiencies in both periods under CRS, i.e. TE_CRS2/TE_CRS1. The results presented in

Table 4-3 indicate that three firms (A, D and E) experienced decline in total technical efficiency by 25%, 43.8% and 10% accordingly, because they did not expand their production while the technology in the sector shifted upwards (more precisely, both firms, A and E, maintained their production while firm D even reduced it). Firm B did not change its technical efficiency because it was fully efficient in both periods (hence it could not become more efficient). Firm C improved its technical efficiency (by 12.5%) by moving closer to the frontier in the second year and hence reducing its inefficiency.

Technical efficiency changes (TEff) can be further decomposed into two components: '*pure' technical changes* and *scale efficiency changes*. In the case of the former, firstly one needs to calculate technical efficiencies for each farm in each period relative to VRS. The calculations are analogues to those in the total technical efficiencies presented above, but this time with reference to VRS frontier. For example, for firm C it is: in year 1, TE_VRS1=2/3.64=0.55 and in year 2, TE_VRS2=3/4.47=0.67. Then, changes in 'pure' technical efficiency can be simply calculated by a ratio of TE_VRS2/TE_VRS1 for each firm. The changes in scale efficiency are obtained as a ratio of changes in the CRS efficiency over that of VRS , or in other words the ratio of change in total technical efficiency to change in 'pure' technical efficiency. As

Table 4-3 indicates, the changes in technical efficiency were mainly due to changes in scale efficiency rather than 'pure' technical efficiency. The latter changed only in the case of two firms, C and D, by 22.2% and -35%, respectively, while the former changed in all the firms (except leading farm B). Generally, the scale efficiency declined considerably, which means that for all the firms their distance to the CRS frontiers was larger than to VRS frontiers.

Finally, the changes in TFP result from all the changes in technical efficiencies and technology. The highest productivity improvements were visible in the case of the three firms (B, C, and E), though for different reasons. In firm B, productivity increased due to technological advancement (the firm set up the frontiers for all other firms); in firm C, primarily due to the catching up effect of the firm towards 'best practice' technology (it increased production at a greater rate than technological change); and in firm E it was because it managed to decrease the amount of its input while maintaining its production at an unchanged level.

Table 4-3 Decomposition of the Malmquist TFP Index in the numerical example

firm	Technological Change (TechCH)	Technical Eff. Change (TEff)	"Pure" Tech. Efficiency ('Pure'TE)	Scale Efficiency	TFP Change
	bestTech2/bestTech1	TE_CRS2/TE_CRS1	TE_VRS2/TE_VRS1	TEff/'Pure'TECH	TechCH*TEff
A	1.33	0.75	1.00	0.75	0.99
B	1.33	1.00	1.00	1.00	1.33
C	1.33	1.12	1.22	0.92	1.50
D	1.33	0.56	0.65	0.87	0.75
E	1.33	0.90	1.00	0.90	1.20
mean	1.333	0.844	0.955	0.883	1.125
firm	**Technological Change (TechCH)**	**Technical Eff. Change (TEff)**	**"Pure" Tech. Efficiency ('Pure'TE)**	**Scale Efficiency**	**TFP Change**
A	33.0%	-25.0%	0.0%	-25.0%	-1.00%
B	33.0%	0.0%	0.0%	0.0%	33.0%
C	33.0%	12.0%	22.4%	-8.2%	50.0%
D	33.0%	-43.8%	-35.0%	-13.5%	-25.0%
E	33.0%	-10.0%	0.0%	-10.0%	20.0%
mean	33.3%	-15.6%	-4.5%	-11.7%	12.5%

Source: Author’s own calculations

Box 4-4 Data Envelopment Analysis (DEA)

The TFP decomposition method requires linear programming techniques to identify the technology frontier and measure the distance to that frontier for each observation (firm) in the sample. This is termed Data Envelopment Analysis (DEA).

DEA was originally designed in fact only for calculating efficiencies of individual firms and was first proposed by Charnes et al. (1978). However, following Fare et al (1994), one can use DEA-like linear programming to calculate the appropriate distance functions to also measure TFP changes over time, and TFP decomposition into particular efficiency changes. For the i-th firm, in order to measure the TFP change between two periods (t and s), output-orientated under constant returns to scale (CRS), we would have to solve the following 4 Linear Programming (LP) problems (Coelli et al. 1998):

$$\max_{\phi,\lambda} \phi = [d_o^t(y_t, x_t)]^{-1}$$
$$\text{subject to } -\phi y_{it} + Y_t\lambda \geq 0$$
$$x_{it} - X_t\lambda \geq 0$$
$$\lambda \geq 0$$

$$\max_{\phi,\lambda} \phi = [d_o^s(y_s, x_s)]^{-1}$$
$$\text{subject to } -\phi y_{is} + Y_s\lambda \geq 0$$
$$x_{is} - X_s\lambda \geq 0$$
$$\lambda \geq 0$$

$$\max_{\phi,\lambda} \phi = [d_o^t(y_s, x_s)]^{-1}$$
$$\text{subject to } -\phi y_{is} + Yt\lambda \geq 0$$
$$x_{is} - Xt\lambda \geq 0$$
$$\lambda \geq 0$$

$$\max_{\phi,\lambda} \phi = [d_o^s(yt, x_t)]^{-1}$$
$$\text{subject to } -\phi y_{it} + Y_s\lambda \geq 0$$
$$x_{it} - X_s\lambda \geq 0$$
$$\lambda \geq 0$$

where: X and Y are matrices of the inputs and outputs respectively of all observed (N) farms; x_i and y_i are respectively the input and output vectors of the i-th farm; λ is a N×1 vector of constants; ϕ_i is the technical efficiency of the i-th farm, bounded by 0 and 1, with a value of 1 indicating a technically efficient firm.

The variable returns to scale (VRS) DEA model is obtained by adding the constraint N1'λ = 1, where N1 is a N×1 vector of ones. This is a convexity constraint ensuring that a firm is benchmarked against firms of a similar size. When conducting both constant returns to scale (CRS) and variable returns to scale (VRS) DEA, the scale efficiency is obtained as a ratio of the CRS efficiency measure over the VRS measure. Technical efficiency under CRS is called total technical efficiency and technical efficiency under VRS is called pure technical efficiency.

4.5.2.4 Interpretation of TFP components

A combination of factors explain the existence of various types of (in)efficiency and technological changes. Technical efficiency, which in practice show how effectively the resources are used with a given technology and scale, can potentially be explained by what is called X-(in)efficiency. This type of inefficiency results from either internal (within the firm) factors, such as bad management practices, inappropriate work norms, distorted motivational factors and transaction costs, or those external to the firm, such as inappropriateness in regulations, property rights and ownership forms, or exposition to competitive pressure (if this does not exist it may contribute to sub-optimal use of inputs and technologies). Technical efficiency can coexist with scale inefficiency, as the latter represents only one productivity component and, therefore, can be offset by superior technical efficiency (e.g. by improving management or limiting principal-agent problems) or ability to faster adopt new technology (e.g. easier raising of capital for new investment, if capital market is malfunctioning) (Guba, 2000).

Technological change in its general meaning refers to the advances in the state of knowledge and consists of three inter-linked forces: research and development (R&D), adoption and diffusion (A&D) and an institutional component (OECD, 1995b). One may distinguish a few important properties of technological change. Firstly, its bias against any of the production factors. If technological change leaves the optimum factor ratio unchanged then it is called *neutral*. However, in practice technological change influences relative resource endowment, and as such is not neutral, and today most technological advances tend to be of the *labour-saving* type. The second feature of technological change refers to whether it requires adaptation of an existing process via acquisition of new inputs (usually of a mechanical character) or whether it uses existing labour and capital to produce more of the same product. In the case of the former we talk about *embodied* technological change, while in the latter about *disembodied* change. The third property is its scale bias, which exists because certain technologies require a particular size in order to be fully utilised. Today technological advancements seem to be more adjusted to medium and small firms, but historically mechanical technologies have tended to favour larger scale operations. Another property of technological change worth mentioning is whether it refers to innovation of product or process, where the former means non-cost related operations (e.g. product proliferation and differentiation) and the latter mainly reduces costs enabling technological advancement (OECD, 1995b).

All the above described techniques and methods towards productivity structure and changes are used in the empirical chapters (Chapter 5 and Chapter 6) with application to Polish farm data in order to verify the research hypotheses.

4.6 Conclusions

- Although it is possible to assess approximate competitiveness based on a single measure (e.g. DRCs), this however would say little about the determinants of overall competitiveness and hence would not allow for a formulation of an integrated strategy for its improvement. Therefore, increasing numbers of authors have suggested the application of mixed theories and various methods to understand competitiveness. This author is attempting to do this by formulating an eclectic theoretical model.

- Particularly important in analysing competitiveness is distinguishing its 'price' aspects from the 'technical' aspects of the concept. As for the former, it is exogenous to a firm's relative prices in the sector, and should be analysed together with macroeconomic interactions in the whole economy, which is especially important for developing and transition economies such as Poland. As for the latter, which is to great extent endogenous to a firm or sector, understandings of the mechanism of technological processes and efficiency changes in the sector are crucial for assessing long-term competitiveness and should never be underestimated in the research on competitiveness.
- Productivity, which is a complex concept itself, is also worth analysing together with competitiveness because whatever the relative price development (favourable or not), productivity should always be at the heart of any programmes aimed at the improvement of competitiveness because it assures long-term comparative advantage of any sector and to a great extent depends on the producers themselves. Therefore, policy makers should switch from short-run intervention-oriented policy towards more forward-looking policy orientated on modernisation of the sector.

5 Empirical Assessment of Changes in Competitiveness

The goals of this chapter are twofold. Firstly, to provide evidence to support the formulation of the first two research hypotheses; secondly, to verify the hypotheses empirically using the methodology introduced in the previous chapter.

5.1 Price transmission mechanism from the world and national economy to agricultural sector

The contribution of agricultural relative prices to the competitiveness of the sector depends on the extent to which these prices are influenced themselves by world (international) prices, domestic macroeconomic policies and sector specific policy interventions. An important role is also played by market efficiency, including (im)perfections of competition.

In the area of international prices there has been a lively debate in the economic literature on the degree of price transmission from world commodity markets into domestic producer prices in small open economies (Valdes and Foster, 2002). Some authors have provided evidence to show that such transmission can be very significant, though totally different in the shorter and longer-run. Tyers and Anderson (1992) calculated the transmission rate of world price variations for European producers and obtained less than 10% in the short-run and 20% in the long-run, while Sarris (1999) came up with rates of 24% in the short-run and almost 58% in the long-run[25]. One of the most controversial papers, however, was by Mundlak and Larson (1992), whose research concluded that elasticity of transmission can be close to unity and that, usually, ‘variations in world prices are the major contributors to variations in domestic prices’ (Valdes and Foster, 2002:10). Many have argued with their findings, however. Quiroz and Soto (1995) carried out cross-country analysis of the transmission of world agricultural prices in 78 countries and found evidence to show that in most cases, transmission was low in the sense that it took at least two years to transmit 50% of international price shocks to domestic markets (Valdes and Foster, 2002).

Despite the differences in views on the significance of price mechanisms, most authors agree that the size of the effect from world distortions varies significantly from country to country. In Australia, Canada, New Zealand and Uruguay, 50% or

[25] These percentages indicate the scale of the influence of world prices on domestic ones. For example, a fall in world prices by 100% may translate into 10% fall in domestic prices in the short-run and 20% in the long-run. Obviously, in the longer run, external forces have greater influence on domestic prices than in the shorter run, as exposure to the forces (shocks) lasts longer and protection becomes more costly.

more of any given shock from world prices is transmitted within a year into the agricultural sector, while in 30 other countries analysed by Quiroz and Soto (1995) virtually no international price signals penetrated the sector (Valdes and Foster, 2002).

From the point of view of this analysis, it is interesting to ask how agricultural producer prices in Poland have been affected not only by changes in world prices, but also by dynamically changing domestic macroeconomic policies and by sectoral policy. Based on our theoretical framework (see Chapter 4), the influence of macroeconomic policies will be studied in terms of their unintended (indirect) influence on agriculture via their determining of the exchange rate, while the influence of sectoral policy will be directly measured by the extent to which it determines border protection and direct interventions.

Firstly, several preliminary observations on what the Polish research results are likely to yield is necessary at this point. Generally in the case of countries with fixed exchange rates and reasonably low inflation, the expected price transmission elasticity is close to one, while in countries with floating exchange rates and stable macroeconomic situations we would expect low rates of transmission, because the final effect of world price changes on real domestic prices might be overwhelmed by exchange rate variations (Valdes and Foster, 2002). In Poland, we can expect the transmission rate somewhere in the middle of the zero-one range, however, the value will probably significantly differ in certain periods during the 1990s due to changes in agricultural trade restrictions, exchange rate regimes, and other policy changes. Therefore, a more carefully analysis of the sub-periods of the 1990s, taking into account the specific conditions prevailing at each stage is, necessary.

5.1.1 World agricultural prices

Generally speaking, the long-term trend in world agricultural prices is downward and fluctuations around it substantial. This results from the specific features of the sector. Long-term price developments are poor, largely due to the fact that income and price elasticity of demand for agricultural products is low, and as such, as the incomes of nations grow, demand for agricultural commodities increases disproportionally. If one adds to this the continued improvement in the productivity of world agriculture excess supply of commodities trends appear to be unavoidable, with all their depressing consequences for world commodity prices (Tomek and Robinson, 1990).

In the short-term, fluctuations are considerable not only due to inelastic demand but also due to reasons of supply. If one also adds the fact that agricultural production generally fluctuates considerably (as it relies on unpredictable weather conditions), then changes in prices are unavoidable if no measures are undertaken. Such features of the agricultural sector are often used as arguments in favour of agricultural policy interventions (Lipsey and Cristal, 1995).

Valdes and Foster (2002) claim that the key question facing domestic policy is not the volatility of world prices, but rather the periods of exceptionally low price levels, falling below the long-term trend. Practically all quantitative analyses on agricultural protection conclude that protectionist subsidy policies depress world short-term prices relative to what would otherwise be the case with lower protection (Valdes and Foster, 2002). Evidence shows that this depression of world prices results largely from developed countries, which tend to heavily protect their agricultural sectors, while developing and transition countries usually tax them heavily (implicitly or explicitly) (Valdes, 2000). Whatis more, most developed countries usually consolidate their agricultural markets in order to better protect their products even if their interests are not entirely the same, as has been the case in the European Union's Common Market (Siwiński, 1976). However, this entails even stronger protectionism and, hence, a further negative impact on world agricultural prices.

In addition, according to the study by Cashin, Liang, and McDermott (1999), devoted to price shocks on world agricultural commodity markets in the period 1960-1997, the distribution of volatility of prices is not symmetric in the sense that low prices tended to last longer than high prices (Valdes and Foster, 2002).

By the start of the 2000s many commodities had already become more expensive in Poland than on world markets. Cereals, pork, and poultry were cheaper in the EU than in Poland (if we compare market prices converted into a single currency). Even more commodities are more expensive in Poland if one compares subsidised EU prices (including export refunds) with Polish market prices (see Table 5-1).

Table 5-1 Comparison of average Polish and EU prices with and without export refunds(2001/2002)

Commodities	EU prices with refunds as % of Polish prices	EU market prices w.o. refunds as % of Polish prices
Soft wheat	81%	83%
Rye	64%	94%
Barley	79%	79%
Oats	70%	93%
Skimmed milk powder	95%	100%
Butter	66%	140%
Gouda cheese	79%	109%
Ementaler cheese	101%	129%
Beef	104%	146%
Pork	96%	96%
Poultry	71%	91%

Source: SAEPR/FAPA (2002)

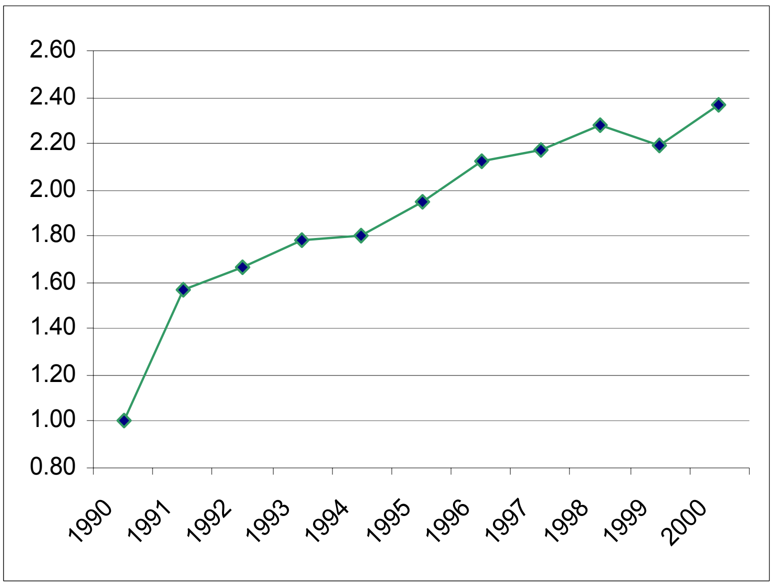
If a country is a net importer of agricultural commodities, as Poland has been since 1993, import tariffs and quotas are required to stop domestic prices being affected by lowering world prices. If, however, a country is a net exporter (as Poland is in the case of several agricultural commodities) tariffs are also necessary, but are insufficient in themselves – export subsidies are also necessary. However, all these measures can be used at a limited level because of Poland's international commitments. In March 1992, the first Poland-EC Association Agreement came into force, followed in mid-November 1993 by the EFTA-Poland Free Trade Agreement. In April 1994, Poland signed both final documents of the Uruguay Round and the declaration on the World Trade Organisation (WTO). Various measures were also abandoned in line with the 'pre-accession' European Agreement, the so-called 'double zero option' (i.e. zero duty and zero export subsidies).

Nevertheless, as Pouliquen (2001) claims, in CEECs, including Poland, the low penetration of domestic markets by certain exportable products from the EU (such as wheat and oil seeds) is almost exclusively thanks to customs protection and not the competitiveness of these products.

5.1.2 The Real Exchange Rate

Real exchange rate appreciation in Poland, combined with liberalisation of agricultural trade, has been the second potentially significant factor contributing to depression of real domestic prices for (tradable) agricultural commodities. Over the period 1990-2000, the real value of the zloty more than doubled (Figure 5-1). Hence, most of the prices of basic commodities expressed in foreign currencies considerably increased over time. Dollar prices of wheat, barley, oil seeds, sugar and milk were much higher at the end of the 1990s than at the beginning (Table 5-2). The smallest increase was in the case of sugar (4%), and the biggest price jump (by 177%) in the case of milk.

Figure 5-1 Real Effective Exchange Rate Index (1990=100)



Source: IFS (2002)

At the same time, the growing value of the zloty had a depressing effect on real domestic prices expressed in PLN, which meant a considerably decline in all real prices of basic commodities, with the exception of milk (where prices increased in PLN by 25%) (see Table 5-2). The declines were generally larger in the case of livestock products (on average about 65%) than plant products (on average about 40%).

Overall, such price developments were undesirable from the competitiveness point of view, as Polish agricultural sector products became more expensive on international markets, while at home producers faced declining real output prices and, hence, pressure on incomes and profitability.

Table 5-2 Basic Polish commodity prices per ton expressed in real PLN and US dollars (at 1990 prices)

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2000/1990
Commodities							Prices						Change
Wheat	PLN	81	47	66	74	57	64	86	67	55	47	51	-38%
Barley	PLN	71	40	48	70	51	58	71	59	47	42	48	-32%
Oilseeds	PLN	63	36	43	66	47	53	63	48	40	37	42	-34%
Sugar	PLN	140	101	127	105	107	122	109	95	84	76	65	-53%
Milk	PLN	63	61	78	75	65	79	78	79	73	72	79	25%
Beef	PLN	791	561	593	659	776	778	968	876	815	471	283	-64%
Pork	PLN	1042	752	697	653	763	603	583	588	550	443	360	-65%
Poultry	PLN	971	804	848	614	788	643	690	600	531	472	343	-65%
Wheat	US$	86	76	118	134	110	147	213	157	135	109	118	38%
Barley	US$	74	64	86	128	99	133	175	138	114	98	111	50%
Oilseeds	US$	67	58	77	120	91	122	155	111	98	85	97	46%
Sugar	US$	147	163	227	190	204	281	269	223	206	175	153	4%
Milk	US$	66	98	139	136	125	182	194	186	179	168	183	177%
Beef	US$	833	904	1060	1197	1487	1786	2396	2049	2002	1093	660	-21%
Pork	US$	1097	1210	1246	1186	1463	1385	1442	1377	1351	1029	839	-24%
Poultry	US$	1022	1295	1516	1116	1510	1477	1708	1404	1303	1096	800	-22%

(i) Deflated by CPIs
Source: Author's calculations based on OECD CSE/PSE database

5.1.3 Border measures

The initial liberalisation of trade in agricultural commodities (possible since 1990 under the Law on Economic Activity), which allowed almost fully free trade, lasted until mid-1991. Subsequently, restrictions were imposed when it started to become clear that liberalisation had led to very strong competition from highly subsidised imported products from western countries or eastern countries with undervalued currencies. By August 1991 the average tariff rate had risen to 26.2%, compared to its initial 10.4% (OECD, 1995a). The ad valorem tariff for some products (poultry, eggs, potato flour, beer, sugar) was increased in March 1992. In the same year, a new measure, ‘import tax’ of 6% on agricultural products, was introduced, which was nothing if not an additional tariff. Moreover, in 1993 the specific minimum tariffs fixed in US dollars were increased and fixed in ECUs (OECD, 1995a) and turnover tax on imported goods (with a 5% rate on basic food products) was replaced by the VAT system (with a rate of 7%) equally applied to imported and domestic products. In 1994, parliament adopted a law and introduced variable import levies on agricultural commodities (OECD, 1995a).

Other measures included import prohibitions (applied to pure alcohol and unflavoured vodka and to animals and livestock products for health, safety and environmental reasons), import quotas (administratively distributed), import licensing and various certificates (e.g. certificate of origin, quality, etc.). Export subsidies, which had been very important, became virtually abandoned after 1990. However, the Agricultural Market Agency (ARR) could indirectly grant export subsidies (e.g. through export promotion programmes). Besides, VAT was also applied to the products and there were some export prohibitions (permanently introduced on protected plants and animals and occasionally extended to other products in the event of domestic shortages), an export licensing system (on exports of dairy products subject to the International Dairy Arrangement) and export quotas (on exports of young cattle, sheep and mutton to the EU) (OECD, 1995a).

Protectionism would appear to be growing still if one compares actual duties applied by Poland in 1997 with those in 1999, with all the duties increasing over the period and those for pork even exceeding the ceiling agreed with the WTO (see Table 5-3)[26]. They are converted into ad valorem equivalents by using common world prices for 1997 and 2000 (see Pouliquen, 2001).

Table 5-3 Main custom duties reciprocally applied between three CEECs and the EU (ad valorem % equivalents)

Commodities	Poland		Ceiling	Hungary		Ceiling	Czech Republic		Ceiling	EU:ceiling
	1997	1999	2000	1997	1999	2000	1997	1999	2000	2000
Wheat	20	70	76	41	35	32	23		21	46
Oilseeds	15		27	0	0	0	66	65	60	0
Sugar	68	100	172	70-74	100-160	68	65	162	60	169
Butter	40	111	166	130	110	102	75		68	136
SKM*	80	111	108	70	56	51	43		37	70
Cheese	35		160	79-86	61-73	67	10		9	87
Beef	45		182	92	77	72	38	38	34	108
Pork	60	83	64	57	53	52	42	40	39	38
Poultry	60	80	99	50	42	39	49		43	25

*Skimmed milk powder

Source: Pouliquen (2001)

26 The duties presented here are full duties applied above the quotas at reduced duty of the European Agreement and the WTO’s minimum or current access.

Despite this growing protectionism, some measures were negotiated aimed at reducing protectionism, for example, preferential import quotas (under the Uruguay Round) and free tariff-quotas (the 'double-zero option' signed with the EU).

5.1.4 Direct market interventions

Poland has direct market interventions in grain, milk and pork markets, all undertaken by the Agricultural Market Agency (ARR). Their main objectives are to stabilise the markets and support domestic prices (Pazura, 2003). To achieve these objectives, the ARR has been undertaking two types of actions: i) contributing to market price supports by making purchases at prices higher than the relevant border price equivalents; ii) subsidising storage costs by making intervention purchases during harvest at prices which do not account for expected storage costs. According to Safin (2000), if all costs of direct interventions are aggregated (including the financial costs of ARR operations) the estimated transfer of 1 PLN to farmers through ARR market intervention costs each taxpayer about 4 PLN, raising questions about the efficiency of the ARR's support, especially when the outcome (in the sense of satisfying the main objectives) is generally poor.

On the other hand, Poland's total budgetary net transfer to the agricultural sector per capita is almost twice and three times smaller than in the Czech Republic and Hungary, respectively. The discrepancy is even larger (five times smaller net value of support per capita) if Poland is compared with the EU (Table 5-4).

Table 5-4 Value of total support: taxpayers' annual transfers to the agro-food sector (USD million)

	1986-1988	1997	1998	1999	US$ per capita
Poland	3 044	1035	968	1003	25.95
Hungary	1 507	478	683	740	73.68
Czech Republic	2 315	415	414	461	44.85
EU	27 468	64389	61822	57203	152.7

Source: Pouliquen (2001)

5.1.5 Formulating the research hypothesis

Based on the above overview, real protection of the sector appears to have increased in the 1990s, also evidenced by the Producer Support Estimate (PSE), which almost doubled between the early and late 1990s. (see also Appendix 5-2, Table A. 5-6). However, at the same time, there was strong pressure exerted from outside the sector: from low world prices and the considerable real appreciation of the domestic currency. The strength of such pressures meant that interventions alone were insufficient. Part of this thesis is aimed at showing empirically the extent to which this was the case. Besides, it is also interesting to consider which of the pressures was higher, external markets (world agricultural commodity prices) or those stemming from the domestic economy (determining Poland's exchange rate). The key questions are how policy interventions have worked during periods when both of the above effects were operating in the same direction (putting pressure on domestic relative prices) and how the effects have been counteracted? The exchange rate effect was strong and as such, if it was strengthened by decreasing world prices, any policy would probably have been unable to offset them together at the same time.

More generally, one may formulate questions in the following hypothesis:

Hypothesis 1: Relative agricultural (output-input) prices deteriorated during the analysed period mainly due to the strong pressure stemming from macroeconomic adjustment which was too strong to be offset by sectoral policy interventions.

In order to empirically verify this hypothesis and answer the research questions stated above it is necessary to disentangle the influence of macroeconomic effects from direct policy ones. This requires decomposition of changes in real domestic producer prices divided into: i) real world price changes; ii) changes in real exchange rate; iii) policy interventions. For this the method of Quiroz and Valdes (1993) is used (detailed in Chapter 4). Then a comparison of the decline in real output prices against real input prices is made in order to discover the relative price changes.

5.1.6 Data

For the purposes of this analysis the data range was 1990-2000. The main variables used were the following: i) domestic market prices of 11 basic agricultural commodities (wheat, maize, barley, oil seeds, sugar beet, milk, beef, mutton, pig meat (pork), poultry, eggs) in PLN obtained from GUS and the OECD CSE/PSE Database; ii) border (reference) prices of all the commodities were c.i.f. or f.o.b. prices (depending on whether the commodity was net imported or net exported in the case of Poland) obtained from the OECD CSE/PSE Database; iii) exchange rates - nominal exchange rates (PL/EUR and PLN/US$), as well as CPI for Poland and countries of the European Monetary Union (as a proxy for EU) and CPI for the USA all came form IFS Database published by the IMF. In this analysis the CPI indices were used to deflate output prices. This large simplification is justified by the fact that we do not have output price indices for particular commodities in EU countries (as there are for Poland), therefore for symmetrical purposes this simplification has been undertaken. Note, this was done in the same way in the original paper by Valdes (1996), who initiated the method (also note, however, that in all other analyses in this thesis exact output price indices for Poland are used to deflate the particular outputs).

The rest of the world is represented by the EU and USA, proportionally 60% and 40%, respectively (these weights were used for constructing the effective exchange rate and the world CPI). The base year for all indices is 1991.

5.1.7 Results

We analysed the decomposition of real output commodity prices in three time sub-periods (1991-1993, 1994-1995, and 1996-2000) and for the whole ten-year period (see Table 5-5). At the beginning of the transformation (1990 to mid-1991), liberalisation of agricultural trade coincided with a fall in the world prices, which resulted in strong pressure on the domestic market and a considerable decline in real output prices, strongly manifested also in farmers lobbying for restoration of border measures. Protection as such increased over 1991-1993. This was not only positive, but also the highest of all analysed sub-periods (it changed by a cumulative 57.3%, see Table 5-5). However, at the same the period also saw the quickest appreciation of Polish zloty (by 63.3% cumulative change) and, in addition, world agricultural prices declined (by 14%). The latter was due to the fall mainly in pork, maize and poultry prices. This resulted in the overall decline in real producers' prices by 20% (Table 5-5).

During 1994-1995, the situation has changed quite substantially. World prices increased, which although did not last long, was substantial (34.4%), and at the same time the overall appreciation of the domestic currency was weaker than before (14.8%). This allowed for a small increase in real product prices despite the fact that the sector was actually net taxed by the sectoral policy at that time.

Between 1996-2000, the decline in real commodity prices was the largest of all periods (44.2%), as international prices fell substantially again (almost 40%), which was additionally reinforced by real exchange rate appreciation (19.2%). The policy was far too weak to respond to this, as border protection had little room for tightening at that time, on the contrary, in fact various tariff-quotas and other liberalising measures were undertaken (see Section 5.1.3).

All in all, the results indicate that the main factor underlying the considerable decline (by 60% cumulative change) in real domestic agricultural prices during the 1990s was the real exchange rate appreciation (97.4% cumulative change), amplified by the fall in border prices (19.4% cumulative change) (see Table 5-5). The pressure stemming from those two factors acting together was so strong that policy interventions could compensate for half the decline in real domestic prices of agricultural commodities - if there had been no intervention at the time, the decline in real domestic prices would have amounted to nearly 117%, instead of 60%.

Table 5-5 Decomposition of Real Agricultural Output Prices in Poland, 1991-2000

	Changes (in %) :	1991-1993 (v)	1994-1995 (v)	1996-2000 (v)	1991-2000 (v)
Total changes in: (vi)	**real domestic price** (i)	**-20.0**	**3.6**	**-44.2**	**-60.6**
	real border price (ii)	**-14.0**	**34.4**	**-39.8**	**-19.4**
	real exchange rate (iii)	**-63.3**	**-14.8**	**-19.2**	**-97.4**
	intervention (1+t) (iv)	**57.3**	**-16.0**	**14.8**	**56.2**
Wheat	real domestic price	-9.9	-14.2	-23.3	-47.4
	real border price	-7.9	15.4	-8.2	-0.7
	real exchange rate	-63.3	-14.8	-19.2	-97.4
	intervention (1+t)	61.3	-14.7	4.0	50.7
Maize	real domestic price	-14.1	9.5	-47.9	-52.4
	real border price	-17.6	32.6	2.8	17.9
	real exchange rate	-63.3	-14.8	-19.2	-97.4
	intervention (1+t)	66.8	-8.3	-31.5	27.1
Other corps	real domestic price	0.0	-19.7	-19.1	-38.9
	real border price	26.8	23.9	8.9	59.6
	real exchange rate	-63.3	-14.8	-19.2	-97.4
	intervention (1+t)	36.5	-28.7	-8.9	-1.1
Oilseeds	real domestic price	4.6	-21.8	-24.4	-41.6
	real border price	-5.6	14.8	-35.7	-26.5
	real exchange rate	-63.3	-14.8	-19.2	-97.4
	intervention (1+t)	73.6	-21.8	30.5	82.3
Sugar	real domestic price	-28.6	15.6	-62.6	-75.6
	real border price	-14.2	34.5	-61.9	-41.6
	real exchange rate	-63.3	-14.8	-19.2	-97.4
	intervention (1+t)	49.0	-4.1	18.5	63.3
Milk	real domestic price	17.4	5.8	-0.8	22.5
	real border price	13.6	18.5	10.9	42.9
	real exchange rate	-63.3	-14.8	-19.2	-97.4
	intervention (1+t)	67.2	2.2	7.5	77.0
Beef	real domestic price	-18.3	16.6	-101.0	-102.7
	real border price	10.4	24.4	-10.0	24.7
	real exchange rate	-63.3	-14.8	-19.2	-97.4
	intervention (1+t)	34.6	7.1	-71.8	-30.1
Mutton	real domestic price	-22.8	25.8	-8.6	-5.6
	real border price	17.9	26.1	20.2	64.2
	real exchange rate	-63.3	-14.8	-19.2	-97.4
	intervention (1+t)	22.6	14.5	-9.5	27.6
Pork	real domestic price	-46.8	-7.9	-51.5	-106.3
	real border price	-31.3	14.4	-17.7	-34.7
	real exchange rate	-63.3	-14.8	-19.2	-97.4
	intervention (1+t)	47.8	-7.4	-14.6	25.8
Poultry	real domestic price	-45.9	4.6	-62.8	-104.0
	real border price	-15.5	30.9	-16.8	-1.4
	real exchange rate	-63.3	-14.8	-19.2	-97.4
	intervention (1+t)	33.0	-11.5	-26.8	-5.3
Eggs	real domestic price	-5.8	-9.5	-30.9	-46.2
	real border price	-9.2	-12.4	16.5	-5.0
	real exchange rate	-63.3	-14.8	-19.2	-97.4
	intervention (1+t)	66.7	17.7	-28.2	56.2

(i) = (ii)+ (iii) + (iv), i.e. (i) $\Delta \ln P_{it} = \Delta \ln P^{w}_{it} + \Delta \ln RER_t + \Delta \ln (1+T_t)$ Where:

P_{it} = real domestic price of good i = nominal price in PLN at time t / domestic CPI

P^{w}_{it} = real world price of good i = nominal price converted by Nominal Effective Exchange Rate (NEER) / world CPI

and: Nominal Effective Exchange Rate equals=0.6*PLN/EUR+0.4*PLN/US$, and World CPI = 0.6*CPI_EU+0.4*CPI_USA.

RER_t =Real Effective Exchange Rate = (NEER / domestic CPI)* world CPI

T_t = rate of direct intervention (calculated as a residual)

(v) cumulative percentage change

(vi) The weights used for summing the resutls are the shares of the products in global production

Source: Author’s own calculation

From the policy point of view, it is important to note that the interventions were too weak to compensate real domestic prices when both RER and world prices worked simultaneously. However, it most often attempted to act counter-cyclically (for most products) and managed to prevent a higher decline in real prices than would otherwise have been the case (from RER and world prices together). For example, 6 out of 11 analysed product were under pressure from both decreasing world prices and real appreciation at the same time (see column 1991-2000 for each product), and in 5 such cases policy responded in the intended direction, in the sense that it managed at least partially to prevent the transmission of external 'shocks' into real prices of those commodities (Table 5-5).

Last but not least, since we know that there was what became known as the 'price scissors' phenomenon during the 1990s (i.e. the index of input prices outweighed the index of output prices in most of the years – see also Figure 4-2) and since we have showed that real output prices declined considerably over the period we can conclude that the relative output-input prices declined as well.

Hence, we can positively verify Hypothesis 1, and conclude that relative prices indeed declined during the 1990s, the main reason being a strong real exchange rate appreciation amplified byan overall declining trend in world prices, not offset by domestic agricultural policy.

According to the theoretical model developed in this work (see Figure 4-1) our results lead us to the conclusion that downward pressure on competitiveness stemming from a deterioration in relative prices can only be compensated for in a sustainable way by improvements in total factor productivity in the farm sector (and to a very limited extent also by changes in factor proportions) if competitiveness is to be maintained. Therefore, in the next section the time series of the total factor productivity of the sector is analysed.

5.2 Changes in productivity of the farm sector

The methodology outlined in Chapter 4 makes it clear that the main determinants of TFP changes are technological and efficiency changes. Government policy may affect agricultural TFP through three channels: direct support of agricultural Research and Development (R&D), various forms of support to producers other than agricultural R&D (e.g. support for investments through credit policies, income support, input subsidies, etc.), and other factors which go beyond the sphere of agricultural policies (OECD, 1995b). This thesis primarily focuses on evidence of technological changes, R&D and investments in the Polish agricultural sector, which in turn should lead to the formulation of the second research hypothesis.

5.2.1 Evidence of technological changes in Polish agriculture

In Western Europe, consecutive stages of technological progress in agriculture clearly followed one another. As Woś (1998a) has shown, four technological revolutions are discernible. Until the middle of 20th century agriculture was dominated by 'mechanical technologies'; soon after World War II it was dominated by what he calls a 'chemical age', which then paved the way for 'biological progress', and during the last quarter of the century progress stemmed largely from informatics. In contrast, agricultural technological progress in Poland has had a largely integral character (all the stages overlapping), with its advancement depending on the economic power of farms and their ability to absorb 'progress'. Therefore, the better farms have already passed through the stage of mechanisation and are focused on chemical technologies, with prospects for biological advancement soon, while the weaker farms cannot afford even complex mechanisation. Because there are more small farms in Poland that larger ones the whole process has lasted longer and the gains have been smaller (as economies of scale were not fully utilised).

Institutions have also played an important role in technological progress. The mix of institutions involved and their interactions are of vital importance in the process (OECD, 1995b). In the so-called *Induced Development Model* for agriculture, institutional changes constitute a part of innovations (so-called 'institutional innovations') i.e. legal and organisational solutions which serve for more efficient use of technological progress and reinforcement of incentives for faster productivity growth (Wilkin, 1986 after Hayami and Ruttan, 1971). In Poland, technological progress has been traditionally induced mainly by institutional mechanisms - because of distorted markets the role of creating progress was taken over by institutions which were also responsible for its implementation (Woś, 1998b). This, however, did not work very successfully. Agricultural research institutions responsible for R&D were very fragmented, coming under the responsibility of different ministries with no central authority to co-ordinate efforts, establishing very weak links between research and extension (OECD, 1995a).

Besides, in Poland, traditionally priority was given to the supply of machinery for state farms, hence, most machines used later by private farms were designed for large farms and, consequently, were too big for the generally smaller, private, farms (OECD, 1995a). This raises the question as to whether this progress was efficiently utilised. On the other hand, there is some evidence that this technological requirement of scale forced some structural changes in Poland, intensification of production and concentration of production factors (land and other things) (Woś, 1998a). However, new technologies should not only bring about structural changes in the sector but also necessitate cultural and managerial changes (OECD, 1995b). This, however, seems rather moderate in Poland, one of the obvious barriers being the poor access of farmers to higher education.

Examination of the specific indicators of technological progress in Polish farms during the 1990s leads to the conclusion that the most spectacular progress seems to have been made in biotechnology and to a lesser extent in mechanical and chemical technologies (see Table 5-6). Mechanical progress is indicated by more powerful machinery used by individual farms and an increase in overall energy-consumption in agricultural production. Thanks to mechanical progress, chemical progress was also possible, as the former provided tools needed for the application of new chemical inventions. However, chemical progress is a very demanding process as it requires a high level of knowledge and control systems, and as such the indicators provided in Table 5-6 do not reveal the whole truth about such advancement as real indicators of improvement are lacking.

Table 5-6 Selected indicators of technological advancement in Polish individual farms

	1990	1995	1996	1997	1998	1999	2000
				Mechanical technology			
Average nominal motor power in kW in thousands of units	28.7	30.5	30.5	31	31	31	31.6
Use of energy per global agricutlural output tons per billion PLN in constant 1984 prices	12.35	16.36	-	-	-	-	17.52
				Chemical technology			
Consumption of mineral or chemical fertilizers per 1 ha of agricultural land in kg (i)	136	74.6	80.1	80.9	83	81.2	80.7
Consumption of lime fertilizers per 1 ha of agricultural land in kg (i)	147.4	130.3	124.7	137.1	126.7	99.1	90
Supply of pesticides in active substance per 100 ha in of agricultural land in kg (ii)	51.5	47.8	66.3	66.3	60.5	58.8	61.7
				Biotechnology			
Artificial insemination of sows in % of total sows	17.7	35	43	48	44.9	43.5	52.8
Artificial insemination of cows in % of total cows	50.3	55.4	59.7	58.9	54.9	51.7	56.1
Protein feed sales for agriculture in % of harvested crops	8.5	12.5	11	11	10.4	11.6	13.6
Supply of agricutlure with qualified seed in thousand tons (i),(ii)	291.9	179.3	231.5	218.2	234.5	209.3	207.9
				Other			
Ecological farms units (ii)	27	235	236	207	182	513	949

(i) 1990 means here 1989/1990, etc.

(ii) in the whole agriculture

Source: GUS (2001a), Woś (1998a)

Besides, the use of fertilisers and pesticides is highly dependent on policy. In the 1980s the use of chemical sources was much higher because they were subsidised. Then, at the beginning of the 1990s, the subsidies were largely reduced, though more in the case of mineral and chemical fertilisers than lime fertiliser (Woś, 1998a) and hence we can see that the use of the latter declined far less than that of the former (see Table 5-6). All in all, the decline in chemical intensification was an economic problem (on the demand side) rather than a break down in the chemical progress, which appears to have continued.

Biotechnological progress is revealed in crop production in the form of increasing quality of seeds and feeds and, in livestock production, in genetic improvements (Table 5-6).

Other dynamic progress has been in ecological production. This type of farming is based on various types of technological advancement and also requires a high knowledge and education for establishment of cultivation standards, consulting services, inspection and certification systems. During the 1990s the number of ecological farms increased from 27 to almost 1,000 (GUS, 2001a), although total agricultural land devoted to ecological farming did not exceed 0.02% of the total agricultural area (Kadys, 2002).

5.2.2 Investments in physical capital in the agricultural sector

For technical advancement and technological progress, investments in physical (and human) capital are essential. The official data indicate that agricultural investments in physical capital in the 1990s declined considerably. Due to declining incomes and the general crisis in the sector both the rate of investment (ratio of investment to disposable income) and absolute spending on investments in agriculture declined compared to pre-transition levels. Some producers decided to make cost savings by avoiding investments, starting in turn to perceive agricultural business as unprofitable (Szemberg, 2002). The cuts in investments contributed to lower income, which, in turn, resulted in further cuts in investment (as both are highly correlated with each other). This triggered a kind of spiral of‘declining income-investment’ (Woś, 2000b).

At the beginning of the transformation, in 1991, the rate of investment was still quite high, 21.2 (see Table 5-7). This can be attributed to previous investment habits inherited from the pre-transition period, when, for example, in the 1980s the rate of investment was on average 22.5. However, in 1992 the rate declined almost by half and in 1993-1996 stayed at around 10. It subsequently recovered slightly but never regained its level of 20, widely see as optimal for the agricultural sector (Woś, 2000b).[27]

More important than the rate of investment was its absolute amount. The dynamics of real year-on-year investment spending in agriculture were on average about 16 points lower than in the economy as a whole over the analysed period. This difference was large and there came a point in 2000 when real investment in the economy as a whole was 124% higher than in 1990, while in agriculture it was 59.5% lower (Table 5-8). This decline in real investments resulted in an ageing of productive potential. The rate of depreciation (i.e. the ratio of total depreciation to gross physical assets) increased on average from 56.9% in 1996 to 68.2% in 2000 in the private sector.

[27] An even larger drop in incentives for investment in the 1990s was noted in the farms surveyed by IERiGŻ (see Woś, 2000b).

Table 5-7 Income, Investments and a rate of investments in the private farm sector

Years	Gross Nominal Disposible Income in Individual Farms, mln PLN (A)	Nominal Investment Spending in Agricultural Private Sector, mln PLN (B)	Rate of Investment in Agricutlural Private Sector (C=B/A*100)
1991	3088.2	654.9	21.2
1992	4572.9	565.3	12.4
1993	6830.8	678.7	9.9
1994	8503.8	894.9	10.5
1995	12156.3	1263.4	10.4
1996	13331.7	1977.4	14.8
1997	13930.3	2190.4	15.7
1998	13933.9	1893.2	13.6
1999	11286.5	2022.2	17.9
2000	10933.3	1808.3	16.5

Source: Woś (2000b), GUS (2001c) and author's calculations

Agricultural investments carried out by the private sector were generally larger than those in the public sector. In 1993, the private sector invested in nominal terms 43.5 PLN/ha, while the public sector invested only 13.6 PLN/ha. However, in 1994-1997 the dynamics of investments in the public sector had been much higher than that in the private sector. As a result, public investments considerably caught up, averaging 76.1 PLN/ha compared to 94.4 PLN/ha for the private sector. In 1998, there was a sudden weakening of the growth trend in both sectors, though they soon recovered, with investments in 1999-2000 averaging in the public and private sectors 113.5 PLN/ha and 143.1 PLN/ha, respectively (GUS,1998:170 and 2001c:89).

The structure of investments in the agricultural sector also changed over the 1990s. Between 1993-1995 the most important were investments in buildings (on average covering 36.8% of all investment spending), followed by machinery and tools (28%), transport (21.1%) and other investments (14.1%) (GUS, 2001a). However, in 1997-1999 the scale of investments in machinery and tools considerably increased, averaging 36.6% of all investment spending. Only in 2000 did the scale of investments in buildings slightly exceed that of machinery and tools (33.7% versus 32.7%), though investments in machinery remained considerably higher than in the early 1990s (GUS, 2001a).

Table 5-8 Dynamics of investment in agricultural sector comparing to those in the whole economy

Years	Agriculture current prices	Agriculture, constant prices (i)		Economy, constant prices (i)	
	mln PLN	previous year=100	1990=100	previous year=100	1990=100
1990	107.0	57.0	100	89.9	100
1991	695.2	52.4	57	95.9	95.9
1992	600.1	68.9	51	100.4	96.6
1993	720.1	93.8	57.6	102.3	98.7
1994	944.5	104.0	35.8	108.1	106.6
1995	1356.4	111.0	39.6	117.1	124.7
1996	2142.9	129.5	51.3	119.2	148.6
1997	2358.3	96.5	49.5	122.2	181.6
1998	2022.9	83.1	41.1	115.3	209.4
1999	2122.5	102.2	42	105.9	221.8
2000	2078.7	96.4	40.5	101.4	224.9

(i) the data are directly taken from GUS, so no deflators were directly constructed

Source: Woś (2000b), GUS (2000), GUS (2001c)

The breakdown of investments according to farm size is also of interest (see Table 5-9). It is clear from the data that the larger the farm, the more likely it is to invest. Farm size also tends to determine investment priorities. The smallest farms (1-5 ha) preferred to invest in residential buildings (57.1% of all farms in this group) and the development of technical infrastructure (32.9%). Among farms in the medium group (5-15 ha),, most also invested in residential buildings (42.3%) and infrastructure (27.5%), but in addition, modernisation of farm buildings is also important (26.7%). In the group of second medium farms (15-30 ha) priorities start to change, with the second most popular investment, after modernisation of residential building (51%), comes modernisation of farm buildings (46.1%) and third, technical infrastructure (31.8%). The largest farms differ substantially from all the other groups in terms of investment priorities. Modernisation of residential buildings is not the number one priority for this group (it is second, undertaken at 76.8%), with investment in farm buildings (in 95.2% of all largest farms) in top spot. Also very popular are investments in transport (67.2%), technical infrastructure (57.8%), and buying new land (52.4%). As usual, the largest farms are crop producers, so not surprisingly 41.3% of all the largest farms invest in expanding or changing their crop production. In summary, this data clearly reveals that farm size tends to determine incentives and possibilities for investments and, while in all groups of farms below 30 ha the priority is modernisation of residential buildings, incentives or/and possibilities shift for those over 30 ha toward modernisation of production process[28].

[28] It is worth mentioning that farm accounting data from IERiGŻ (which is used later for empirical verification of various research hypotheses) shows similar tendencies in terms of the scale and dynamics of agricultural investments as GUS data. For more details see Woś (2000b).

Table 5-9 Structure of investment spending in individual farms in 2000

	1-5 ha	5-15 ha	15-30 ha	30+ ha
Investment in:	*as a % of all farms in each size group*			
Buying land	1.4	5.1	14.9	**52.4**
Buying tractors	1.1	2.8	6.6	25.2
Buying other machines, tools and means of transport	5.6	13.1	26.6	**67.2**
Construction, restructuring and modernisation of residential buildings	**57.1**	**42.3**	**51**	**76.8**
Construction, restructuring and modernisation of farm buildings	17.3	**26.7**	**46.1**	**95.2**
Expanding and change of activity- plant production	3.5	6.7	18.6	41.3
Expanding and change of activity- livestock production	4.9	14	10.4	24
Development of technical infrastructure	**32.9**	**27.5**	**31.8**	**57.8**

Source: GUS (2001b)

To conclude, it is questionable if the observed level of investment allowed for a positive development of the sector, in the sense that it exceeded the restitution level and allowed for capital accumulation. In all probability, only the largest and the most wealthy ones could have achieved such a level, but the number of such farms may not exceed 600,000 (Woś, 2000b).

5.2.3 Formulating the research hypothesis

The purpose of the analysis so far has not been to thoroughly explore the determinants of TFP, but to develop various expectations for possible TFP changes before the empirical research starts. Hence, the most important point to take from the above overview of the potential main driving forces of productivity growth in the Polish agricultural sector is its distinct lack of optimism. Productivity changes in the sector, even if they were positive in some periods of the 1990s, were not very rapid (especially in the early and late 1990s). Considerable differences in productivity between different groups of farms (depending on their size, specialisation, type of activity, and other characteristics) are also highly likely.

All in all, technological changes and other determinant of TFP were revealed to be rather weak and probably contributed little to factor productivity improvement and thus, to higher competitiveness. Hence, changes in TFP most likely neither reduced the inherited productivity lag nor offset the considerable pressure stemming from unfavourable relative prices and deteriorating sectoral terms of trade (discussed in Section 5.1). One can therefore formulate these possibilities into the form of the following hypothesis:

Hypothesis 2: Changes in total factor productivity (TFP) did not offset the pressure of deteriorating relative prices during the analysed period and hence the competitiveness of the sector declined in the analysed period.

Verification of this hypothesis requires answering the following research questions:

1/ Were the changes in TFP positive or negative during the analysed period (1996-2000)?

2/ If the changes were positive, how strong was the productivity increase? Was it strong enough to offset the deterioration in agricultural relative prices?

3/ If the changes were negative, how strong was the productivity decline, and due to which elements: technological or efficiency change?

5.2.4 Data

The analysis required a rich set of data. As such, it was mostly obtained from an institution with a long tradition in surveying farm accounts and a very well developed methodology, namely the Institute of Agricultural and Food Economics (IERiGŻ) in Warsaw. Data access was provided by the Farm Accounting Department at the IERIGŻ, which has co-ordinated the survey since 1926.

5.2.4.1 Farm sampling

The sample is based on annual bookkeeping by farms dispersed all over Poland. Nevertheless, it is not a representative sample and is based on purposeful sampling. According to IERiGŻ, random and representative sampling was not possible at that time for several reasons: (i) the financial and personnel capacity constraints of the institute; (ii) the deliberately broad set of information collected (which had to limit the number of farms in order to come up with a reasonable size of panel); (iii) dependence upon the goodwill of farm households to participate in the survey (Mech, 1999).

Finally, the IERiGŻ survey covers about 1,200 farms per annum (the number varies from year to year because some farms quit and others are added), and is drawn from all 16 administrative regions in Poland (*voivodships*). As a result of the deliberate choice of farms the sample is biased towards larger farms (see Table 5-10 comparing GUS and our sample of 979 initially drawn farms from the IERiGŻ database).

Table 5-10 Comparison between the records of the IERiGŻ farm sample selected for the study and GUS official data

	TOTAL	1-2 ha	2-5 ha	5-10 ha	10-15 ha	15 ha +
No of holdings						
IERiGŻ (1999)	979	20	106	230	192	431
GUS (2000) (i)	1,881	448	614	448	186	186
Distribution of farms (in%)						
IERiGŻ (1999)	100	2	10.8	23.5	19.6	44
GUS (2000) (i)	100	23.8	32.6	23.8	9.9	9.9
Distribution of Land (in%)						
IERiGŻ (1999)	100	0.1	1.6	6.9	9.6	81.8
GUS (2000) (i)	100	4.8	14.7	23.6	16.6	20.3
Average Land area (ha)						
IERiGŻ (1999)	25.1	1.5	3.6	7.3	12.3	46.7
GUS (2000) (i)	7.2	1.4	3.2	7.1	12.1	29.3

(i) in thousand

Source: IERiGŻ sample and GUS (2001a)

For example, the Central Statistical Office (GUS) indicates that 23.8% of Polish farms are in the land size group between 1-2 ha, and only 9.9% in the group of more than 15 ha, while in the IERiGŻ sample the distribution is reversed, and participation in each group is 2% and 44% respectively. Average farm area in the IERiGŻ sample is also three times larger that the average in the population, 25.1 ha, compared to 7.2 ha. With respect to the largest size category, its average area in the IERiGŻ sample is 46.7 ha, and according to GUS, only 29.3 ha. Similarly with occupied land for this group – it is 81.8% in IERiGŻ and only 40.3% in the real population.

In this situation, important questions are raised as to the consequences of a biased sample for our analyses. Firstly, since the bias is towards larger and more market-oriented farms it seems that the sample is still, or even more, appropriate for this analysis, given its focus on competitiveness, which makes more sense for farms which compete, or in other words, which are involved in commercial activities and are market oriented. Secondly, the data has been commonly used in a lot of studies (including serial publications) and has proved reliable, especially in reflecting the dynamics and structure of problems in overall individual farm sector.

To conclude, one should keep in mind that deficiency of the data affects the research in two ways. Firstly, one has to be wary of generalising outcomes for the whole individual farm sector. Secondly, regional analyses are ruled out (originally planned), because the sample is even more unrepresentative for voivodships, especially after 1999, as the sample was designed long before the local government reform, and was based on the old 49 voivodship division. However, having taken this on board, the problem can be put aside in further analysis in this work.

5.2.4.2 The data extraction process

Data are collected in the form of annual bookkeeping records (the selected farms fill in the book all year). The data is then collected and transferred from the books to more manageable formats designed by IERiGŻ, before being tested for correctness and published in the form of several indicators and in articles. Generally, the data are coded first into an ASCII code and then transferred into a computer, R-11. Finally, the data can be available in Excel files, which this author used for further calculations in SPSS, Eviews, and DEAP programs.

5.2.4.3 Product and input coverage

For the analysis of productivity changes, output and input data were aggregated into one category of output and four categories of inputs. OUTPUT is expressed as a value of total output and comes from aggregation of 10 basic products selected from the data set: wheat, rye, barley, rape seed, sugar beet, potatoes, milk, beef, pork, poultry as well as of two categories of other crop and other livestock products.

Inputs are aggregated into four categories: LAND, expressed as utilised agricultural area in hectares; LABOUR, recalculated into annual work units (AWU[29]), CAPITAL, approximated by the sum of capital depreciation[30] (i.e. the reduction in the value of assets arising from wear and tear) and interest paid from investment credits (i.e. forgone return on financial capital) as suggested by Corden (1984) and Griliches (1960). The final category, INTERMEDIATES, includes the following intermediate inputs: seeds, fertilisers, minerals, chemicals, feeds, fuel and other energies, expressed in values.

All the variables, before aggregation, were converted into real terms, i.e. all the nominal values of variables were deflated by appropriate price indices to take account of substantial inflation, which persisted during the analysed period. They were then transformed into implicit quantity indices (with 1996 as the base year). All the price and volume indices are presented in Appendix 5-1.

Since the information on prices was not directly available from the database, the price indices were constructed based on the data from the Polish Central Statistical

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[29] AWU is a commonly used variable representing labour input. It is expressed in full-time working units per annum, instead of hours. It recalculates the hours into the equivalent of full-time workers. For example, AWU equal 1 means that whatever the number of people were working on the farm, they all together worked as much as one full-time worker, which is 8 hours per working day over the whole calendar year (equalling 2,200 hours per year). For more methodological details on this and other variables see Appendix 6-1, Table A.6-3.

[30] Depreciation was provided in original database. It was calculated by IERiGŻ in linear way according to the current accounting standards.

Office (GUS, 2001a). Each product's OUTPUT value during each year was deflated by the appropriate procurement price index of the given year. A similar method was used to aggregate inputs, though input price indices were used. Depreciation was deflated by a price index built as a weighted average of price indices of fixed assets (buildings for animals, machinery and tools, breeding livestock), where the weights were attributed according to the importance of the particular asset in total fixed assets. The second component of capital input - value of interest paid from credits - were deflated by the index of the nominal interest rate (the lowest charged by commercial banks to private borrowers at that time to take account of preferential credits to farmers). For all intermediates the existing indices from GUS (2001a) were adopted. Labour and land were expressed in quantities, so they did not require a deflation procedure. All the implicit volumes and price indices are presented in Appendix 5-1.

5.2.4.4 Characteristics of the final sample

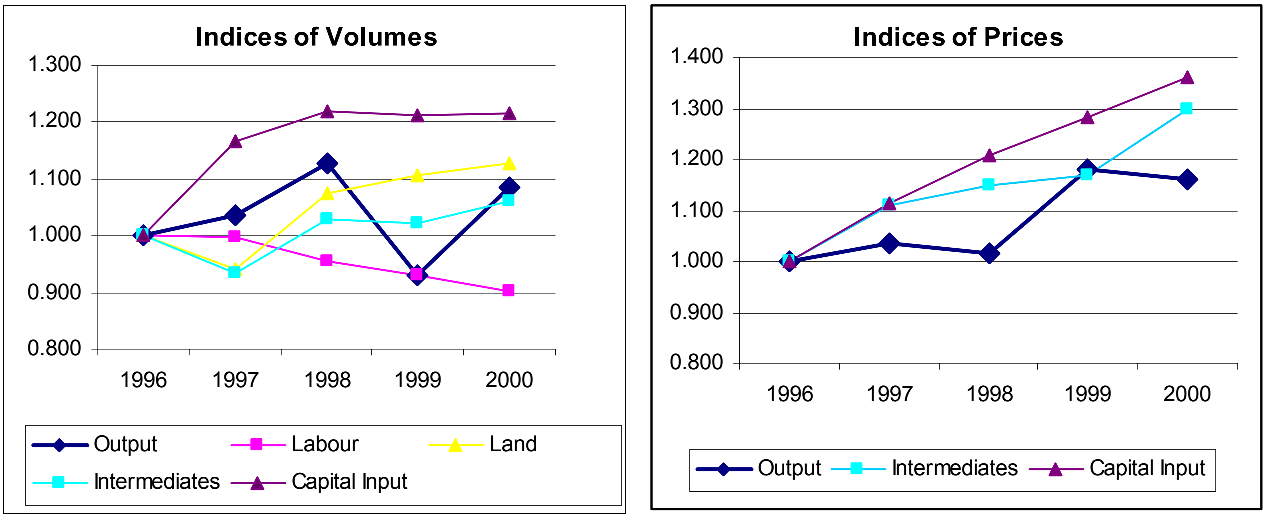
From the original sample of 979 farms, firstly the balanced sample (i.e. the same farms repeated in all the years) was drawn, consisting of 914 each year. However, it had to be further reduced to 811 farms due to methodological requirements, i.e. a resampling procedure had to becarried out in order to deal with outliers and assure stability of the results (for more details see Box 5-1).

The real output in the sample increased after 1996 for two consecutive years, and then it fell to its lowest point (down 3.5% from the previous year's level) due to an unfavourable mix of poor weather and economic conditions, before recovering again in 2000 (see Figure 5-2). On average, it amounted at 60,000 zlotys, and in 2000 its level was 8.6% higher than in 1996 (see Table 5-11).

The use of labour in the sampled farms gradually declined during the analysed period. In 1996, the average number of full-time workers (or annual work units) was above 2, but in 2000, it had declined by 9.7% (to 1.88). Most probably this was a result of changes in the overall production structure which favoured capital over labour. There was a decline in labour-intensive food production, such as that of potatoes (volume of production declined by 32.9% and number of farms by 3.8%), sugar beet and milk (the number of farms dropped by 69% and 9.4% respectively) and at the same time a considerable increase in capital-intensive activities. Production of poultry increased by 21.5%, wheat by 31.8% and rape seed by 91.1% (see Appendix 5-1, Table A. 5-1).

This decline in labour input at a time of over-employment in agriculture was also visible in the Polish agricultural sector overall (the number of people employed in the agricultural private sector declined by 16,000 between 1996 and 2000, GUS 2001a), which indicates a possible improvement in productivity. According to Józwiak (2002), this can be explained by the behaviour of the largest farms, which invested mostly in less labour- and more capital- intensive production, for example big broiler farms. At the same time, smaller farms, which faced a lack of capital, tried to maintain their production by utilising their own land and labour as efficiently as possible.

Figure 5-2 Development of Implicit Volumes and Prices, 1996-2000



Source: Author's own calculations

In contrast, the average agricultural farm size increased in our sample by 12.6% (from 21.35 ha in 1996 to 24.04 ha in 2000). According to GUS (2001a), the average size of individual farms in Poland also increased, but only by 3% between 1996-2000.

Another characteristic of our sample is the overall increased volume of fertilisers and chemicals. Their usage increased in our sample by 27% and 67.2%, respectively, during the analysed period (see Table 5-11). Fertilisers and chemicals contributed the most to the overall 6% increase in intermediates. Feeds increased by only 2.7% and even declined if expressed in value per unit of livestock production. Of all intermediates, only seeds declined, gradually by 14.2% over the five years.

While the value of capital assets (buildings, machinery and breeding livestock) decreased moderately (4.9%), the use of capital inputs (expressed by the sum of depreciation and interest) increased considerably (by 25.8%). About three quarters of this increase was due to higher interest paid by farmers for their credits, which indicates, mainly, the increasing real costs of credit. The remaining quarter of total increases was the result of increased depreciation, which indicates that farms were using more capital.

Table 5-11 Characteristics of the sample (in real terms)

1996-2000	*Units*	*Mean*	*Std.Dev.*	*Min.*	*Max.*
Output	('000 PLN)*	**60.01**	65.51	1.53	724.27
Labour	(annual working units)**	**2.00**	1.02	0.22	8.02
Land	(hectares)	**22.43**	27.26	1.20	265.10
Intermediates	('000 PLN)*	**25.88**	31.82	1.40	351.19
seeds	('000 PLN)*	**2.52**	3.36	0.03	34.02
fertilisers	('000 PLN)*	**3.75**	6.61	0.02	81.32
chemicals	('000 PLN)*	**1.74**	4.58	0.01	70.12
feeds	('000 PLN)*	**17.36**	23.48	0.05	283.96
fuels	('000 PLN)*	**0.76**	0.99	0.01	23.71
Capital (assets)	('000 PLN)*	**75.75**	89.14	2.22	831.34
building	('000 PLN)*	**29.56**	41.66	0.05	445.25
machinery	('000 PLN)*	**7.67**	8.65	0.16	104.56
livestock	('000 PLN)*	**39.01**	50.80	0.28	467.79
Capital inputs (services)	('000 PLN)*	**8.94**	10.39	0.31	133.16
interests	('000 PLN)*	**1.95**	4.50	0.00	76.51
depreciation	('000 PLN)*	**7.66**	7.81	0.31	76.09

* all values are expressed in constant 1996 prices
** total labour hours transformed by using the ratio of 2200 hours per man year

years	**1996**	**1997**	**1998**	**1999**	**2000**
Output	57.94	59.92	65.38	53.89	62.90
Labour	2.09	2.08	1.99	1.94	1.88
Land	21.35	20.10	22.98	23.66	24.04
Intermediates	25.65	23.95	26.36	26.23	27.20
seeds	2.79	2.54	2.44	2.43	2.40
fertilisers	3.30	3.67	3.78	3.80	4.20
chemicals	1.29	1.54	1.76	1.97	2.16
feeds	17.69	15.56	17.84	17.54	18.18
fuels	0.78	0.81	0.82	0.75	0.64
Capital (assets)	80.73	69.31	77.47	74.49	76.76
building	32.21	27.51	31.12	29.62	27.33
machinery	8.07	7.57	7.76	7.20	7.72
livestock	40.80	34.61	39.02	38.20	42.43
Capital inputs (services)	7.37	9.57	9.25	9.26	9.27
interests	1.25	2.04	2.28	2.06	2.07
depreciation	6.58	8.22	7.71	7.88	7.91

Indices of change (1996=1.000)

years	**1996**	**1997**	**1998**	**1999**	**2000**
Output	1.000	1.034	1.128	0.930	1.086
Labour	1.000	0.997	0.955	0.931	0.903
Land	1.000	0.941	1.076	1.108	1.126
Intermediates	1.000	0.934	1.028	1.023	1.060
seeds	1.000	0.908	0.875	0.871	0.858
fertilisers	1.000	1.110	1.143	1.151	1.270
chemicals	1.000	1.191	1.360	1.523	1.672
feeds	1.000	0.880	1.009	0.992	1.027
fuels	1.000	1.040	1.054	0.970	0.825
Capital (assets)	1.000	0.859	0.960	0.923	0.951
building	1.000	0.854	0.966	0.919	0.848
machinery	1.000	0.938	0.962	0.892	0.956
livestock	1.000	0.848	0.956	0.936	1.040
Capital inputs (services)	1.000	1.299	1.255	1.256	1.258
interests	1.000	1.635	1.825	1.645	1.654
depreciation	1.000	1.248	1.171	1.198	1.202

Source: Author's own calculations

5.2.5 Results of TFP changes

Before presenting the final results, two remarks should be made. Firstly, the results were tested for stability, and after the resampling procedure proved to be robust (see Box 5-1). Secondly, they indicate a high variability in productivity from one year to the next (see Appendix 5-2, Table A. 5-4). This, however, is what we expected because agricultural production is subject to large variations resulting from factors beyond human control, for example, the weather. Hence, in order to eliminate accidental observations and present overall trends, all the results on productivity and efficiency changes will be presented as annual averages over 1996-2000. Such an approach is also justifiable because of the character of presented variables, such as technological progress, which by definition is a long-term variable and even a five-year period is not very long to be able to draw firm conclusions.

Total factor productivity growth and its two main components are analysed here: technological change (which accounts for a shift of the production possibility frontier over time) and changes in technical efficiency, where the latter was further broken down into changes in 'pure' technical efficiency (efficiency changes under CRS) and changes in scale efficiency (efficiency changes under VRS). The methodology was detailed in Chapter 4 and the empirical results are presented in Table 5-12.

5.2.5.1 Productivity changes and farm size

Productivity results vary substantially between different groups of farms, depending on their size, type of activity and specialisation. As for size groups, the larger the farm, the higher the technological progress, which means that in groups of larger farms the leaders (efficient farms) can improve their technologies quicker than their counterparts in groups of smaller farms. This is what one might expect, as larger farms are usually more likely to be technologically advanced for several reasons. Firstly, as they are generally better off than smaller farms they have easier access to capital (credits, etc.) and can invest more in new technologies. Secondly, they usually have more capital-intensive and less labour-intensive production techniques, which form *embodied* technological change. Thirdly, they may also have higher investment incentives due to the forward-looking approach to their business, etc. The technological progress in the group of the largest farms (over 30 ha) was 2%, while in the two groups of smaller farms it was 1.6% (15-30 ha) and 1.3% (5-15 ha) – see Table 5-12.

Box 5-1 Testing for stability of the results

The Data Envelopment Analysis (DEA) method of estimating productivity changes is very sensitive to data errors and outliers (Bauer, et al.,1998), therefore it requires application of some additional techniques assessing the robustness and stability of results. The most appropriate technique is called *resampling*, which calculates an empirical distribution of an original sample based on its various sub-samples. There are various *resampling* methods, which most generally divide into two groups. First is a sampling with replacement of observations (i.e. bootstrap), which allows for approximating the sampling distribution of the DEA estimators by Monte Carlo simulation, where repeated resamples of the observed data produce repeated estimates. Confidence intervals obtained this way allow for assessing if results are statistically significant or not. Second is sampling without replacement of observations (i.e. jack knife), which cuts off the selected observations and this way creates new sub-samples. This method allows for a comparison of the DEA efficiency estimates obtained from the whole sample with those from the reduced sub-samples, and if they are similar it proves the stability of the results. If not, resampling is continued until the results from two consecutive sub-samples are highly correlated. In the case of this thesis, the bootstrapping procedure was unmanageable due to the very large original sample (914 farms over 5 years) as it would require a highly powerful hardware working constantly for more than a month. Therefore, the jacknife type of resampling was applied. In practice, it required generating the DEA results three times: first for the whole sample of 914 farms, then for the resampled sample with most efficient farms deleted (811 farms were left), and again for the second time resampled sample (686 farms were left). Then the correlations between the efficiency estimates in all three samples were compared:

Spearman Correlations Sig. (1-tailed)	1st resampling (811 farms)	2nd resampling (624 farms)
Full sample (914 farms)	0.056**	-
1st resampling (811 farms)	1**	0.959**

** Correlation is significant at the .01 level (1-tailed)

Low correlation between the results obtained from the full sample and 1st sub-sample indicate the existence of some outliers in the former, although the high correlation between the 1st and the 2nd sub-samples indicates that stability was gained, and 811 farms create the final sample.

Table 5-12 Decomposition of the Malmquist TFP index, annual percentage changes over 1996-2000[31]

1996-2000	Technological change (iii)	Technical Efficiency change: Total (iv)	Technical Efficiency change: "Pure" Technical Efficiency (v)	Technical Efficiency change: Scale Efficiency (vi)	TFP change (vii)
			Land groups		
1-5 ha	-2.4%	**2.4%**	1.0%	**1.4%**	0.0%
5-15 ha	1.3%	-2.7%	-2.4%	-0.3%	-1.4%
15-30 ha	1.6%	-1.5%	-1.4%	-0.1%	**0.1%**
30+	**2.0%**	-3.4%	-3.0%	-0.4%	-1.5%
			Activities		
Crop	**2.1%**	-1.8%	-3.0%	**1.2%**	**0.3%**
Livestock	1.1%	-2.2%	-2.1%	0.0%	-1.0%
Mixed	0.5%	-2.7%	-2.6%	-0.1%	-2.2%
			Specialization		
Single type of activity (i)	1.8%	-3.2%	-2.8%	-0.4%	-1.5%
Distinguishing type of activity	**2.0%**	-0.8%	-0.9%	0.1%	**1.1%**
Various and changabe types of activities (ii)	-1.5%	**0.3%**	0.3%	0.0%	-1.1%

(i) For example milk production
(ii) In this group are farms with various types of activities and those which were changing the types
(iii) Sift in the production frontier (frontier is made of the best farms in each group)
(iv) = (v) + (vi) and (vii) = (iii)+(iv)

Source: Author's own calculations

In contrast, the smallest farms (1-5 ha) noted technological regress (2.3% annually), perhaps indicating that even the best farms (those which create technological progress) in this group could not afford the sufficient (i.e. enough to lead to positive growth effects) investments in technology. Most probably, this was due to a squeeze in profitability of their production and declining incomes which restrained them from investing. However, these small farms were able to offset the deterioration in technological change by increasing their scale efficiency (by 1.4% annually). The technological decline and overall technical efficiency growth (by 2.4%) means that this group became more consolidated in the sense that while the best farms become worse on average over those five years, the previously weaker farms did catch-up in terms of factor productivity with the better ones in this group.

The fact that the catch-up effect was due to an increase in scale efficiency and not 'pure' technical efficiency (Table 5-12) can be logically explained by the fact that in the short- to medium-term it is easier for small farms to adjust their scale of production towards more optimal (i.e. enlarge the farm), rather than more advanced

[31] Geometrical averages

technology (which requires not only financial capital but also knowledge) and/or improvements to farm management (which also requires sufficient education).

Surprisingly, in the group of the largest farms (above 30 ha), despite the fact that technological progress was the highest there, there was also the highest decline in technical (in)efficiency (by 3.4%) which overweighed the progress made, and resulted in the highest productivity drop (by 1.5%) of all the size groups (see Table 5-12). Similarly, in the middle group (5-15 ha), despite the positive technological change (1.3%), productivity declined (by 1.4%) due to a technical efficiency fall (by 2.7%). In both groups, considerable decline in technical efficiency was not attributed to a drop in scale efficiency but stemmed from 'pure' technical inefficiency. Hence, the results indicate the existence of large heterogeneity among the farms within those groups, which results from the fact that while the best farms improve quickly and move the production frontier upwards, the rest of the farms do not catch-up with them (cannot increase their efficiency more than proportionally to the shift in the frontier).

Another feature of this group is that the changes in efficiency of scale were less important (0.4% decline) than changes in 'pure' technical efficiency (a 3% decline). This generally suggests that it was not size-related but management-related problems that occurred amongst these farms. Another possible explanation concerns investments undertaken by the farms (capital intensity increased in the group above 30 ha, see Table 5-13 and Appendix 5-2, Table A. 5-5). Bought machinery could not be fully utilised due to lack of owner knowledge (e.g. some of their functions were not used) or improper size (the machine's capacity was unadjusted to the scope of production), or due to obsolete capital. There is evidence of negative effects of over-capitalisation and ageing of capital on the efficiency of Polish farms (Latruffe, et al. 2003).

5.2.5.2 Productivity changes and type of activity

There were also considerable differences in TFP patterns between groups of different activities (Table 5-12). Only the arable farms were able to slightly improve their productivity (by 0.3%), while livestock and mixed farms experienced a considerable fall in productivity (1.0% and 2.2% respectively) over the analysed period. In crop farms this was mainly driven by a high technological progress (2.1%), which may be explained in the following ways. In crop production, Poland appears to have had a higher initial technological lag than in livestock production and the initial inefficiency was also larger in arable farms than in livestock ones. Therefore, an improvement in the technology of crop production was more desirable and hence was able to trigger investments in technology, which could bring about a quicker advancement (higher marginal effect of those investments) than in livestock farms. Besides, the crop producers benefited from a more favourable intervention policy than livestock producers over the analysed period. This was visible, for example in higher (by a few points percentage) producer subsidy equivalents (PSE) for crop products than for livestock during this period (see Appendix 5-2, Table A.5-6). Another hypothetical explanation is that the arable farms, to a larger extent than livestock farms, benefited from advancement in intermediate inputs, with better quality fertilisers, certified seeds, chemicals, pesticides, etc becoming more common. Lastly, this positive technological progress could be explained by various indirect effects, as, for example, the fact that they were on average, larger and better-off farms, and probably as such had better access to preferential investment credits and hence invested more at that time, etc.

However, technological progress in arable farms was accompanied by a decline in technical efficiency (1.8%), which was due to decline in 'pure' technical efficiency (3.0%) and this despite a considerable improvement in scale efficiency (1.2%). The latter was most probably due to the fact that the farms, while operating at that time under increasing returns to scale (Latruffe, et al. 2003), were able to consolidate their land – the average size of farms in this group increased by 6 ha over the five years (see Appendix 5-2, Table A. 5-7). However, the decline in 'pure' technical efficiency might indicate managerial problems. According to Latruffe at al. (2003), these problems are related to the fact that arable farms in Poland usually hire more external labour and rely less on family labour (similar as in the case of large farms) and again the reliance on family labour proved more beneficial to the efficiency of farms as 'pure' technical efficiency in arable farms declined much more than in livestock farms. It is important to note, that arable farms proved quite heterogeneous, i.e. while the best farms in this group grow quickly and shift the production frontier (causing significant technological progress), the other farms cannot catch-up with them as they cannot improve their efficiency, especially that connected to bad management practices and maybe also with principle-agent dilemmas.

Livestock and mixed farms also experienced a positive technological change (led as always by the best farms in the groups), although both also experienced a decline in technical efficiencies (by 2.2% and 2.7% respectively). This means that the majority of the farms were not able to catch-up with technological advancement dictated by the leaders, neither by increasing their efficiency of scale, nor technical efficiency, hence TFP in both these activity groups declined. A higher decline was in mixed farms than in livestock farms, probably due to differences in level of specialisation (this is discussed in the next section).

5.2.5.3 Productivity changes and specialisation[32]

Patterns of TFP changes also depended on farm specialisation. The best performing farms were those with two or three stable types of activity - only in this group did productivity increase (1.1.%). In contrast, groups of farms which had a single type of activity or various and changeable types of activities experienced declines in productivity of 1.5% and 1.1%, respectively. The success of the group with two or three stable activities was due to high technological progress (2.0%), accompanied by a small drop in technical efficiency performance (0.8%). This means that the shift in technology (dictated by leaders) was followed by the rest of farms in the group, i.e. they were able to improve their efficiency and technology more than proportionally and move closer to the production frontier (and to the leaders). This may possibly be explained by the fact that this group, although specialised in one production, also however maintained other activities, so if one activity became less profitable they could benefit from the others. As such, the success of the group could be probably attributed to good risk management on-farm risk diversification.

Surprisingly, the group with single activity, although it had similar technological progress (1.8%) as the former group, was so diverse that while leaders were shifting the frontier upwards, the rest of the farms lagged increasingly behind them. As a result, overall technical efficiency decreased substantially (3.2%) and productivity declined by half of this (1.5%). This may be explained, for example, as follows: if one activity was profitable over the analysed period, then the farm specialising in this activity had resources to invest in better technology of production and, hence, grew quickly and boosted technological progress. However, farms with activity that became unprofitable in that time, underwent serious problems because they needed time and resources to change or diversify their single production. Hence, at first they had to cover losses and only later invest in change of the activity type, and as such were not able to catch-up with profitable and well-off farms. Generally, their failure was due to the large risk of single specialisation. It would seem that the profitability of different activities divided the group into profitable leaders pooling the progress and unprofitable followers struggling with profitability and hence unable to catch-up with their more fortunate counterparts. For each specialisation group it would be interesting to examine (in future studies) which single activities were building and pushing the frontier upwards and, which was in a catch-up position. This explanation appears consistent with the general observation of high instability of farm markets over the period, including ineffective stabilisation policy.

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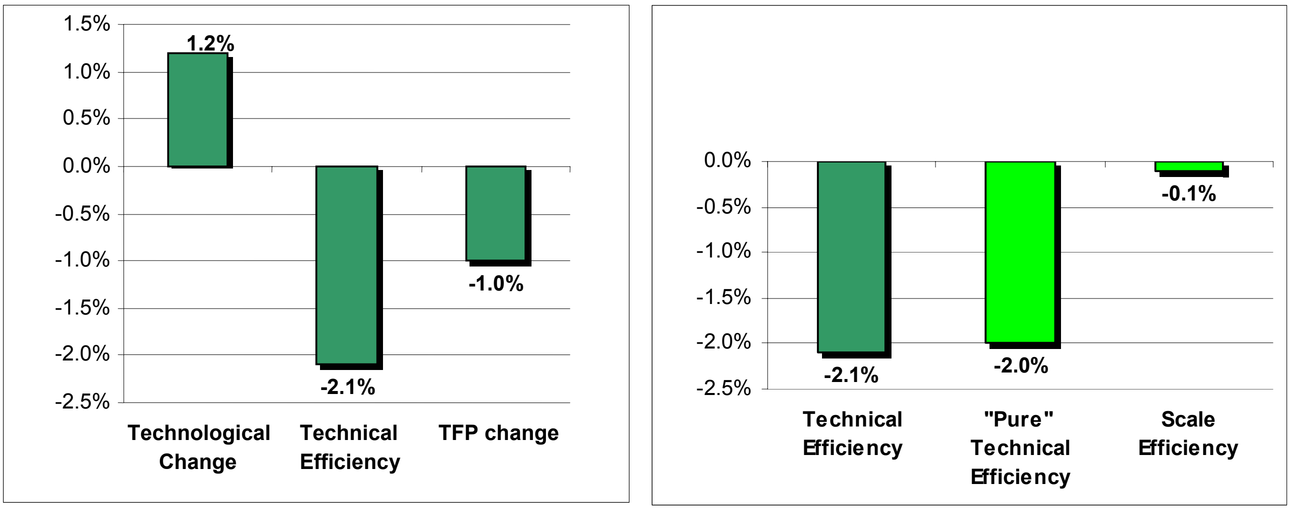
[32] The groups of specialisation were built based on definitions of types of activities by IERiGŻ. The basic several types of activities were aggregated into three specialisation groups in order to assure a sufficient size of the groups for analysis and to assure different stages of specialisation. Hence, comparing IERiGŻ's names here, single activity means 'jednokierunkowe' (in Polish); distinguishing type gathers 'dwukierunkowe', 'trójkierunkowe', and 'z wyróżniającą się gałęzią główną'; various and changeable and 'wielostronne', those which were changing between all of the categories between 1996-2000.

A different situation occurred in the case of the group of farms with various and changeable activities, which experienced negative technological change (1.5%). One conceivable explanation may be that even the best farms lacked a minimum level of specialisation, so they had no incentives to sufficiently invest in a certain technology, because they probably could not find one technology which could serve all the types of production they had. There was a slightly positive increase in technical efficiency (0.3%) in this group, which indicates that while the leaders failed and pushed the frontier inwards, the rest of the farms were able to catch-up with them and the group probably became more homogenous.

5.2.5.4 Overall productivity changes

All the findings on productivity decomposition discussed above can be summarised in the following picture (see Figure 5-3). Technological progress over the analysed period, (defined as the Malmquist decomposition methodology) turned out to be rather weak (1.2% annually) and by far outweighed by the decline in technical efficiency (-2.1% annually), which declined mainly due to a fall in ‘pure’ technical efficiency (-2%), rather than scale efficiency (as the latter was negligible, -0.1%). As a result, Polish farms experienced an annual average decline in total factor productivity of 1% between 1996-2000.

Figure 5-3 Change in Total Factor Productivity and its decomposition over 1996-2000



It is clear that this fall in productivity was due to lack of good management and a technical lag rather than scale inefficiency. This does not, however, mean that the latter should not be improved. On the contrary, it should be improved as the arablefarms operate under IRS and livestock farm under DRS (Latruffe, et al. 2003), so both can still adjust their size to that which is optimal.

As all initial research questions have now been addressed, the thesis can now move onto verification of its underlying hypothesis. The earlier outlined suspicion that changes in total factor productivity may have been weak, but positive, turned out to be incorrect, as actual changes were negative. Consequently, the hypothesis that changes in TFP did not offset the changes in relative prices during 1996-2000 was accepted.

To conclude, the outlook was gloomier than had been initially thought, as although slow but positive TFP growth had been expected, it turned out to be negative. Thus, productivity not only did not offset pressures on the farm sector but even contributed to its decline. This TFP fall was caused mainly by a drop in technical efficiency. At the same time technological progress was evident but slow. So the verification statement is as follows.

Hypothesis 2 is accepted, since the total factor productivity of the Polish farm sector declined in the second half of the 1990s and, therefore, not only did not offset the adverse effects of the changes in relative prices but even amplified them, hence, competitiveness of the sector declined.

5.3 Changes in techniques of production (factor proportions)

According to our theoretical model (see Chapter 4), we would normally at this point have to calculate deviations of observed factor proportions from the optimal ones in order to find out if competitiveness could be sustained due to improved factor allocation[33]. However, after verification of the two first hypotheses we are practically exempted from this exercise because we can be absolutely sure that changes in factor proportions, which are very limited in agricultural production (as explained earlier), cannot possibly rescue deteriorating competitiveness in the face of strong and fundamental pressures exerting downward pressure on it. As such, instead of dealing with this negligible factor the focus (in the next chapter) moves onto on the most important area, namely total factor productivity and how to find out why it 'did not work' at that time. Thus, the following section makes only a few observations on the overall changes in factor proportions in our sample.

The technique of production in this theoretical model is defined as a combination of inputs (physical and human) needed for production of certain products. Generally, based on different combinations of production factors, we can divide the techniques into capital-intensive, labour-intensive, land-intensive, etc. (Józwiak, 2002).

[33] Please note, that in original approach by Nishimizu and Page (1986) this element is residual, but in this theoretical model, competitiveness is the residual, so factor proportions are endogenous, but still negligible, as also showed in the original study.

Not surprisingly, if we analyse farms of different sizes the most labour intensive techniques are used in the smallest farms. The reliance on labour decreases with farm size, while the importance of capital increases - the labour/capital ratio decreases from an average 0.55 in farms 1-5 ha, to 0.13 in farms above 30 ha, as indicated in Table 5-13. As for land-intensive techniques, they obviously increase with farm size, and the land/capital ratio is on average 1.6 times higher in the largest, than in the smallest farms (on average it is 3.03 and 1.85 respectively). However, in all the groups of farms the importance of capital-intensive techniques crowds out the importance of those which are labour- and land-intensive over time (both labour/capital and land/capital ratios decline in all groups over 1996-2000). This process is quicker in the larger, than in the smaller farms where, for example, the labour/capital ratio declined between 1996 and 2000 by 14% in farms 1-5 ha against a 29% decline in the group of the largest farms.

Among various activities, the most labour-intensive was on average livestock production, with an average labour/capital ratio of 0.29, though in all the groups the exchange of labour for capital occurred very quickly and ranged from 38% in crop farms to 22% in the livestock farms (calculated as the change in the labour/capital ratio between 1996-2000). Land intensity, not surprisingly, was greatest for arable farms (an average land/capital ratio of 2.71), but generally declined in all activity groups over the analysed period.

As for specialisations, it is difficult to say much unambiguously about factor proportions, though generally it seems that the most capital intensive farms were those with the most specialised single activities, as they had the smallest average labour/capital and land/capital ratios. Other specialisations were very similar to each other in this respect. Common to both was increasing capital-intensity over time.

Table 5-13 Changes in factor proportions in different groups of farms size, activity and specialisation

	Labour /Capital	Land /Capital	Labour /Capital	Land /Capital	Labour /Capital	Land /Capital
	1-5 ha		Crop		Single activity	
1996	0.63	2.04	0.21	3.08	0.25	2.75
1997	0.51	1.67	0.15	2.41	0.19	1.96
1998	0.55	1.84	0.14	2.62	0.19	2.38
1999	0.53	1.82	0.13	2.65	0.19	2.45
2000	0.54	1.86	0.13	2.77	0.18	2.47
	5-15 ha		Livestock		Distinguishing activity	
1996	0.45	2.45	0.35	2.76	0.37	2.95
1997	0.36	2.05	0.28	2.05	0.29	2.28
1998	0.37	2.24	0.29	2.43	0.31	2.65
1999	0.35	2.24	0.28	2.50	0.28	2.59
2000	0.34	2.28	0.27	2.54	0.28	2.71
	15-30 ha		Mixed		Various activities	
1996	0.29	2.58	0.18	2.89	0.32	2.82
1997	0.22	2.03	0.13	1.85	0.26	2.23
1998	0.24	2.21	0.12	2.37	0.25	2.43
1999	0.24	2.27	0.13	2.45	0.25	2.55
2000	0.24	2.34	0.12	2.43	0.26	2.89
	30+ ha					
1996	0.17	3.57				
1997	0.13	2.74				
1998	0.12	2.92				
1999	0.12	2.93				
2000	0.12	3.00				

Source: Author's calculations based on the IERiGŻ sample

5.4 Conclusions

- In this chapter we have accepted two hypotheses: one concerning the determinants of decline in relative (output–input) prices in the agricultural sector over the 1990s, the other concerning the responsiveness of total factor productivity of producers aimed at sustaining the sector's competitiveness in the second half of the 1990s. The verification of these two hypotheses together allows us to conclude that overall competitiveness of the farm sector in Poland declined between 1996-2000 because the fall in relative prices was amplified by declining world commodity prices, which had a high level of penetration in the domestic agricultural sector, while at the same time, total factor productivity did not respond positively to these forces.
- Generally speaking, the results indicate a more gloomy picture than what one initially would have expected. Initially we believed that productivity in the farm sector had increased during the analysed period, though only slightly. And in turn, therefore, the pressure of relative prices in the sector (stemming to a large extent from macroeconomic and external pressure) would be to some extent compensated by increased productivity, though we did anticipate the rather weak response of increasing productivity not offsetting such price pressure. The reality turned out to be worse than expectated and the research indicates declining productivity and, therefore, a fall in competitiveness over the period 1996-2000.
- The challenge for future policy results from the fact that a further appreciation of the zloty can be expected to coincide with liberalisation. As such, unless the world price increases considerably (which is unlikely) one can expect further pressure on a decline in domestic real output prices. Productivity would then have to quickly recover to prevent a further decline in sector competitiveness.
- Productivity has to be improved, not only due to relative price pressure, because this is a necessary condition for the sector anyway, due to the fact that it lags behind the other sectors in the economy (to mention only labour productivity and a general technological lag). As such, in order for agriculture to positively contribute to the overall well-being of the country, it has to catch up with productivity.
- However, technological progress itself does not assure positive productivity growth, as we can see from the research. It turned out that technological progress must be accompanied by an improvement in efficiency in order to boost factor productivity. This study has little room for a deeper analyses of efficiency itself, although from previous studies based on a similar sample to IERiGŻ's, in which this author participated (see Latruffe, et al., 2003), the main obstacles to efficiency improvement were: the fact that the farms are too small and overcapitalised, and that generally low education of farm managers (owners) does not allow for efficient management practices.

- Last but not least, although the overall picture is not very optimistic it was visible that farms differ considerably even within certain groups. There were strong leaders (farms quickly developing and advancing in technology) especially in the groups of larger , crop oriented farms and those with two or three activities forming a type of specialisation. Such leading farms were able to push the productivity of their whole group onto a growth path. While in the groups of the smallest farms, mixed and with various and changeable activities, the deteriorating situation of the leaders usually meant that the whole group experienced a decline in productivity.

The changes in TFP analysed here have only started a discussion on various possible determinants of productivity. However, the next chapter analyses in detail all the determinants and verifies their significance, importance and direction in influencing TFP.

Appendix 5-1: Data characteristics

Table A. 5-1 Production structure

years	1996	1997	1998	1999	2000
('000 PLN)*		Mean			
Wheat	9.87	10.44	12.05	13.80	13.01
Rye	3.18	3.53	3.57	3.17	2.86
Barley	5.71	7.05	6.42	5.36	4.61
Potatoes	4.85	3.36	3.55	2.40	3.25
Sugar beet	9.46	10.98	12.64	12.79	14.05
Rape seed	7.73	11.67	14.32	13.63	14.77
Other crops	10.59	11.38	11.55	12.07	12.15
Beef (catle)	4.55	4.87	4.71	4.96	5.20
Milk &milk products	7.57	8.74	9.43	9.55	10.25
Pork	13.43	14.11	17.65	18.03	16.78
Poultry	1.53	1.25	2.05	1.91	1.86
Other livestocks	1.31	1.22	1.10	1.19	0.95
TOTAL OUTPUT	57.94	59.92	65.38	53.89	62.90
* all values are expressed in constant 1996 prices					
Indices of change in mean production (1996=1.000)					
years	1996	1997	1998	1999	2000
Wheat	1.000	1.057	1.221	1.397	1.318
Rye	1.000	1.109	1.125	0.999	0.900
Barley	1.000	1.236	1.125	0.939	0.808
Potatoes	1.000	0.693	0.733	0.495	0.671
Sugar beet	1.000	1.160	1.335	1.352	1.485
Rape seed	1.000	1.510	1.853	1.763	1.911
Other crops	1.000	1.075	1.091	1.140	1.148
Beef (catle)	1.000	1.070	1.035	1.090	1.145
Milk &milk products	1.000	1.155	1.247	1.263	1.355
Pork	1.000	1.051	1.314	1.342	1.250
Poultry	1.000	0.818	1.335	1.243	1.215
Other livestocks	1.000	0.935	0.845	0.908	0.730
TOTAL OUTPUT	1.000	1.034	1.128	0.930	1.086
years	1996	1997	1998	1999	2000
	Number of farms				
Wheat	690	688	677	675	658
Rye	490	465	462	430	391
Barley	462	474	474	458	469
Potatoes	782	775	769	760	752
Sugar beet	255	227	196	172	158
Rape seed	55	56	80	119	93
Other crops	809	808	811	810	811
Beef (catle)	736	727	707	683	663
Milk &milk products	728	709	697	679	660
Pork	727	700	693	685	659
Poultry	747	735	719	701	688
Other livestocks	787	779	766	760	749
TOTAL OUTPUT	811	811	811	811	811
Indices of change in number of farms (1006=1.000)					
years	1996	1997	1998	1999	2000
Wheat	1.000	0.997	0.981	0.978	0.954
Rye	1.000	0.949	0.943	0.878	0.798
Barley	1.000	1.026	1.026	0.991	1.015
Potatoes	1.000	0.991	0.983	0.972	0.962
Sugar beet	1.000	0.890	0.769	0.675	0.620
Rape seed	1.000	1.018	1.455	2.164	1.691
Other crops	1.000	0.999	1.002	1.001	1.002
Beef (catle)	1.000	0.988	0.961	0.928	0.901
Milk &milk products	1.000	0.974	0.957	0.933	0.907
Pork	1.000	0.963	0.953	0.942	0.906
Poultry	1.000	0.984	0.963	0.938	0.921
Other livestocks	1.000	0.990	0.973	0.966	0.952
TOTAL OUTPUT	1.000	1.000	1.000	1.000	1.000

Source: Author's own calucations

Table A. 5-2 Price Indices of Outputs and Inputs

	1996	1997	1998	1999	2000
	Output Price Indices (procurement) (1996=1.000)				
Wheat	1.000	0.889	0.819	0.752	0.889
Rye	1.000	1.033	0.893	0.839	1.006
Barley	1.000	0.889	0.800	0.816	1.065
Potatoes	1.000	0.923	1.112	1.448	1.496
Sugar beet	1.000	1.043	1.062	1.097	1.120
Rape seed	1.000	1.013	1.048	0.752	0.944
Other crop products	1.000	0.932	0.947	0.972	1.100
Beef (catle)	1.000	0.973	0.954	0.996	1.103
Milk &milk products	1.000	1.157	1.196	1.196	1.529
Pork	1.000	1.259	1.146	1.007	1.223
Poultry	1.000	1.066	1.045	0.901	0.979
Other livestocks	1.000	1.122	1.102	1.035	1.236
	Intermediates Price Indices (1996=1.000)				
Seeds	1.000	1.092	1.142	1.133	1.405
Fertilisers	1.000	1.106	1.189	1.252	1.343
Chemicals	1.000	1.129	1.224	1.296	1.352
Feeds	1.000	1.107	1.130	1.130	1.246
Fuel	1.000	1.155	1.257	1.478	1.890
	Capital Input Price Indices (1996=1.000)				
Capital input Index	1.000	1.114	1.208	1.284	1.360
buildings	1.000	1.121	1.217	1.295	1.381
machinery	1.000	1.086	1.163	1.240	1.288
livestock	1.000	1.170	1.335	1.380	1.455
Lending rate*	1.000	1.098	0.995	0.990	1.049

* the lowest rate charged by commercial banks to private borrowers (end-year)
EBRD (2002)

Source: Author's own calculations based on GUS (2001a) and EBRD (2002)

Table A. 5-3 Implicit Output and Inputs Volumes

All the farms (811)	**1996**	**1997**	**1998**	**1999**	**2000**
			Implicit Output and Input Volumes		
Output	1.000	1.034	1.128	0.930	1.086
Labour	1.000	0.997	0.955	0.931	0.903
Land	1.000	0.941	1.076	1.108	1.126
Intermediates	1.000	0.934	1.028	1.023	1.060
seeds	1.000	0.908	0.875	0.871	0.858
fertilis	1.000	1.110	1.143	1.151	1.270
chemicals	1.000	1.192	1.360	1.524	1.673
feeds	1.000	0.880	1.009	0.992	1.027
fuels	1.000	1.040	1.054	0.970	0.825
Capital Input	1.000	1.165	1.218	1.214	1.215
interests	1.000	1.489	1.825	1.645	1.654
depreciation	1.000	1.120	1.171	1.198	1.202
	1996	**1997**	**1998**	**1999**	**2000**
			Nominal Values		
Output	1.000	1.072	1.146	1.099	1.258
Labour	1.000	0.997	0.955	0.931	0.903
Land	1.000	0.941	1.076	1.108	1.126
Intermediates	1.000	1.035	1.181	1.197	1.376
seeds	1.000	0.992	0.999	0.986	1.205
fertilis	1.000	1.228	1.359	1.441	1.706
chemicals	1.000	1.345	1.664	1.975	2.261
feeds	1.000	0.974	1.140	1.121	1.280
fuels	1.000	1.201	1.325	1.434	1.560
Capital Input	1.000	1.299	1.472	1.558	1.653
interests	1.000	1.635	1.816	1.629	1.734
depreciation	1.000	1.248	1.415	1.538	1.635
	1996	**1997**	**1998**	**1999**	**2000**
			Price Indices		
Output	**1.000**	**1.037**	**1.016**	**1.181**	1.159
Intermediates	1.000	1.108	1.150	1.170	1.298
seeds	1.000	1.092	1.142	1.133	1.405
fertilis	1.000	1.106	1.189	1.252	1.343
chemicals	1.000	1.129	1.224	1.296	1.352
feeds	1.000	1.107	1.130	1.130	1.246
fuels	1.000	1.155	1.257	1.478	1.890
Capital Input	1.000	1.114	1.208	1.284	1.360
interests	1.000	1.098	0.995	0.990	1.049
depreciation	1.000	1.114	1.208	1.284	1.360

Source: Author's own calculations

Appendix 5-2: Final results

Table A. 5-4 The Malmquist Index Summary of Annual Changes

year	Technological Change	Technical Efficiency	"Pure" Technical Efficiency	Scale Efficiency	TFP Change
1996/97	-20.8%	27.1%	-16.8%	-4.8%	0.7%
1997/98	29.5%	-21.7%	23.2%	5.1%	1.4%
1998/99	-19.0%	2.3%	-16.2%	-3.3%	-17.1%
1999/00	10.4%	2.9%	7.4%	2.8%	13.6%
mean	**-2.1%**	**1.2%**	-2.0%	-0.1%	**-1.0%**

Source: Author's own calculations

Table A. 5-5 Means of output and inputs by farm size

	Output ('000 PLN)*	Labour (AWU)**	Land (ha)	Intermed. ('000 PLN)*	Capital ('000 PLN)*
			1-5 ha		
1996	13.52	1.12	3.63	5.28	1.78
1997	12.65	1.14	3.71	5.26	2.23
1998	13.09	1.07	3.56	4.68	1.93
1999	12.80	1.04	3.55	4.65	1.95
2000	12.67	1.01	3.52	4.74	1.89
			5-15 ha		
1996	31.10	1.71	9.38	12.77	3.82
1997	30.21	1.69	9.50	11.54	4.64
1998	31.15	1.59	9.51	11.79	4.24
1999	26.16	1.51	9.53	11.33	4.25
2000	28.90	1.43	9.48	11.32	4.17
			15-30 ha		
1996	58.96	2.29	20.53	26.10	7.96
1997	61.28	2.26	20.69	24.22	10.18
1998	66.28	2.25	20.96	26.12	9.48
1999	57.98	2.23	21.22	25.98	9.34
2000	62.13	2.17	21.40	26.82	9.14
			30+ ha		
1996	148.23	3.13	64.71	68.11	18.15
1997	162.75	3.27	67.60	65.08	24.69
1998	179.42	3.08	72.90	74.75	24.97
1999	139.86	3.02	74.28	75.29	25.39
2000	174.45	3.01	77.09	79.50	25.71

* in constant 1996 prices
** AWU=annual working units

Source: Author's own calculations

Table A. 5-6 Producer Subsidy Equivalents by Commodity

%	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Wheat	-40	7	19	12	10	26	21	26	15	22
Maize	17	30	26	27	23	23	25	26	0	-1
Barley	-23	-1	21	10	6	24	23	21	23	26
Oilseeds	-20	13	19	32	13	24	10	14	11	24
Sugar	34	27	12	27	27	45	36	45	44	67
Milk	-28	-5	-8	-17	1	-3	6	18	12	9
Beef	2	0	-17	2	-1	21	10	1	-39	-109
Baranina?	-28	10	4	22	20	11	12	10	2	12
Pork	-1	-33	4	25	5	-9	-6	20	26	-16
Poultry	54	62	37	49	37	32	23	25	34	15
Eggs	38	47	41	54	54	43	39	54	54	38
Weighted Average										
PSEP	**-5**	**-3**	**8**	**17**	**11**	**13**	**12**	**22**	**19**	**7**

Source: OECD PSE/CSE Database

Table A. 5-7 Means of output and inputs by type of activity

	Output ('000 PLN)*	**Labour** (AWU)**	**Land** (ha)	**Intermed.** ('000 PLN)*	**Capital** ('000 PLN)*
			Crop		
1996	73.41	2.17	32.24	25.51	10.47
1997	76.21	2.13	33.68	26.62	13.95
1998	84.41	1.98	37.06	26.67	14.13
1999	55.71	1.92	38.21	27.28	14.41
2000	82.78	1.86	38.35	27.10	13.85
			Livestock		
1996	48.72	2.03	15.96	23.88	5.78
1997	50.66	2.03	14.95	21.77	7.28
1998	54.38	1.95	16.63	24.21	6.84
1999	49.54	1.91	17.12	23.66	6.85
2000	51.04	1.85	17.37	24.76	6.83
			Mixed		
1996	92.90	2.20	35.56	39.55	12.31
1997	96.28	2.25	31.61	32.42	17.08
1998	106.86	2.07	40.01	41.05	16.91
1999	75.90	2.06	40.29	39.44	16.47
2000	102.91	2.02	41.69	41.84	17.14

* in constant 1996 prices
** AWU=annual working units

Source: Author's own calculations

Table A. 5-8 Means of output and inputs by specialization

	Output ('000 PLN)*	Labour (AWU)**	Land (ha)	Intermed. ('000 PLN)*	Capital ('000 PLN)*
			Single activity		
1996	66.05	2.12	22.96	31.28	8.35
1997	68.91	2.11	21.43	29.33	10.94
1998	76.05	2.01	25.14	32.38	10.57
1999	65.03	1.97	25.91	32.01	10.57
2000	71.71	1.94	26.26	33.42	10.65
			Distinguishing activity		
1996	33.24	1.73	13.94	12.53	4.72
1997	35.25	1.71	13.55	13.24	5.95
1998	38.41	1.67	14.22	12.65	5.36
1999	30.65	1.63	14.81	13.25	5.73
2000	36.90	1.54	14.82	13.98	5.47
			Various and changable activities		
1996	50.36	2.09	18.35	22.19	6.50
1997	52.45	2.12	18.11	20.12	8.12
1998	54.92	2.04	19.52	21.83	8.02
1999	43.65	1.99	20.37	21.33	7.98
2000	51.07	1.90	21.11	22.33	7.30

* in constant 1996 prices
** AWU=annual working units

Source: Author’s own calculations

6 Determinants of Total Factor Productivity in the Polish Farm Sector

This chapter aims to shed more light on the determinants and obstacles to productivity improvements in the farm sector. Firstly, the set of potential factor productivity determinants is discussed, followed by a brief overview of the main characteristics of the Polish farm structure. This is followed by results from the factor, ANOVA, cluster and pooled regression analyses, offering insights into the significance, direction and relative importance of the various determinants of productivity.

6.1 Potential determinants of TFP differences in the farm sector

As was discussed in Chapter 5, changes in factor productivity result from changes in technology and technical efficiency, where the latter is divided into two: ‘pure’ technical efficiency and scale efficiency. Based on this approach one can start thinking about the possible determinants of the TFP levels - features determining which farms are more productive than the others.

Technology

If one thinks of technology here in its broader sense, the possible measurable determinants of TFP may include various ***techniques of production*** (labour-, capital- and land-intensive), other types of ***factor proportions*** (on-farm versus off-farm factors), level of production ***specialisation*** (overall specialisation or specialisation in certain types of activities), etc. However, as one would expect, more capital-intensive techniques are also usually more technologically advanced, as was visible in our previous analyses. On Polish farms this may not be the case, so it is interesting to find out the empirical impact of this variable, measured by some ratio of capital to labour. Land-intensive techniques can also be expected to positively contribute to productivity, given the derived earlier positive relationship between productivity growth in crop oriented activities. As such, this is measured using a ratio of land to labour. These expectations imply that labour intensive techniques may be on average less productive than capital- and land-intensive techniques.

The literature on productivity in agricultural sectors in transition suggests that family labour may be more beneficial to efficiency and productivity than off-farm labour (see examples in Latruffe, et al., 2003), which justifies testing whether this is the case on Polish farms in this research. Various variables can therefore be defined which take into account the proportions of off-farm to own inputs, e.g. shares of rented land and hired labour.

Specialisation is also expected to significantly influence productivity, as usually better technologies allow for higher specialisation. Therefore, one may expect it to have a positive impact on TFP as it allows for more efficient use of factors connected with better organisation of work, experience, etc. As was showed in the previous chapter, the type of specialisation also matters as, generally, crop-oriented specialisation improved faster during the analysed period than others (livestock and mixed). One can therefore construct at least two measures of specialisation, one indicating overall 'concentration' of production and the other indicating specialisation in crop production (based on expectation from previous analyses that an important type of specialisation may occur).

'Pure' technical efficiency

Revealed problems with 'pure' technical (in)efficiency (discussed in the previous chapter) call for testing of some variables which may help in explaining the problems. Due to the character of this type of inefficiency one can expect some problems with ***human capital***, which has the highest impact on the management of farms. This can be described by various sociological measures such as education, age, experience and even the gender of the farm manager (owner). One may expect better educated, generally younger and experienced farmers to be more likely to be productive than those without any agricultural education and retired (although the latter are more experienced as well). Gender is an interesting variable, though it is doubtful if it has a significant impact on productivity. This can also be verified.

Scale efficiency

Farm size seemed to be a very important factor when changes in productivity were analysed, and can also be expected to matter in terms of productivity levels. Besides, many previous studies have discussed the influence of size on productivity and efficiency of farms and the findings have been far from unanimous (see Chapter 3). Generally, utilising economies of scale should allow a lowering of the unit costs of production and positively contribute to TFP, though some empirical findings do not confirm this. Therefore, this work will attempt to grasp the various notions of ***farm size*** or scale of production (as suggested in various studies, see also Section 6.6.5) and, based on the available data, analyse: physical farm size (measured in hectares) and well-being (measured by values of output and assets). One can also conceive of farm size in terms of labour used.

Others

Other factors may also have a significant impact on TFP. Firstly, ***soil quality***. Without doubt, farms which operate on good quality land have far better productivity results than other farms due to the large benefits from greater land productivity. The quality of land is an easily measurable variable, and can be included in this analysis. Typical for Polish farms is ***fragmentation of land***, which may also have a significant influence on productivity. When the farm consists of too many plots and the plots are dispersed this causes many organisational problems (e.g. with shifting machinery) and with waste of resources (fuel, time, etc.). Another variable suggested in the literature and worth considering is the ***financial situation*** of the farms. It may be expected that farms which want to be productive invest more and for that they need investment credits or other long-term financing. Usually this can be measured by some financial ratios revealing the reliance of farms on external financing. It may also be interesting to verify if productivity significantly depends on governmental aid. This can simply be measured by the reliance of farms on ***direct subsidies***. It is not clear, however, if such aid indeed has a significant and positive influence on TFP.

All in all, based on previous analyses in this thesis, other studies and general economic knowledge, various expectations as to which factors may determine TFP come to mind. However, before defining the particular measures and initiating empirical analyses, it is worth making a short overview of the Polish farm structure and production factors in order to have some anticipation of possible differences among Polish individual farms. An understanding of the main facts concerning the potential determinants of TFP should also enable us to formulating further research hypotheses.

6.2 Structure of the Polish farm sector

Changes in the Polish individual farm structure in the 1990s were somewhat limited. The average size of individual farms increased by less than one hectare over ten years, from 6.3 ha in 1990 to 7.2 ha in 2000, while the number of the farms declined from 2,137.5 thousand to 1,880.9 thousand over the period (GUS, 2001a). The land cultivated by individual farms increased from 77% of the total area to 82% in 1996, with the remainder used by co-operatives (3%), some non-privatised state farms (7%) and other corporate farms (8%), as indicated in Table 6 1. The number of employed in agriculture remained very high compared to other countries in the region. The share of total labour force employed in agriculture in Poland remains at a two-digit level and in 2001 amounted to 28.3% (for comparison it was 8.5% in the Czech Republic and 12.5% in Hungary in 1999) (GUS, 2001a).

The initial structure of the sector was also very different from those in other CEECs, as collectivisation in Poland was never seriously advanced (in contrast to the Czech Republic and Hungary), despite some attempts in the early 1950s (Zawalińska, 1999). The existing state-owned farms were mainly concentrated in the northern and western parts of Poland where they made up almost 40% of agricultural land use in comparison with 18% of the national average in 1990 and reduced to 7%. At the same time in the Czech Republic and Hungary co-operatives and state farms prevailed – see Table 6 1.

Table 6-1 CEC-3 farm structure according to land use

	co-operatives(i)		state farms (ii)		other corporate farms (iii)		private/individual farms (iv)	
Share in total agricultural area (%)								
	pre-transition	current(v)	pre-transition	current(v)	pre-transition	current(v)	pre-transition	current(v)
Poland	4	3	19	7	-	8	77	82
Czech Republic	61	43	38	2	-	32	0	23
Hungary	80	28	14	4	-	14	6	54
Average size (ha)								
	pre-transition	current(v)	pre-transition	current(v)	pre-transition	current(v)	pre-transition	current(v)
Poland	335	222	3140	620	-	333	6.6	7
Czech Republic	2578	1447	9443	521	-	690	5	34
Hungary	4179	833	7138	7779	-	204	0.3	3

(i) collective pre-transition, transformed into private (producer) cooperatives/associations currently

(ii) state farms pre-transition,remaining state farms and state held/controlled enterprises currently

(iii) joint stock, limited liability companies and other business entities currently

(iv) houshold plots pre-transition, individual (part-time) farms currently

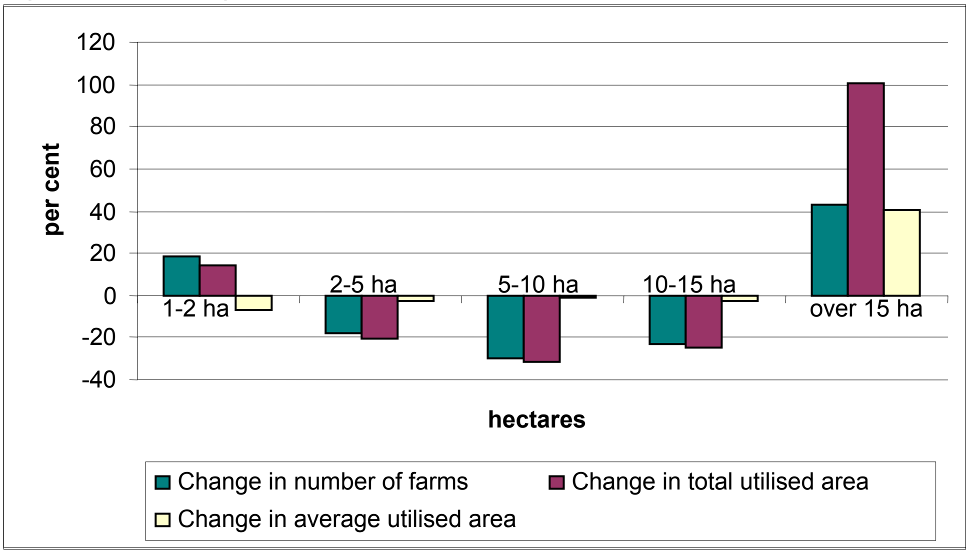
(v) for Poland and Hungary the data are of 1996, and for the Czech Republic of 1995

Source: European Commission (1998a)

Another distinct feature of the Polish farm sector is the visible polarisation in the structure of farms. Both shares of the smallest and largest farms in the total farm number increase, while medium-sized holdings decrease in number and share of land use. The share of individual farms of 1-2 ha increased from 17.7% in 1990 to 23.8% in 2000 and for 15 ha farms and more from 6.1% to 9.9% of all individual farms (GUS, 2001a).

It is interesting that at the beginning of the transition many expected that in Poland, as in other CEECs, small-scale peasant production would quickly disappear. Kydd et al. (1997), for example, argued that in economies of transition the typical bi-modal structure of farm size distribution would be replaced by unimodal distribution, according to the patterns established before in Western Europe and North America (Davidova, et al., 2002). However, the Polish experience has been different, as explained above and illustrated in Figure 6-1.

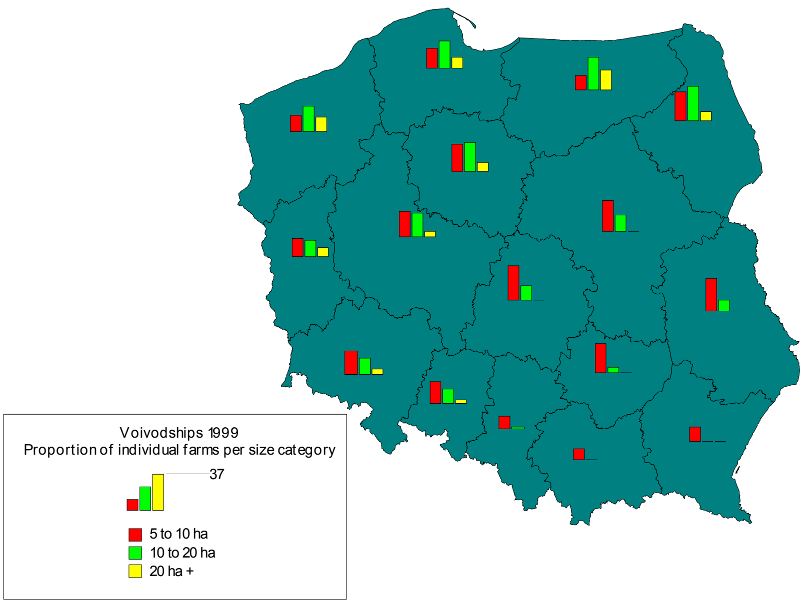
Figure 6-1 Changes in Individual Farm size and number between 1990-2000



Source: GUS (2001a)

The Agricultural Property Agency (APA), a state agency, continues to play an important role in land transactions as a supplier of land for sale or lease, since private supply does not meet demand. However, this causes asymmetries in farm size increases because the distribution of APA land is very uneven, with more state land concentrated in western and northern Poland, where the number of private farms is relatively small (about 30% of the total) (World Bank, 2001). As a result, APA land accounted for 60-80% of land transactions in these regions, compared with 30-40% in central and southern parts of the country. This in turn, resulted in the average purchase and lease contracts in western and northern regions (on average between 1990-1996) being around 7.1% and 16.2% respectively, compared with 3.2% and 4.5%, respectively, throughout the rest of the country (World Bank, 2001). This increased the asymmetries between the regions which existed before 1990, and an uneven distribution of individual and small individual farms is visible, with predominantly-small scale farms in south-eastern regions, and large farms in northern and north-western regions, as illustrated in Figure 6-2.

Figure 6-2 Proportion of individual farms per size categories in voivodships, in 2000.



Source: Based on GUS (2001a)

There is another duality in Polish agriculture; that is the co-existence of peasant and market-oriented farming. According to A. V. Chayanov (a widely recognised agricultural scientist on peasant agriculture), the chief feature of the peasant household is that it is both a production and consumption unit and that the domestic and agricultural functions are inextricably interlocked (Grigg, 1982). Indeed, Polish farms are of peasant character, which is characterised by: (i) family ownership, (ii) reliance on family labour, (iii) priority of own consumption, (iv) maximising income per head of family member not profit, (v) assuring continuation of a tradition of family farming, (vi) small-scale production (Woś, 2000a, Davidova, et al., 2002).

The existence of regions with predominantly small individual farms and regions with other farm structures are best observed in a regional context, which to a large extent is the result of historical and political factors from the past. In southern and eastern regions, the farms tend to be smaller and private farms are the almost exclusive form of farming, unlike in the northern and western regions, where the farms are on average larger and individual farms co-exist with other forms of farming.

The question is how do these different farm structures relate to differences in productivity? Which structural and other farm characteristics can assure positive total factor productivity? Which properties of farms matter for farms to be able to improve productivity? These questions will be addressed in the following sections and empirically verified later.

6.2.1 Key facts on production inputs

Land

In 2000, individual farms in Poland occupied a land area of 13,510.3 thousand hectares. 4.8% of the land was occupied by the smallest group of individual farms (1-2 ha), followed by two medium groups (2-5 ha and 10-15 ha), with 14.7% and 16.6%, accordingly, and then by the last medium group (5-10 ha), with 23.6%. The rest,which accounted for most of the land, was occupied by the group of largest farms (over 15 ha) (GUS, 2001b).

The farms are quite fragmented. Most of the land of the individual farms (61.6%) in 2000 consisted of 2 to 5 plots and the distance between the house and the most remote plot did not exceed 2 km for 59.2% of farms. Most such farms were located in the southern voivodships: Dolnośląskie (71.2%) and Małopolskie (70.2%). However, there were regions where the situation was worse. The highest percentage of farms with the most remote plot being more than 5 km from the house was in the eastern voivodships: Podlaskie (19.5%) and Lubelskie (16.1%) (Polish regions are depicted in the Map A. 6-1 in Appendix 6-1), (GUS, 2001b).

The smallest farms are mostly in southern Poland, where the farm size is on average smaller than 4 ha, mainly in the Małopolskie and Podkarpackie voivodships. Large individual farms are mainly found in the northern parts of Poland, with an average farm size of bout 12 ha, as in Warmińsko-mauzurskie, Zachodniopomorskie and Pomorskie (GUS, 2001b).

Between 1999-2000 new land was purchased by only 2% of all individual farms and there were more such farms in the groups of larger farms, i.e. 20% in the group with over 50 ha, but only 0.5% in farms of 1-5 ha. The largest spending on new land per farm was also in the group of the largest farms. On average, land per single farm of over 100 ha was 39 ha, while for all the individual farms the average was 6 ha. Only 8.6% of the farms rented land and proportionally largest farms (over 100 ha) rented land more often (70% of the farms), compared to small farms (1-2 ha), where the percentage renting farms was only 4% (GUS, 2001b).

Labour

Average daily working hours per person amounted to 6.5 h in 2000, however, this increases with farm size, from 3.7 h per person in 1-2 ha farms to more than 8 ha in farms over 30 ha. Almost 28% percent of people working (exclusively or the majority of the time) on own farms declared only 2 h working days during the year. And another 24.4% declared 3-5 h per day, while only 22.8% worked from 6-8 h per day. There is also an increase in average working hours per day in terms of farm size (GUS, 2001b).

Migration out of agriculture has been rather slow, and in the last years a reverse migration has even been observed, with unemployed people migrating from cities to villages. According to GUS statistics, there were 1,180.2 thousand people living in villages registered as unemployed, and only 3.7% (43.6 thousand) of them owned individual farms in 2000 (GUS, 2001b). However, most people with farms are not allowed to register as unemployed (IERiGŻ, 2001), therefore the figure does not reveal the full extent of the situation.

There are as such in fact two types of unemployment on farms: registered and hidden. The IERiGŻ (2001) estimated hidden unemployment on farms at 0.5 million people in 2000. The estimation of hidden unemployment is based on farm surveys in which farm owners declare how many family members (of productive age) are necessary on the farm compared to actual number of working (staying) there. The surveys revealed that the highest hidden unemployment is in the group of small farms, 1-3 ha, where only 12.9% of all people working on the farm are necessary, and 35.7% work part-time, and are looking for other jobs (thus constituting hidden unemployment because they do not register as unemployed). A similar problem is also in the group of 3-5 ha farms, but is less significant on larger farms. The regions which are the most affected by hidden unemployment and partial farm employment are in the south-eastern and eastern voivodships.

Physical Capital

The main physical production inputs in Polish individual farms are tractors, combine harvesters, mowers, other machines and agricultural tools, irrigating machinery and farm buildings (barns, grain stores. etc.). In 2000, tractors were in the hands of 1,061.8 thousand individual farms, which means that the number of farms with tractors had increased by 4.2% compared to 1996. 57.6% of all individual farms had tractors. The number of tractors in farms increased by 7.5% between 1996 and 2000. Generally speaking, the percentage of farms with tractors increased with the size of farms up to 10 ha, beyond that size the percentage fell. Among all farms with tractors, 8.4% were in the group of smallest farms (1-2 ha), 9.5% in group 2-3 ha, 17% in the group 3-5 h, and the most, 32.4%, in the group of 5-10 ha, followed by lower percentages: 16% in the group of 10-15 ha, 7.5% in the group 15-20 ha, and 6.8% in the group above 20 ha (GUS, 2001b).

Almost all tractors (99.2%) were owned by farms in 2000, and only 0.8% were shared between farms. Surprisingly, the highest percentage of shared tractors (3.8%) was in the group of the largest farms (above 100 ha), while in the group of thesmallest farms the percentage was half that.

The average agricultural area in hectares per tractor declined by 13.7% from 1996 and, in 2000 amounted to 10.1 ha, which may indicate the overall increasing capitalisation of Polish farms. Large farms (over 50 ha) differed from that average considerably, with agricultural area per tractor in this group amounting to 37.7 ha/tractor. In all size groups of farm the ha/tractor ratio decreased, so it may indicates that either farms use old tractors or technological improvements are not aligned with the land structure.

The share of farms using fertilisers and pesticides tends to increase with farm size. In 2000, 76.9% of farms were using nitric fertilisers (N), 20.2% phosphorous fertilisers and 16.5% potassium. Most of the farms were also using a mix of all the above. Generally, 81% of individual farms bought fertilisers and pesticides in 2000, with the share of 65% of 1-2 ha farms, 75% of farms 2-3 ha and 83% farms above 3 ha.

Financial capital

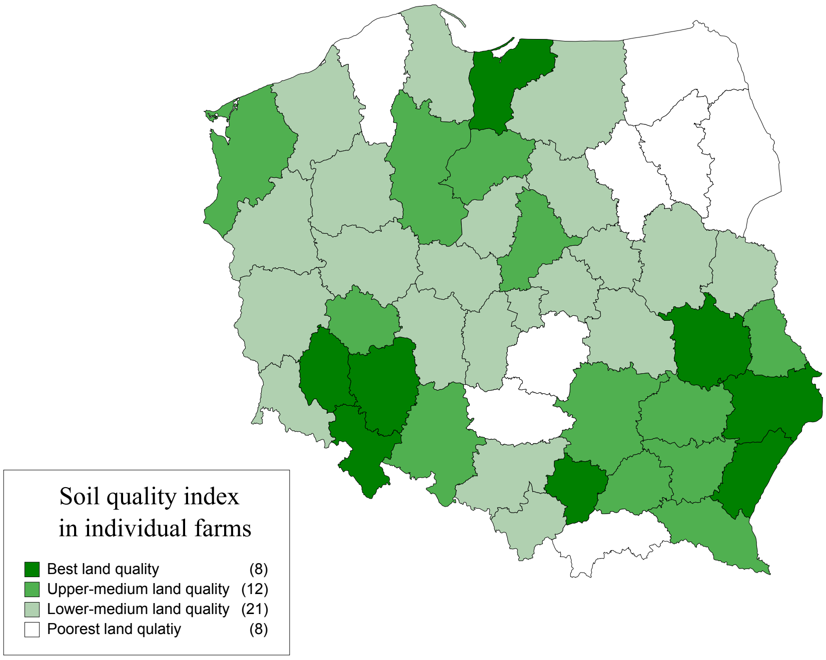
In 2000, 21.2% of individual farms had external financing in the form of credits and the percentage of such farms rose according to farm size: there were 6-9% such farms up to 3 ha, 14-27% farms 3-10 ha, 40-76% in the rest of largest farms. At the same time, 21.6% of individual farms were paying back credits and interest. The percentage of such farms also increased with farm size: 10% of them were up to 3 ha, 27% 5-10 ha, and 77% in the group above 50 ha. Average annual debt repayment amounted to PLN 5.7 thousands (GUS, 2001b).

6.2.2 Evidence concerning the quality of production inputs

Land

The overall quality of land in Poland is not very high. Among six classes of soil quality only the first three are suitable for intensive production. They amount, however, to only 26% of total utilised agricultural land in Poland. Using another indicator of land quality, the index of soil quality published by GUS, one can see that 19.9% of all individual farms have the poorest land quality (a soil quality index below 0.4). Land quality is connected to farm size and geographical region. Most of the best quality land is in hands of the largest farms, and at the same time in this group there is the lowest share of the poorest land. In contrast, smaller and medium farms usually have worse quality land.

Map 6-1 Soil quality in individual farms



Source: GUS (1997)

The relationship between size and quality may result to some extent from the correlation of farm size with type of production because most larger farms have crop production which requires better soil quality. Land quality also differs regionally among individual farms (see Map 6-1), with the best farms in the south-east, west and northern parts of Poland.

Physical Capital

The quality of physical capital is difficult to assess based on the available data. Indirectly, one can value it based on the fact that in individual farms it has aged and is overall already mostly obsolete. Over the 1990s, overall sales of new machines fell considerably. For example, between 1995 and 1999 the sale of new tractors fell by 42%, rotative mowers by 53%, potato harvesters by 93% and milking machines by 81% (Table 6-2). An important factor contributing to this was an increase in their prices. For example, the retail price of an Ursus (Polish tractor) increased between 1997-1999 by 20%, in terms of wheat value (Szemberg, 2002).

Table 6-2 Sales of the new agricultural machinery on the domestic market, 1995-1999

in units	1995	1999
Tractors	9,030	5,247
Fertiliser distributors	7,210	6,403
Crop seeders	7,047	2,063
Rotative mowers	18,290	8,635
Combine harvester	439	400
Potato combines	1,536	105
Sugar beet combines	135	12
Milking machinery	501	91

Source: GUS (2001a)

There is evidence that capital has also been ageing in recent years and has become obsolete. According to Zalewski (2002), the average age of tractors in the hands of individual farms is about 21 years. This is also confirmed in a survey by Szemberg (2002), which showed that the majority of surveyed farms bought second-hand machines between 1996-2000. The rate of the capital ageing seems to be quite high. For example, the share of 11 year or older machines in total machinery increased from 50% in 1996 to 70% in 2000 (in the aforementioned survey).

Management and education

One may consider management as a proxy for human capital. Generally, in most individual farms (97.4%) one family member was a manager of the farm in 2000. In the rest of the farms, management was hired from outside the household. The latter was much more common for larger farms (above 30 ha) and the percentage of farms with a hired manager increased with farm size: from 0.6% in the group 30-50 ha, 1.4% in group of 50-100 ha, up to 8.9% in the group above 100 ha. Most farms with hired managers were in central voivodships, Warmińsko-mazurskie (1.4%) and the least in eastern voivodship, Podlaskie (0.02%), as almost all managers were family members working on the farms there (see Map A. 6-1). (GUS, 2001b). There is no information, however, on whether farm managers are also farm owners, though in most cases one may expect this to be the case.

Out of all the managers of individual farms, 56.9% had an agricultural education in 2000. Among them, 20.2% had medium or higher agricultural education. There was a positive correlation between increasing education level and the size of farm. Share of managers with medium or higher education was 9.2% in the group of smallest farms (1-2 ha) and as much as 58.4% in the largest group of farms (over 100 ha). At the same time, the percentage of managers without agricultural education on average decreased with farm size, from 61.5% in the farms between 1-2 ha, to 10.7% in the farms above 100 ha in 2000 (GUS, 2001b).

There were also regional differences in terms of farmer education. The highest percentage of farms with managers without any agricultural education was in southern voivodships: Śląskie (58.9%), Małopolskie (56.7%), Świętokrzyskie

(55.7%) and Podkarpackie (55.3%) in 2000 and, at the same time, in the latter three voivodships there was the smallest percentage of farm managers with the higher agricultural education. Most of the farms with the best educated managers were situated in the western part of Poland, in Dolnośląskie (4.8%), Zachodniopomorskie (2.7%) and Lubuskie (2.5%) (GUS, 2001b).

Of all of the individual farms, only 2.8% were bookkeeping, and the percentage was much higher for larger farms than for small ones – 39.1% in the group above 100 ha, and by contrast only 0.5% in the group of 1-2 ha farms (GUS, 2001b).

Experience

As the population of farmers is generally ageing it is not surprising that many report long years of farming records. Most of the managers (62.9%) in individual farms had more than 10 years of experience in managing a farm, and 33.9% of them had over 20 years of experience in 2000. In regional terms, farms with the most experienced managers (over 20 years) were in Świętokrzyskie (40.6%), Małopolskie (39.5%) and Śląskie (39.3%) and with the least experienced (up to 2 years) in Podkarpackie (10.2%), Lubuskie (10%) and Opolskie (9.5%). It is, however, difficult to say if generally more experienced farmers (managers) are better able to become better qualified in the sense that they can learn and adopt new technologies. It is More likely that this is the case up to a certain age (GUS, 1998).

6.2.3 Formulating the research hypotheses

To conclude, Polish agriculture is clearly diversified in terms of the dispersion of production factors and certain groups of farms also differ in terms of the abundance and quality of the factors. Significant differences between the groups in terms of productivity can also be expected. The previous chapter proffered expectations that size, specialisation and types of activities may divide farms performing well in terms of TFP and those unable to follow them. Hence, one can expect profiles (combinations of factors) that will decide which farms are more productive than others, and those which cannot become productive at all.

More precisely these expectations can be formulated into the following hypotheses:

Hypothesis 3: There are significant differences in characteristics between productive and unproductive farms and both have unique profiles (i.e. combination of features determining factor productivity).

Hypothesis 4: There are several significant determinants of TFP, but they differ largely in terms of the strength of their impact on TFP.

In order to verify the hypotheses, the following research questions need answering:

1/ Which factors have a significant and positive influence on farm TFP ('boosters') and which have negative effects ('obstacles')?

2/ What were the clear profiles of productive and unproductive farms?
3/ What was the relative significance of 'boosters' versus 'obstacles' in determining the TFP?

6.3 The data

The data used in this part of the thesis also comes from the Farm Accounting Survey provided by the Institute of Agricultural and Food Economics (IERiGŻ) in Warsaw. As such, the input and output coverage is the same as in Chapter 5, Section 5.2.4.3. There are 10 basic crop and livestock outputs (wheat, rye, barley, rape seed, sugar beet, potatoes, milk, beef pork and poultry) and four categories of inputs (land, labour, capital and intermediates) (Table 6-3). However, in addition also derived and calculated here are many new explanatory variables (including socio-demographic information about the age, gender, years of agricultural education of the farm owner[34] and others) which will be introduced later. As it is a spatial analysis, the results are presented for one year, 1999.

[34] What we call a farm owner is actually a farm manager, but in most cases this is the same person.

Table 6-3 Main categories of inputs and outputs in the sample

INPUTS	OUTPUTS
• Labour (own and hired expressed in hours) and labour wage • Physical inputs (intermediate consumption): 1/ for crop production: Seeds, Fertilisers, Chemicals, other costs of crop production 2/ for livestock production: Feeds, other costs of livestock production 3/ Overall production inputs Repair and maintenance, Fuel and lubricants and other energies, Depreciation of physical capital (e.g. buildings for animals, means of transport, machinery and tools) • Land (own and rented in ha) and Land rent • Financial capital (balance sheet with long and medium term assets and liabilities) and Banking Interests	Values and Quantities of production and marketed production of: • Wheat • Rye • Barley • Potatoes • Sugar beet • Rape seed • Beef • Milk and milk products • Pork • Poultry • Other crop and livestock products

Source: Author's own compilation

6.4 Methodology

The methodology on the Tornqvist-Thail index (an appropriate measure for spatial analyses in contrast to the Malmquist index, which is generally more appropriate for dynamic analysis) was introduced in Chapter 4, so here discussion relates only to some practical problems that occurred during the empirical analysis.

6.4.1 Methodological problems[35]

Productivity differences were estimated by the construction of a Tornqvist-Theil TFP index (see Section 4.5.2.1) for all farms in the sample, relative to a base case 'average farm'. The concept of an 'average base firm' was introduced by Caves, Christensen, and Diewert (1982), applicable for cross-section and panel data to addressed the issue

[35] This methodology description is based on Ratinger (2001)

of making straightforward comparisons of TFP between firms. Their solution was to construct a hypothetical firm ('average firm') whose sub-component expenditure shares are the arithmetic mean expenditure shares for all firms, and whose sub-component quantities are the geometric means of the sub-component quantities across all firms (Pesaran and Schmidt, 1999). Comparisons for individual firm observations *i* are then made relative to reference firm *b*, as in the equation below:

(6-1) $$t_1 = \frac{1}{2}\sum_{j=1}^{n}\left(R_j^i + R_j^b\right)\left(\ln Q_j^i - \ln Q_j^b\right) - \frac{1}{2}\sum_{k=1}^{m}\left(S_k^i + S_k^b\right)\left(\ln X_k^i - \ln X_k^b\right)$$

The Equation (6-2) presents the relative Tornqvist-Thail index *t* (previously derived in Section 4.5.2), where each farm *i* is compared to an 'average farm' *b*, where both produce *n* outputs *Qj (j=1,...n)* using *m* inputs *Xk (k=1,...m)*; *Rj* is the share of the *j*'th output revenue in total revenue for each firm, and S_k is the share of *k*'th input cost in total cost for each farm. As far as the 'average farm' is concerned, the shares for output and input are defined respectively as follows:

(6-2) $$R_j^b = \frac{\sum_i W_{i,j}}{\sum_i \sum_j W_{i,j}}$$

(6-3) $$S_k^b = \frac{\sum_i C_{i,k}}{\sum_i \sum_k C_{i,k}}$$

where, *W* is revenue and *C* is costs.

Thus, the results for each farm's TFP are interpreted relative to the sample mean for which TFP equals 1 (all the results were normalised). Therefore, the firms (or farm in our case) with TFP above unity are called productive and below this, unproductive.

There is, however, a methodological problem with this formula, in case of multiple-output technology, and it is present particularly in countries with smaller farms, where the farms rarely produce all basic outputs (but it is assumed that an average farm produces all basic outputs), and in this case the formula is no longer appropriate (the problem of 'empty entries'). This is the case for Polish farms, so Equation (6-2) is not quite applicable here. The remedy, however, is to calculate the TFP index based on a cost function $C(w,y)$ instead of a production function (see Equation (6-4) in the case of those farms which do not produce all the analysed products, as suggested by Ratinger (2001).

If the underlying functional form is translog:

(6-4) $$\ln C(w) = \beta_0 + \sum_i \beta_j \ln(w_i) + \frac{1}{2}\sum_i \sum_j \beta_{ij} \ln(w_i)\ln(w_j)$$

and farmers exhibit cost minimisation behaviour (which we assume), then the accurate productivity index is given by:

(6-5) $$T_i^* = \frac{A(i)}{A(bi)} = \frac{\frac{C_b}{Q_b}}{\frac{C_i}{Q_i}} exp\left\{\frac{1}{2}\sum_{k=1}^{m}\left(S_k^i + S_k^b\right)\left(\ln w_k^i - \ln w_k^b\right)\right\}$$

(Chambers, 1988: 245).

Diewert and Lawrence (1999) claim that the use of cost functions has a major advantage over production functions in that statistical estimation of the unknown parameters that characterise technology is much more accurate using cost function techniques than the production function.

Closely related to TFP is also the concept of profitability, which can be measured by any kind of private cost-benefit ratio (see Section 6.4.2.) Formally, for a single output technology there is a straightforward relationship between the productivity index and the private cost-benefit ratio, as follows:

(6-6)

$$T_i^* = \frac{\frac{C_b}{p_b y_b}}{\frac{C_i}{p_i Q_i}} \frac{p_b}{p_i} \prod_k \left(\frac{w_{k,i}}{w_{k,b}}\right)^{\frac{1}{2}\left(S_k^i + S_k^b\right)} = \frac{P\_CB_b}{P\_CB_i} \frac{p_b}{p_i} \prod_k \left(\frac{w_{k,i}}{w_{k,b}}\right)^{\frac{1}{2}\left(S_k^i + S_k^b\right)} =$$

$$= \frac{P\_CB_b}{P\_CB_i} \prod_k \left(\frac{\frac{p_b}{w_{k,b}}}{\frac{p_i}{w_{k,i}}}\right)^{\frac{1}{2}\left(S_k^i + S_k^b\right)} = \frac{P\_CB_b}{P\_CB_i} * (price\_index(i, base))^{-1}$$

The above identifies that the relative efficiency is a deflated relative profitability (Capalbo, Antle, 1988: 54, 87). Thus, the relative profitability (a ratio of P_CB_K and P_CB_{base}) was also calculated. The Tornqvist price index, then, has the following form:

(6-7)

$$P_i^* = \prod_j \left(\frac{p_{j,i}}{p_{j,b}}\right)^{\frac{1}{2}\left(R_j^i + S_j^b\right)} \prod_k \left(\frac{w_{k,b}}{w_{k,i}}\right)^{\frac{1}{2}\left(S_k^i + W_k^b\right)} =$$

$$= exp\left\{\frac{1}{2}\sum_{j=1}^{n}\left(R_j^i + R_j^b\right)\left[\ln p_{j,i} - \ln p_{j,b}\right] + \frac{1}{2}\sum_{k=1}^{m}\left(S_k^i + S_k^b\right)\left[\ln w_{k,b} - \ln w_{k,i}\right]\right\}$$

Another methodological problem, related to the first one, was that there were no prices for products which were not produced by farms. In this case, the price of the base farm production (the average) has been used. Therefore, the price index monitors the differences in prices of actually produced outputs or used inputs. Hence, two TFP indices had to be calculated and are presented in the results separately, one appraising prices for all inputs, including own land and labour and one with actually paid costs only. The evaluation of prices of own farm inputs by shadow prices is another methodological problem, which is, however, more precisely discussed in Appendix 6-1).

Finally, the issue of returns to scale should be addressed. As Caves et al. (1982) demonstrated, the Tornqvist index can capture differences in output not explained by differences in input use but due to differences in technology, efficiency and returns to scale, although without distinguishing these sources. If constant return to scale is assumed, then the index measures relative productivity only. However, otherwise it also captures differences in output explained by returns to scale. This calls for care in interpreting results. However, Hughes (2000) claims (after Capalbo, Ball and Denny, 1988[36]), that because the Tornqvist index measures differences in output levels not explained purely by differences in input levels, it is still entirely suitable for comparing firms of different sizes in industries without constant returns to scale.

6.4.2 Profitability methodology

As there is a close relationship between TFP measured by the Tornqvist Index and profitability indices (presented above), the measures of the latter are described in more detail here. Besides, in the literature, profitability is sometimes equalised with firm competitiveness, which makes it also worth analysing from this point of view. From the definition, the measure of farm profitability compares farm revenues with farm costs. The analysed measure is a ratio of costs to revenues for each farm. Hence, lower than unity indices indicate a profitable farm (as costs are lower than revenues) and *vice versa*. For the i'th farm, the general form of private cost-benefit ratio (P_CB), is taken to be:

(6-1) $$P\_CB_i = \frac{\left(C_i^t + C_i^f\right)}{R_i}$$

where C^t_i is the cost of tradable inputs, C^f_i is the cost of non-tradable factors of production and R_i is revenue excluding current subsidies net of taxes. The revenue side includes proceeds from sales of agricultural products, the value of non-marketed output, proceeds from other activities and net current subsidies. Costs include labour, land, capital (depreciation and interest) and intermediate consumption. One may take

[36] For a precise reference, see Hughes (2000).

into account two possible types of revenue (R) and two types of costs (C). These types of revenues differ from each other in terms of current subsidies (whether they are included or not) and costs differ in terms of the inclusion or not of own farm costs (own labour and land):

R_1 = total revenue including the value of no-marketed output;

R_2 = R_1 + current subsidies net of taxes;

C_1 = intermediate consumption +depreciation + interest paid + paid wages + paid rent.

C_2 = intermediate consumption +depreciation + interest paid + (paid wages + shadow wages) + (paid rent + shadow rate), where shadow prices were evaluated according to the criteria presented in Appendix 6-1.

Hence, one can construct three profitability measures as follows: (i) Private Cost Benefit Ratio (P_CB), calculated with the use of R_2 and C_2; (ii) cost-revenue plus subsidies (C_Rs) calculated with R_2 and C_1 (it exactly matches the entries in the EU's Farm Accountancy Data Network, FADN); (iii) cost-revenue without subsidies (C_R) using R_1 and C_1.

The rationale for calculating these three different ratios of profitability is to give an insight into the effect of direct budgetary transfers and the valuation of all factors at opportunity costs on different farm types and farms located in different agri-environmental regions (as shadow prices differ regionally).

6.5 Total factor productivity and profitability results[37]

Productivity scores presented in Table 6-4 indicate that a minority of the Polish farms in the sample are productive[38]. If the costs of own resources are included, only 35% of farms are productive, but even if only the paid costs are included, the percentage is only 38%. The productive farms, however, operate on 63% of the land and produce 56% of the output. There is a high variation of individual farm productivity around the sample mean (which was normalised to 1), and the standard deviation was 0.829 when costs of own resources are estimated.

The profitability results are also very pessimistic. If Polish farmers are assessed in terms of paid and unpaid costs (i.e. including their own labour and land as measured by P_CB ratio), then 91% cannot cover their costs and are loss-making, as indicated in Table 6-5. Even if only the costs of paid factors are taken into account (C_Rs

[37] These calculations were carried out by the author within the EU Commission's 5th Framework Programme IDARA (Strategy for Integrated Development of Agriculture and Rural Areas in CEE Countries), QLRT-1526.

[38] Productive means TFP>1.

measure), 40% cannot cover their costs with their own revenues. As direct payments make such a small contribution to total agricultural revenues (on average less than 0.03%) there are no differences in the number of farms that are profitable according to the C_R and C_Rs ratios, since subsidies play only a small role in the revenues of Polish individual farms[39].

Table 6-4 TFPs 1999 descriptive statistics

	TFP1 (all costs)	TFP2 (paid cost)
Max	5.641	4.9891
Min	0.02	0.027
Average	1	1
Stand. Dev.	0.829	0.706
Number of productive farms (TFP>1)	346	378
% of productive farms in the sample farms	35%	38%
Number of non-productive farms (TFP<1)	633	601
% of non-productive farms in the sample farms	65%	60%
% of sample UTIL_UAA in productive farms	63%	62%
% of sample output in productive farms	56%	55%
% of sample labour input in productive farms	39%	42%

Source: Author's own calculations

Table 6-5 Descriptive Statistics, Profitability Ratios, IERiGŻ Farm Sample, 1999

	P_CB	C_R	C_R s
Max	99.881	3.631	3.631
Min	0.375	0.318	0.318
Average	3.827	1.007	1.007
StandDev	5.043	0.321	0.321
Number of profitable farms	85	591	591
% of profitable farms in the sample	9%	60%	60%
Number of loss making farms	894	388	388
% of loss making farms in the sample	91%	40%	40%
% of sample UTIL_UAA accounted for by profitable farms	27%	63%	63%
% of sample output accounted for by profitable farms	18%	72%	72%
% of sample labour input accounted for by profitable farms	10%	66%	66%

Source: Author's own calculations

[39] Note that this low level of direct subsidies is due to the fact that they cover the following direct payments: 1/ for biotechnological progress in crop production (based on the amount of authorized land and types of crop; per ha of land; up to certain limits), 2/ for biotechnological progress in livestock production (based on the farm accounting and official requests; submitted up to certain limits, per head of animal), 3/ for the costs of combating animal contagious diseases and medical examinations of sick animals (more precisely, for vaccination, veterinarian actions, examinations, injections, etc.), 4/ for costs of monitoring of soil quality, crop and animal production quality, 5/ agricultural geodetic activities, 6/ for calcium fertilizers (only if they are of domestic origin; fulfilling the standards, etc.), 7/ crop protection and production with use of ecological methods.

Table 6-6 Distribution of IERiGŻ Sample Farms according to Profitability Ratios, 1999

	P_CB			C_Rs		
Range	Average	STD	Frequency	Average	STD	Frequency
0-1	0.749	0.174	85	0.83	0.109	591
1.01-1.25	1.113	0.062	60	1.102	0.065	239
1.26-2.5	1.808	0.361	307	1.494	0.257	141
Above 2.51	5.809	6.205	527	2.881	0.305	8

Source: Author's own calculations

According to the P_CB ratio, most of the farms have a ratio above 2.51 and thus are very far from the break-even point (see Table 6-6). About 60% of the sample farms could cover their costs only if the opportunity costs of own land and labour were zero (that is, not included). Overall, profitable farms are, on average, larger. This is evidenced by the fact that while only 8.7% of farms in the sample are profitable by the P_CB measure, these farms account for 26.9% of the total utilised agricultural area (UTIL_UAA) of the total sample and 18.2% of total output.

6.6 Determinants of productivity differences among the farms

- This section looks for determinants of farm productivity among all the available data of farm characteristics obtained from the IERiGŻ. Because there are many such variables we will first attempt to find a set of them which comprehensively describe the farms and summarise the essential information contained in the other variables. As such, factor analysis will firstly be carried out (Section 6.6.1).
- Secondly, the selected set of farm characteristics will allow a check on the correlation between productivity and profitability performance of farms, and, with help of ANOVA, allows an assessment of those variables which differentiate significantly between productive and unproductive farms and between those that are profitable and unprofitable (Section 6.6.2).
- Thirdly, we are interested in comparing productivity and profitability results among different profiles (combinations of characteristics) of farms, to complement earlier knowledge by one-by-one comparison of structural variables on farm performance. For this purpose the Cluster analysis is used (Section 6.6.3).
- Finally, we look for the relative importance of farm characteristics in determining productive and unproductive farms. This will entail pool regression (cross-section and time-series) analysis (Section 6.6.4).

All the aforementioned techniques allow a verification of the hypotheses and answers to the research questions concerning differences between productive and unproductive farms. These differences lead to differences between farm competitiveness (because the farms do not differ greatly in terms of prices, their relative competitiveness is largely determined by productivity differences).

6.6.1 Initial categories of TFP determinants

Initially we included 63 variables which characterise the possible determinants of TFP, describing farm size, specialisation, techniques of production and all other categories which were discussed at the beginning of the chapter (the most important initially derived variables are presented in Appendix 6-1, Table A. 6-3). However, the number of variables then had to be narrowed down to a smaller set of factors which would summaries the essential information contained in all of the variables. For this purpose factor analysis was chosen as an appropriate statistical technique (a step-by-step explanation of this analysis is presented in Appendix 6-2).

Finally, the following set of farm characteristics was extracted from the IERiGŻ database in the course of the analysis, which could be classified most generally into 5 groups. The group of variables characterising ***size of farms and scale of production***, include: total farmed area (UTIL_UAA), total labour input (AWU), the value of gross output[40] (GROSSOUT) and total assets (TOTAS). The group characterising ***technologies*** including techniques of production and factor proportions cover: capital per labour measured as quantity of depreciation per annual work unit (DEPAWU) and land per annual work unit (LANDAWU) as well as shares of hired labour and rented land in total labour and land (PORPALAB and PORRESAU respectively). The group also includes degree of specialisation, which was measured as the share of crop output in the total value of output and by the Herfindahl index (PROCRO, HERFINDAHL). The third group accounts for ***human capital*** and includes farmer's agricultural education. The IERiGŻ survey classifies agricultural education into six categories with 1 equal to no education and 6 to higher education[41]. For the purposes of this analysis, information on education was recorded in three categories: EDUD1 no education; EDUD2 (initial categories 2, 3, and 4) medium education and EDUD3 (initial categories 5 and 6) high education. The fourth group covers ***financial indicators*** of farms' external financing (LEVERAGE, DEBTOAS, RENGO). The last group gathers other possible determinants: ***subsidies***, which are measured in terms of the value of current subsidies and as a percentage of the value of gross output (SUBNET and SUBOUTP respectively), ***soil quality*** of the farm and ***total rented land***. The quality of land was also divided into soil quality classes, based on values of the so-called soil quality index (or soil survey indicator[42]). Diminishing values represent decreasing soil quality. The range in the sample was between 0.15 and

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[40] Initially two values of output were calculated, one with direct subsidies and one without. As there were no differences between the two, given the very low level of direct subsidies only one variable for output is included in the results (GROSSOUT which includes direct subsidies).

[41] The numbers stated are for the following levels of the education: 1=no agricultural education, 2=agricultural courses only but ended with diploma, 3=basic agricultural school, 4=secondary agricultural school, 5=uncompleted higher agricultural education, 6=higher agricultural studies completed.

[42] The same index as the one published by GUS discussed earlier.

1.75. Within the IERiGŻ survey, the quality of a farm's soil was allocated into 6 classes. For this analysis soil was classified into three groups: bad quality, index below 0.45 (SOILQD1), medium quality in the range of index between 0.46-1.24 (SOILQD2) and good quality soil with a soil quality index in the range of 1.25-1.75 (SOILQD3). The whole set of variables and explanations are presented in Table 6-7.

The factor analysis led us to the final set of 7 factors, presented in Table 6-8. Factors are themselves homogenous but heterogeneous between each other. This means that the variables characterising the farms within the factors are 'substitutes' in explaining TFP (they are highly correlated and they carry the same information), but variables in different factors are complementary in characterising the farms as they are not strongly correlated and they contribute significantly different information on farm characteristics. The factors can be named after the most important variables which they represent.

Table 6-7 Variables included in the Factor and Cluster Analysis for the IERiGŻ Farm Sample, 1999

VARIABLES	EXPLANATION
SCALE OF FARM:	
GROSSOUT	Output including current subsidies
TOTAS	Total assets
AWU	Total labour (total annual work units)
UTIL_UAA	Total utilised agricultural area
TECHNOLOGIES:	
DEPAWU	Capital (depreciation) per unit of labour
LANDAWU	Land per unit of labour
PORPALAB	Percentage of paid labour
PORRESAU	Percentage of rented land
PROCRO	Percentage of crop production
HEFINDAHL	Herfindahl Index of specialization
FINANCIAL INDICATORS:	
LEVERAGE	Leverage
DEBTOAS	Debt to asset ratio
RENGO	Rents/rented land
HUMAN CAPITAL:	
EDUD1 (i)	Education level: no agricultural education
EDUD2	Education level: medium agricultural education
OTHER DETERMINANTS:	
SOILQD1(i)	Soil quality: poor
SOILQD2	Soil quality: medium
SUBOUTP	Percentage of the gross output coming from net current subsidies
SUBNET	Total subsidies for production and costs
LANDRENT	Rental (rents and interests paid)/gross output

(i) we do not include the highest education level and best soil quality to the factor analysis in order to keep reference categories (as always in case of dummies in this type of analysis)

Source: Author's own compilation

Factor 1 has five significant variables, all positive and mostly connected with the scale of production, such as: total output, total assets, total land and total labour. There is also a variable indicating the proportion of paid labour in total labour.

Therefore, the first factor could be named *size of farm*. **Factor 2** could be named *technology and techniques of production* because it gathers measures of production intensification, such as: land per AWU and depreciation per AWU. The name of **Factor 3** should be *financial situation,* because here are measures of financial indebtedness such as the debt to asset ratio and leverage, as well as the share of rental payments in gross output. **Factor 4** can be labelled *education*, as it gathers two levels of education: no agricultural education (EDUD1) and medium level education (EDUD2). This factor is negatively related to EDUD1 and positively to EDUD2, indicating that farms exhibit different behaviour depending on the level of education of their farm owner. **Factor 5** gathers *subsidies* in absolute and relative terms. **Factor 6** is related to *soil quality*: negatively with poor quality soils (SOILQD1) and positively with medium quality (SOILQD2). The last factor, **Factor 7**, gathers the proportion of rented land and rent paid, so can be labelled *rental factors*.

Table 6-8 Factor analysis for 1999

Variables/Factors:	1	2	3	4	5	6	7
GROSSOUT	**0.89**	0.15	0.15	0.06	0.03	0.04	0.15
TOTAS	**0.87**	0.27	0.05	0.07	0.04	0	0.15
AWU	**0.79**	-0.26	0.19	0.06	0.05	-0.02	0.12
UTIL_UAA	**0.74**	0.34	0.34	0.05	0.05	0	0.14
PORPALAB	**0.69**	0.16	0.15	-0.02	0.03	0.09	0
DEPAWU	0.32	**0.76**	-0.03	0.07	0.04	0.04	0.12
PROCRO	-0.07	**0.76**	0.07	-0.01	-0.08	0.02	0.09
HEFINDAHL	0.1	**0.73**	0.21	0.01	0.02	-0.04	-0.12
LANDAWU	0.33	**0.7**	0.31	0.06	0.02	0.03	0.1
LEVERAGE	0.29	0.16	**0.89**	0.04	0	0.06	0.02
DEBTOAS	0.33	0.16	**0.89**	0.05	0	0.07	0.04
RENGO	0.04	0.34	**0.57**	-0.06	0.01	-0.02	0.47
EDUD1	-0.09	-0.08	-0.05	**-0.96**	-0.01	-0.01	-0.02
EDUD2	0.03	-0.01	-0.01	**0.97**	0	-0.01	0.03
SUBOUTP	0.01	-0.01	-0.01	0.01	**0.97**	0.02	0.03
SUBNET	0.11	-0.01	0.02	0	**0.96**	-0.02	0.04
SOILQD1	-0.04	-0.11	0.02	-0.02	0	**-0.9**	-0.08
SOILQD2	0.04	-0.09	0.11	-0.03	0	**0.89**	-0.05
LANDRENT	0.16	0	-0.09	0.09	0	0.04	**0.84**
PORRESAU	0.22	0.09	0.36	-0.03	0.09	-0.01	**0.64**
Eigenvalue -15.67%	5.842	2.106	1.874	1.741	1.587	1.354	1.17
% variance -78.37	29.21	10.53	9.37	8.71	7.93	6.77	5.85

Source: Author's own calculations

To conclude, we ended up with 7 groups of characteristics which are the most important and which are believed to summarise the essential information contained in the initial large set of variables. These groups are size, specialisation, financial situation, education, subsidies, soil quality and rental factors. From these groups the variables which will best characterise the profile of the most productive and profitable farms are selected.

6.6.2 Productivity and profitability results for individual farm characteristics

The productivity and profitability scores can be analysed by considering their relationship to the structural characteristics selected in the previous section. We are interested here if farm characteristics, such as size, techniques of production, financial condition etc. are significantly different determinants of productive versus non-productive farms and in profitable versus non-profitable farms. For this purpose, one-way repeated analysis of variance (ANOVA) was applied (the step-by-step ANOVA analysis is presented in Appendix 6-3).

The analysis led us to the following results. Differences in means according to all size measures between the groups of the productive and not productive farms are significant (Table 6-9). Productive farms tend to be larger, have a higher share of paid labour and rented land and are more specialised in crop production. They have more land per labour unit and are more capital intensive, which is represented by a higher depreciation per AWU ratio. These results are in line with Mech's (1999) findings that larger Polish farms are more productive.

Table 6-9 Productivity, ANOVA analysis, 1999

	TFP1 (all estimated costs)			TFP2 (only paid costs)		
	<1	>1	F	<1	>1	F
No. Farms	633	346	-	601	378	-
UTIL_UAA	14.4	44.7	153.92***	15.4	40.5	105.43***
AWU	1.7	2.1	21.715***	1.7	2	16.487***
GROSSOUT	12.1	28.7	106.683***	13.2	25.5	57.084***
SUBNET	0.014	0.029	3.035*	0.015	0.027	2.111
TOTAS	65.1	123.2	118.955***	69.1	112.1	64.184***
PORRESAU	13	23.9	57.108***	13.3	22.5	41.547***
PORPALAB	3.7	11	80.225***	4.2	9.6	44.741***
PROCRO	0.4	0.6	347.144***	0.4	0.6	311.804***
HERFINDAHL	0.5	0.7	242.017***	0.5	0.7	208.799***
SUBOUTP	0.014	0.026	1.886	0.014	0.025	1.801
DEPAWU	4.1	7.9	159.581***	4.4	7.1	80.125***
LANAWU	8.2	21.1	209.609***	8.6	19.4	144.018***

*** significance at 1%, ** 5%, *10%

Source: Author's own calculations

Table 6-10 Cross Tabulations for productivity and qualitative farm characteristics, 1999

	TFP1 (estimated costs)		TFP2 (paid costs)	
	<1	>1	<1	>1
Education (%)				
No education	36.4	23.4	35.6	25.7
Medium level education	60.3	66.5	60.7	65.3
High education	3.3	10.1	3.7	9
Pearson Chi-Square	31.181***		19.558***	
Soil quality (%)				
Poor soil	10.7	3.5	11.1	3.4
Medium quality	82	77.5	81.4	78.8
High quality	7.3	19.1	7.5	17.7
Pearson Chi-Square	42.325***		38.318***	

***significance at 1%

Source: Author's own calculations

Farmer education level and soil quality are also significantly related to farm productivity (Table 6-10). The more productive farms have a higher percentage of farmers with medium and higher education. A larger part of the productive farms operate on good quality soils and a smaller proportion operates on poor and medium soils.

Current subsidies, as measured here, are not an important factor in determining farm productivity (but this is due to specification of this measure, which takes into account only direct subsidies, which are generally small).

As indicated in Table 6-11, farms that were profitable (on both the P_CB and C_Rs ratios) were also significantly larger in terms of total assets, output and labour input. Profitable farms also use more rented land in absolute and relative terms. The farms which are profitable by the P_CB measure also tend to be more specialised, with a higher degree of specialisation in crop production and are also more capital intensive. There are no significant differences between profitable and unprofitable farms (on both ratios) with regard to direct subsidies. Again, given the very low level of direct subsidies in Poland this is not surprising.

Profitable farms also have a higher land to labour ratio and this is significant for both the P_CB and C_Rs measures. Regarding the categorical variables, for the P_CB ratio profitable farms are more likely to have better soils, as one may expect, and a higher level of farmer education (Table 6-12). Considering the C_Rs measure, by which a much higher proportion of farms are profitable, there are no significant differences in terms of education and soil type.

Table 6-11 Profitability, ANOVA analysis, 1999

	PC_B			C_Rs		
Mean	<1	>1	F	<1	>1	F
No. Farms	85	894	-	591	388	-
UTIL_UAA	77.8	20.1	203.502***	26.1	23.7	0.876
AWU	2.1	1.8	5.947**	2	1.6	44.983***
GROSSOUT	37.7	16.1	59.733***	21.4	12.7	29.017***
SUBNET	0.039	0.018	2.332	0.023	0.015	0.878
TOTAS	164	78.2	87.558***	90.1	78.9	4.11**
PORRESAU	32.1	15.4	45.758***	17.8	15.3	3.109*
PORPALAB	16.3	5.3	60.887***	6.5	5.9	0.53
PROCRO	0.8	0.5	345.159***	0.5	0.5	18.534***
HERFINDAHL	0.8	0.6	370.877***	0.6	0.6	0.09
SUBOUTP	0.029	0.017	0.703	0.02	0.015	0.477
DEPAWU	10.9	5	131.794***	4.6	6.9	56.113***
LANAWU	36.9	10.5	337.818***	12.1	13.8	3.447*

*** significance at 1%, ** 5%, *10%

Source: Author's own calculations

Table 6-12 Cross Tabulations of profitability and qualitative farm characteristics, 1999

	PC_B		C_Rs	
	<1	>1	<1	>1
Education (%)				
No education	17.7	33.1	29.8	34.8
Medium level education	69.4	61.9	64.5	59.5
High education	12.9	5	5.8	5.7
Pearson Chi-Square	15.036***		2.767	
Soil quality (%)				
Poor soil	1.2	8.8	6.8	10.3
Medium quality	77.6	80.6	82.1	77.8
High quality	21.2	10.5	11.2	11.9
Pearson Chi-Square	13.374***		4.212	

***significance at 1%

Source: Author's own calculations

The above analyses allows us to start evaluating the hypotheses outlined earlier. The claim is as follows.

After the above analysis one can accept the first part of Hypothesis 3 by saying that, indeed, there are significant differences in characteristics between productive and unproductive farms.

One should note also that the results of ANOVA have some limitations due to the data problems referred in Appendix 6-3, therefore, further analysis is desired not only to expand the analysis on the subject but also to confirm the ANOVA results.

Having analysed the profitability and productivity of Polish farms through the construction of approximate indexes and assessed their relationship with the structural characteristics of farms through a set of initial tests, the next section proceeds to multivariate analysis.

6.6.3 Profiles of productive and unproductive farms

In the previous section, the significance of differences in TFPs with respect to single farm characteristics was tested. This section tests the differences in productivity taking the whole set of farm characteristics (made of a combination of single characteristics) into account. Hence, the homogenous groups of farms based on factors derived in Section 6.6.1 are selected in order to discover which of those groups (profiles) are characteristic for productive farms versus non-productive farms. This will allow us to verify the second part of the hypothesis stated earlier in the chapter.

In order to identify these profiles, cluster analysis was chosen[43], which is detailed in Appendix 6-4. In the course of the analysis, 7 clusters were identified (see Table 6-13, Table 6-14, and Table 6-15). Each cluster is examined for its explanatory credibility in terms of farm performance in relation to productivity, profitability and income[44].

Cluster 1: These are small mixed production farms. They have the smallest utilised agricultural area and second smallest total assets and gross output. Their land and capital intensification measures are also low (land area per work unit and depreciation per work unit). These farms are family farms that neither use much outside labour nor rented land (the average shares of paid labour and rented land are below the sample average). They have low debts as they have not sought or gained access to external funding to develop their businesses. This cluster incorporates farms with owners that tend to be non-educated (97.2 per cent) (Table 6-15). The farms operate primarily on medium quality soil (Table 6-14). The farms in this cluster are characterised by low productivity and are unprofitable (according to all profitability indicators). Their productivity and profitability ratios are one of the worst in the total

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[43] The strength of cluster analysis is that it identifies groups of objects with the maximum homogeneity within groups, while having maximum heterogeneity between groups, hence allowing for identification of unique profiles (Hair et al., 1998).

[44] Here we add a new variable indicating the income,and farm net value added per annual working unit (VADAWU).

sample. They also have a low level of income per family work unit. More than a quarter of all our farms have this profile.

Table 6-13 Cluster analysis for the 1999 Sample and farms performance indicators

Cluster	1	2	3	4	5	6	7	Mean	F (1)
Number of Farms	252	377	67	79	135	19	50		
UTIL_UAA	14.55	15.17	52.99	17.19	38.85	65.93	75.91	25.11	41.931
TOTAS	62.85	63.54	147.75	56.67	142.54	160.51	148.03	85.66	40.027
GROSSOUT	11.39	12.17	26.56	8.65	34.7	38.6	44.81	17.96	37.224
PORPALAB	4.11	4.05	13.12	2.73	9.46	14.99	18.59	6.28	20.198
PORRESAU	11.76	10.59	13.82	14.43	35.18	35.19	40.76	16.83	43.357
LANDRENT	0.04	0.03	0.03	0.03	0.27	0.09	0.07	0.07	181.202
AWU	1.7	1.72	1.36	1.72	2.36	3.05	2.68	1.85	19.992
LANDAWU	8.17	9.06	35.79	9.48	15.59	16.64	29.07	12.76	66.501
DEPAWU	3.85	4.29	14.65	3.76	7.33	6.4	7.42	5.47	83.195
PROCRO	0.45	0.45	0.91	0.4	0.53	0.38	0.61	0.49	82.768
HERFINDAHL	0.55	0.56	0.86	0.57	0.57	0.6	0.68	0.59	130.368
SUBNET	0	0	0	0	0.01	0.83	0	0.02	769.205
SUBOUTP	0	0	0	0	0.01	0.76	0	0.02	351.892
DEBTOAS	0.02	0.02	0.04	0.01	0.03	0.06	0.22	0.03	190.103
LEVERAGE	0.02	0.02	0.05	0.01	0.04	0.07	0.29	0.04	183.774
RENGO	0.01	0.01	0.03	0.02	0.04	0.03	0.08	0.02	48.835

	1	2	3	4	5	6	7	Mean	F (1)
VADAWU	5.72	7.19	14.38	3.01	14.81	13.59	16.92	8.64	24.671
TFP (all costs)	0.79	0.84	**2.15**	0.63	**1.14**	**1.16**	**1.76**	1	73.503
TFP (paid costs)	0.71	0.78	**2.41**	0.55	**1.25**	**1.3**	**2.01**	1	97.065
P_CB	4.98	3.96	1.11	5.94	2.47	2.35	1.53	3.83	12.215
C_R	1.01	0.96	1.18	1.14	0.97	0.94	1.01	1.01	7.561
C_Rs	1.01	0.96	1.18	1.14	0.97	0.93	1.01	1.01	7.597

(1) significant at 1%

Source: Author's own calculations

Cluster 2: These farms are similar to those in Cluster 1, small in terms of land, output, assets and labour. They are mixed farms also relying on family resources, their shares of rented land and paid labour being even lower than the farms in cluster 1. These farms do have a lot of external financing. Their indicators of land and capital-intensive techniques are low. They differ from cluster 1 in terms of owners' level of education. Here the farmers primarily have medium-level education (almost 98%) (Table 6-15) and medium soil quality (92%) (Table 6-14). Not surprisingly, their performance indicators are poor, though better than in Cluster 1. These are low productive farms but can cover their costs if own resources are not valued (note that if the costs are valued by shadow prices then all the clusters are unprofitable, which is indicated by P_CB>1) and they have higher value added per annual work units than in cluster 1. This kind of profile is the most frequent in the overall sample (377 farms are in this cluster) (Table 6-13).

Cluster 3: This is a group of relatively large farms in terms of all indicators of size. They specialise in crop production (91% of the output), have the largest land area per work unit and are also relatively capital intensive (a depreciation per unit of labour nearly three times higher than the sample average). Most of this land is owned and the share of rented land (13.8 %) is lower than the sample average. They have the highest share of the best quality soil in the sample (30% of the farms in the cluster). The farms in this cluster rely more on debt financing than farms in clusters 1 and 2 and their financial indebtedness is close to the average of the sample. The farm owners in this group cover the whole range of educational levels, but with a relatively large representation of high level education (19.4%) and medium level education (65.7%) (Table 6-15).

These are the most productive farms of all and have one of the highest value added per labourer. However, surprisingly, at the same time, many are not profitable.

Cluster 4: These are mixed farms and the smallest in the sample in terms of total assets, gross output and percentage paid labour and one of the smallest in terms of land area. Most of the land (84%) is owned. Land and capital per work unit are low. These farms tend not to rely on credits. Farmers in this group have mainly medium level education (62%), but nearly 37% have primary level education. This cluster has the worst profitability and productivity in the sample. It has almost three times lower value-added per labourer than the sample average. The farms in cluster 4 represent 8% of the sample farms.

Cluster 5: These farms are the most similar to the sample average, particularly concerning specialisation, subsidies and financial indicators. They have, however, double the average percentage of rented land and therefore pay more in rents. In this cluster all educational levels are presented, 12% of the farmers have primary level education, 78.5% have medium level education and the rest have higher level education. Soil quality is medium and high. These farms obtain the highest income per family work unit and one of the highest averages for value-added per work unit. They are both productive and profitable.

Cluster 6: These are the second largest farms if measured by most of the size indicators. Their prevailing specialisation is in livestock. This group has more external financing and liabilities than the average. It also has significantly more rented land. These farms receive the highest amount of current subsidies and subsidies per unit of output. Nevertheless, the percentage of output coming from subsidies is negligible, at 0.8 %, compared with the sample average of 0.02 %. All three types of education are presented in this cluster, but most of all, the medium level. Farms in this cluster are also drawn from all soil quality groups. These farms are also both productive and profitable showing in both slightly better results than those in cluster 5. This however is the smallest cluster (19 farms).

Cluster 7: This is a cluster with the largest farms (76 ha on average). They do not rely only on family resources. These farms hire 19% of their labour force and rent 41% of their land area and use their total labour input. They have the second largest ratio of land and depreciation per working unit. They are slightly more specialised than the average in crop production. They do not use subsidies, but rely most heavily amongst the sampled farms on loans. The farms in this cluster have on average 22% and 29% debt to assets and leverage respectively (the sample average is 3 % and 4 % respectively). This cluster includes farmers from each of three categories of agricultural education, but the share with high education is the highest in the sample (22%). Soil quality is mainly medium. These farms are the second best group in terms of productivity. They obtain the highest level of value-added value per labour. However, these farms are just on the break-even point of profitability.

We can divide all the 7 profiles of farms according to their productivity and profitability performance[45] into four groups: (i) productive and profitable (Cluster 5, Cluster 6, Cluster 7); (ii) productive but unprofitable (Cluster 3); (iii) unproductive but profitable (Cluster 2), and (iv) unproductive and unprofitable (Cluster 1, Cluster 4). In the first group, these are the farms which were most probably leaders in our previous analysis and have been shifting the production frontier in the sector. Unfortunately, all the farms in these groups together account only for 21% of the total sample.

Table 6-14 Classification of Soil Quality by Cluster Groups for IERiGŻ Farm Sample, 1999

SOILQ	Clusters	1	2	3	4	5	6	7	Total
Low	Count				79		1		80
	% row				98.8		1.3		100
	% column				**100**		**5.3**		**8.2**
	% of Total				8.1		0.1		8.2
Medium	Count	232	346	47		100	16	46	787
	% row	29.5	44	6		12.7	2	5.8	100
	% column	**92.1**	**91.8**	**70.1**		**74.1**	**84.2**	**92**	**80.4**
	% of Total	23.7	35.3	4.8		10.2	1.6	4.7	80.4
High	Count	20	31	20		35	2	4	112
	% row	17.9	27.7	17.9		31.3	1.8	3.6	100
	% column	**7.9**	**8.2**	**29.9**		**25.9**	**10.5**	**8**	**11.4**
	% of Total	2	3.2	2		3.6	0.2	0.4	11.4
TOTAL	Count	252	377	67	79	135	19	50	979
	% row	25.7	38.5	6.8	8.1	13.8	1.9	5.1	100
	% column	100	100	100	100	100	100	100	100
	% of Total	25.7	38.5	6.8	8.1	13.8	1.9	5.1	100

Source: Author's own calculations

45 We will assess the profitability based on cost-revenue ratios C_R and C_Rs, which were calculated based on the paid costs only because according to P_CB (which included evaluation of the own factors) all clusters were unprofitable

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1023.982	12	0
Likelihood Ratio	591.511	12	0
Linear-by-Linear Association	4.781	1	0

Source: Author's own calculations

Table 6-15 Classification of agricultural education by cluster groups

EDU	**Clusters**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
None	Count	245		10	29	16	4	7	311
	% row	78.8		3.2	9.3	5.1	1.3	2.3	100
	% column	**97.2**		**14.9**	**36.7**	**11.9**	**21.1**	**14**	**31.8**
	% of Total	25		1	3	1.6	0.4	0.7	31.8
Medium	Count		368	44	49	106	13	32	612
	% row		60.1	7.2	8	17.3	2.1	5.2	100
	% column		**97.6**	**65.7**	**62**	**78.5**	**68.4**	**64**	**62.5**
	% of Total		37.6	4.5	5	10.8	1.3	3.3	62.5
High	Count	7	9	13	1	13	2	11	56
	% row	12.5	16.1	23.2	1.8	23.2	3.6	19.6	100
	% column	**2.8**	**2.4**	**19.4**	**1.3**	**9.6**	**10.5**	**22**	**5.7**
	% of Total	0.7	0.9	1.3	0.1	1.3	0.2	1.1	5.7
TOTAL	Count	252	377	67	79	135	19	50	979
	% row	25.7	38.5	6.8	8.1	13.8	1.9	5.1	100
	% column	100	100	100	100	100	100	100	100
	% of Total	25.7	38.5	6.8	8.1	13.8	1.9	5.1	100

Source: Author's own calculations

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1023.982	12	0
Likelihood Ratio	591.511	12	0
Linear-by-Linear Association	4.781	1	0

Source: Author's own calculations

On the other extreme are farms in the fourth group. As they have problems both with productivity and profitability, their future looks highly unpromising and they will most probably have to transfer out of the sector. They represent 34% of all farms in the total sample. For the other two groups prospects are slightly better but they have to improve productivity or profitability, which may not be easy in either case. These are farms which have to transform if they want to stay in the business. Most probably, those farms which are productive but unprofitable have a better chance of survival if their profitability problems have been transient e.g. due to incurred investments. The other group may be in a worse situation. If its positive profitability results from savings due to delayed investments they may quickly lose profitability and become both unprofitable and stay unproductive, and such behaviour is unsustainable.

If one takes together all the profiles prevailing for the most productive farms (clusters 3, 5, 6 and 7) one can see that they have some common features which distinguish them from the other groups. Clearly, these are usually relatively large farms both in terms of size of the land and of finances (output, assets). Usually, they rely more on off-farm labour and usually also on rented land, though this is true for clusters 5, 6, and 7 but not in the case of the most productive cluster 3 (which has less rented land than unproductive cluster 4). Productive farms also greatly differ from the others in terms of using more land and capital intensive (as such less labour-intensive) techniques of production and generally higher specialisation of production. These farms are also usually more financially indebted than the average farms and have a significantly larger share of higher educated owners than unproductive farms (in case of the former the range is from 9.6%-22%, while in the latter groups this ranges from 1.3% to 2.8%). There are, however, some distinctive features of each of the productive clusters, for example, cluster 3 has the least labour intensive production, cluster 6 definitely relies the most of all on subsidies and cluster 7 is the most financially indebted of all clusters. On the other hand, one can see that some features between the productive and unproductive farms are similar. For example, in one of the most productive clusters (cluster 7) the share of medium and high quality land is almost the same as in the least productive clusters (clusters1 and 2) and the total labour force in most productive clusters is closer to that in unproductive ones than in other productive farms.

The above findings lead to a verification of the second part of the third hypothesis.

Acceptance of the second part of Hypothesis 3 leads to the conclusion that there is no unique profile of productive and unproductive farms (we found t four different productive clusters), though clearly some features are more prevalent for those which are productive (for example larger size), while others are for unproductive farms (for example a higher reliance on own labour, which, on average, is less educated compared to productive farms).

6.6.4 Relative importance of factor productivity determinants

In the previous sections we examined TFP determinants, and found out which variables tend to improve TFP and which contribute to its deterioration. However, those analyses did not allow for an assessment of the relative significance of the variables in determining the productivity of the farms. Therefore, this section is designed to fill in this gap with use of a pooled regression model (i.e. combined cross-section and time-series regression used in the case of panel data).

After the process of model specification (see Appendix 6-5), the results obtained (Table 6-16) seem to be robust. The model explains 46% of the total variation in TFP, which is a satisfactory fit for pooled regression analysis and the significance of the explanatory variables is also good. All the explanatory variables have the expected direction of influence on TFP (the signs of coefficients are as expected) which are consistent with our results from previous sections and with economic theory, and hence can be logically explained.

Again, significant determinants of productivity occurred: size of the farms, techniques of production (factors proportions), specialisation/concentration, quality of inputs (education level and soil quality) and, in addition, land fragmentation (measured by number of plots).

Financial indebtedness (leverage) and subsidies (subsidies per output), both of which were negligible in the case of Polish farms (as discussed earlier), were also insignificant. The regression findings confirm those from previous analyses (ANOVA, factor and cluster analyses) in that respect.

In the next part, however, the relative importance of those variables in explaining productivity is explored.

Table 6-16 Determinants of Total Factor Productivity

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-1.035092	0.105327	-9.827417	0.000
SOILQD1	-0.402305	0.031507	-12.76865	0.000
SOILQD3	0.340718	0.026903	12.66452	0.000
EDUD1	-0.060221	0.01911	-3.151185	0.002
EDUD3	0.100721	0.039884	2.525347	0.012
LOG(TOTAS)	0.155789	0.015792	9.865304	0.000
LOG(HERFINDAHL)	1.366199	0.055607	24.56871	0.000
LOG(LANDAWU)	0.468089	0.017073	27.41718	0.000
LOG(DEPAWU)	-0.217089	0.018168	-11.94899	0.000
LOG(LEVERAGE)	0.000494	0.000883	0.559468	0.576
LOG(PORPALAB)	0.00563	0.000683	8.246866	0.000
LOG(PORRESAU)	0.002339	0.000658	3.5554	0.000
LOG (SUBOUTP)	-0.001967	0.001347	-1.460185	0.144
LOG(PLOTS)	-0.026314	0.012482	-2.108182	0.035
R-squared	0.457265	Mean dependent var.		-0.278
Adjusted R-squared	0.455716	S.D. dependent var.		0.779
S.E. of regression	0.574737	Sum squared resid.		1504.952
F-statistic	295.2709	Prob(F-statistic)		0.000

(i) Dependent Variable: LOG (TFP)
(ii) Panel data of 4570 obs, years 1996-2000
(iii) Method of estimation: Pooled Least Squares
(iv) White Heteroskedasticity-Consistent Standard Errors & Covariance

Source: Author's own calculations

The most important determinant positively contributing to TFP is ***specialisation*** of production, measured here by Herfindahl index. Its high influence on productivity may be able to grasp to some extent the fact that more specialised farms are usually also more technologically advanced and therefore also more productive. However, as was explained in Chapter 5, the farms which specialised in some activities with one distinguishing activity were able to improve their productivity faster than those which specialised solely in a single activity, as probably the former could better diversify the risk concerned with specialisation (risk that the single specialisation may become unprofitable).

A very significant determinant of TFP is also ***quality of inputs***. The model clearly shows that the farms with owners who have no agricultural education and which operate on poor quality land tend to have lower productivity than those which are managed by farmers with high agricultural education and located on the best quality land. This is quite an obvious result because higher education allows for better management of farms, and, as was shown in Chapter 5, a serious problem in Polish farms is their low 'pure' technical efficiency, which results from poor management practices. As such, improvement in education level (which is generally very low compared to that in the cities) would contribute to improvement in productivity. Poor soil quality also obviously hampers total factor productivity by negative effects on land productivity.

The next group of serious determinants of productivity is linked to ***techniques of production***. On average, farms which have more land-intensive techniques (indicated by higher LANDAWU) tend to be more productive than capital intensive ones. In the case of the former, land intensive techniques are correlated with farm size and types of activities. Crop farms are usually larger and also have more land per labour and, therefore, their higher productivity may stem directly from economies of scale, or indirectly from the fact that larger farms have better access to capital, so they invest more in technology and improve their productivity. The phenomenon of lower productivity of more capital intensive techniques of production was addressed earlier. More capital per labour (DEPAWU) in individual Polish farms is not necessarily an indicator of better technology, but shows rather that the farms are overcapitalised, which together with the small size of farms implies inefficient use of this capital (in the sense that it is not fully exploited). Another reason may in fact be that the capital is old and strongly depreciated. Farms prefer to buy cheap, second-hand machinery and keep it for themselves rather than buy new machines and share them with each other. As a result, capital per farm is large (as is shown later, it is larger than in other CEECs) and efficiency of such production is lower. As such, the negative correlation of capital use with productivity may stem both from inefficient allocation of capital and its ageing.

The determinant of productivity connected with ***farm size*** (here measured by total assets) also has a positive influence on TFP, as we might have expected from previous analyses. It is probably also the case in terms of exploiting effects of scale, being better-off and having more resources for investments. As was shown before

(Chapter 5), in the group of larger farms it is the strongest group of leaders which push the technology (production frontier) upwards.

Another, very Poland-specific, determinant contributing to a deterioration in productivity is the large ***fragmentation of farms***. Farms tend to consist of many plots which are sometimes very far from one to another. This has historical roots and customs (of marriage and heritage, for example). This portioning of land and the persistence of a large number of plots do not help in increasing productivity because they bring many organisational problems as well as waste of time, energy, fuel, etc. This may be one more argument in favour of land consolidation in Poland.

Far less important but still significant is the ***proportion of external production factors.*** From this analysis one can conclude that off-farm labour and off-farm land tend to increase productivity of farms, however only slightly. This conclusion does not mean that generally off-farm labour is better than family labour. On the contrary, as has been indicated in various studies (Latruffe, et al. 2003), generally in transition countries, family labour has been superior to paid labour. What this thesis's results indicate is that it is beneficial if a family type of farming is only to some extent supported by off-farm factors, and by this we mean leasing of better land or employing an educated manager to help in running the farm.

Finally, one comes to variables which were insignificant in determining productivity - ***financial indebtedness*** and ***subsidies***. Theoretically, we would have expected leverage (indicators of financial position and external debt) to be positively related to productivity, since farms would be expected to take credits for investments. Indeed, in this analysis it has had a positive sign, though statistically has been insignificant. This may result from the fact that Polish farms have very small financial burdens (credits), insufficient to improve productivity. The problem with crediting agricultural investments seems to be on both sides, demand (farmers are afraid of taking credits given the tendency to declining profitability in the sector) and supply (banks are not eager to offer such credits for agricultural investments as they perceive it to be more risky) - this problem was addressed in Chapter 4. So banks try to avoid a high risk of insolvency of farms, and most farms are not solvent or credible to take the credit. However, this analysis only looks at data on credits longer than one year, and farms may have some shorter credits which are not considered, and which may positively influence productivity if they positively affect liquidity, and in turn creditworthiness and investment. As for subsidies, they are also rather insignificant in the farm accounting in this form as they tend not to be subsidies which farmers obtain but only those obtained directly, and then only in an occasional manner (as discussed earlier).

Analyses to this point enable us to verify the last hypothesis. One can state that:

Hypothesis 4 can be accepted, as there are many significant productivity determinants and they largely differ in relative importance (the range of regression coefficients is wide) and, for example, specialisation has an effect on TFP several times stronger than farm size.

Despite accepting all the hypotheses and carrying out all the calculations, two more issues need addressing here. Firstly, a return to economies of scale, as it was a controversial issue in the literature and hence worth comparing these results with those of others. Secondly, a comparison of the Polish results with other candidate and EU countries. Having the opportunity to participate in the international project IDARA (5th EU framework project) this author has been able to compare the studies with similar ones carried out for the Czech Republic, Hungary, Spain (Navarra region) and England (south-east England). Hence, the last two sections of this chapter are devoted to these issues.

6.6.5 Productivity and scale of production

One of the most interesting and debatable questions in the literature on agricultural economics is whether productivity of producers increases with scale of production. In the case of Polish farms opinions differ, although underpinned by deep studies. Various authors, like van Zyl, et al.(1996), claim that there are no effects of scale in Polish farms, while others, like Mech (1999) and Davidova, et al. (2001) and Lerman (2002) claim to have revealed contrary evidence, empirically proving positive relations between size and productivity in Poland.

Analysing Polish productivity performance depending on farm size is significant from the policy point view point in the context of sufficient farm size to guarantee a minimum level of profitability in the longer perspective and competitiveness vis-à-vis much larger European farms. Besides, it is interesting to contribute to the public debate on the subject especially that there are various differing opinions on this in the literature. Therefore, despite having already pointed out the importance of farm size for productivity improvement, this issue is briefly addressed again from a slightly different perspective.

As indicated in Table 6-17 and Figure 6-3, there is evidence to suggest that larger farms in hectares are also more productive. In each of the analysed years the highest relative productivity was in the largest farms and the smallest in the smallest farms. The smaller the size in the group, the lower the relative TFP, except for the two medium groups 5-10 ha and 10-15 ha, whose productivities were relatively the same in each year. Besides, only the group of the largest farms (over 15 ha) was able to be productive over the whole analysed period, which was not the case in other groups which were below the productivity average level (threshold) of 1. The most stable in relative productivity was the group between 2-5 ha (the productivity almost did not change), which may indicate that there was a kind of stand still in this one of the smallest groups. Middle size groups' (5-10 ha and 10-15 ha) relative productivities were also fairly stable in the period after the decline in 1998. Interestingly, the smallest and the largest farm groups experienced significant drops in relative productivity in 1999-2000, though this did not change the overall ranking of TFPs between the groups (right-hand chart in the Figure 6-3).

A similar picture can be drawn from Table 6-18 and Figure 6-4, where size is measured by total assets instead of physical size. It is clear that the largest farms were the most productive ones during the period, while the smallest were not productive in any of the analysed years. The difference lies, however, in the two further large farm categories (second and third), because they were able to maintain their productivities over the whole analysed periods, and the third was on a threshold, while in total land categories only the largest farms were productive over the entire period. Given that between 1996 and 2000 the TFP Index rose with farm size, measured by both land size and farms' total assets, this confirms the research of those authors who claim to have found a positive relationship between productivity and farm size.

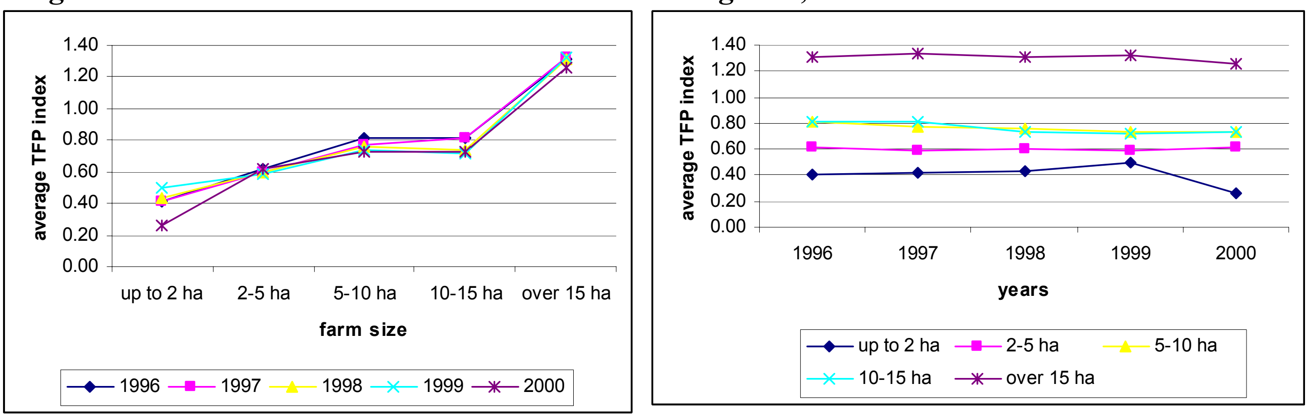
However, this series of TFP indices is relatively short. This author attempted to compare the results with findings from a similar study carried out earlier by Mech (1999), which also calculated static TFP Tornqvist Indices for Poland and also on the IERiGŻ sample for the years 1988-1994 (Table 6-19). Despite some differences between the studies (such as number of farms analysed, slightly different input and output coverage, etc.) the basic methodologies are very similar, which allows one to compare the studies (although not without some caution).

Table 6-17 TFP Index in the different land size categories, 1996-2000

	up to 2 ha	2-5 ha	5-10 ha	10-15 ha	over 15 ha
1996	0.41	0.61	0.81	0.81	1.31
1997	0.42	0.59	0.77	0.81	1.33
1998	0.43	0.60	0.76	0.74	1.31
1999	0.50	0.59	0.74	0.72	1.33
2000	0.26	0.62	0.73	0.73	1.25

Source: Author's own calculations based on the IERiGŻ sample

Figure 6-3 TFP Index in the different land size categories,1996-2000



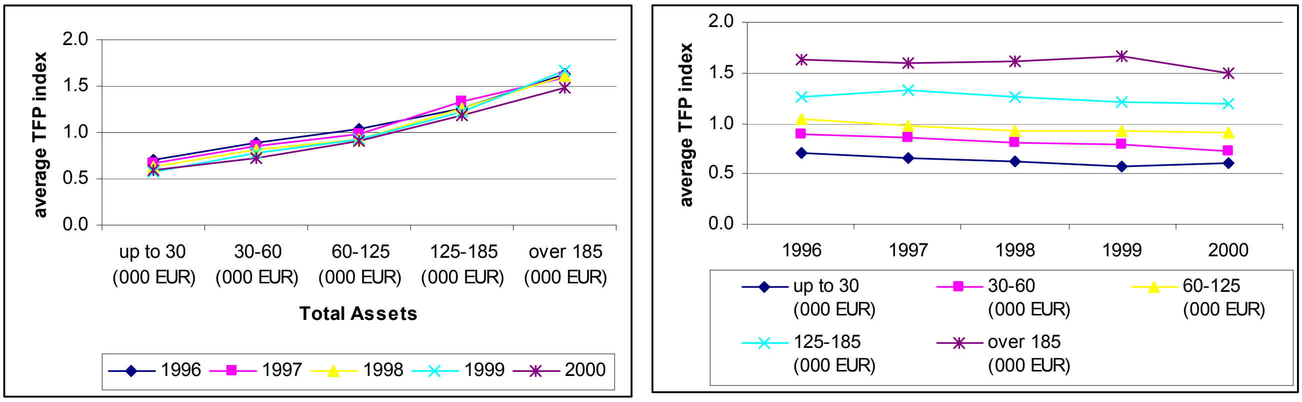
Source: Based on the

Table 6-18 TFP Index in the different financial size categories (Total Assets), 1996-2000

	up to 30 (000 EUR)	30-60 (000 EUR)	60-125 (000 EUR)	125-185 (000 EUR)	over 185 (000 EUR)
1996	0.7	0.9	1.0	1.3	1.6
1997	0.7	0.9	1.0	1.3	1.6
1998	0.6	0.8	0.9	1.3	1.6
1999	0.6	0.8	0.9	1.2	1.7
2000	0.6	0.7	0.9	1.2	1.5

Source: Author's calculations

Figure 6-4 TFP Index in the different financial size categories (Total Assets), 1996-2000



Source: Based on the Table 6-18

First of all, it is clear that both studies again show that larger farms are more productive than smaller ones. Secondly, it seems that productivities of farms were generally higher in the pre-transition period and in the early 1990s than in the mid-1990s up to 2000 (although this is not certain as the fall in productivity after 1994 probably to a large extent resulted from the change in the methodology between the studies). Thirdly, only two groups of the largest farms were productive from the pre-transition period up to the mid-1990s, and only the group of the largest farms was productive for the entire period 1988-2000. What is more, only the group of the largest farms was able even to increase its productivity in the late 1990s compared to the pre-transition period. The rest of the farm groups did worse in the late 1990s compared to the beginning. In particular, the group of the smallest farms, which was productive in the pre-transition period, became unproductive after 1989 (Table 6-19).

Table 6-19 TFP Indices in different land size categories - comparison of Mech (1999) and our study

	1-3 ha	3-7 ha	7-10 ha	10-15 ha	over 15 ha
			Results by Mech (1999)		
1988	1.01	0.8	0.96	1.07	1.15
1989	0.97	0.75	0.97	1.05	1.26
1990	0.91	0.8	0.99	1.1	1.2
1991	0.81	0.86	1.0	1.11	1.21
1992	0.80	0.82	0.98	1.14	1.27
1993	0.76	0.83	0.97	1.14	1.3
1994	0.83	0.83	0.98	1.12	1.23
			Resuts from our thesis		
1996	0.49	0.70	0.85	0.81	1.31
1997	0.42	0.67	0.83	0.81	1.33
1998	0.43	0.68	0.81	0.74	1.31
1999	0.48	0.62	0.82	0.72	1.33
2000	0.43	0.67	0.76	0.73	1.25

Source: Mech (1999) and author’s own calculations

6.7 Productivity of Polish farm in international comparison

It is interesting to compare the performance of Polish farms with their counterparts in other CEECs and the EU countries. A reasonably straightforward comparison is possible thanks to research carried out within the IDARA Project[46] where a similar methodology was applied to four other countries: the Czech Republic, Hungary, south-east England and Spain (Navarra region).

Before comparing the TFP and profitability performance of the farms in these countries/regions, one needs some understanding of the main differences and similarities in the farm structures of the countries. Generally speaking, they fell into three categories according to size (measured by average agricultural land and financial variables as output and assets): the largest farms with adominance of co-operative ownership were in the Czech Republic, medium size farms prevailed in Hungary and S.E. England, while the smallest, individual farms were in Poland and Navarra (see Table 6-20)[47]. Obviously, farm size structure was largely determined by ownership structure in those countries that underwent transition and post-transition

[46] The EU Commission's 5th Framework Programme IDARA (Strategy for Integrated Development of Agriculture and Rural Areas in CEE Countries), QLRT-1526

[47] For all the countries data comes from FADN.

land reforms. As such, large farms emerged from the dominance of co-operatives in the Czech Republic and Hungary, and small farms from private ownership in Poland.

Table 6-20 Comparison of farm structure in the analysed CEE and EU countries

	Czech R	Hungary (i)	Poland	Navarra (Spain)	S.E. England
Average land per farm (ha)	658	202	25	50	141
Average output (EUR) (ii)	532,665	224,073	18,000	97,000	399,753
Average total assets (EUR)	870,542	204,484	86,000	292,000	1,345,154
Average total assets per ha (EUR)	1,450	1,977	3,440	5,840	9,540
Land rented (%)	76	42	17	45	34
Hired labour (%)	50	31	6	10	53
Land per Labour (ha/AWU)	38	53	13	36	41
Capital per Labour (EUR/AWU)	2,421	2,427	1,294	6,281	7,810
Average annual wage paid (EUR per paid labour)	3,552	3,490	2,308	12,312	18,790
Average Labour per farm	32	7.45	1.85	1.49	6.35

(i) For Hungary 2000.
(ii) Output includes net current subsidies.

Source: Based on Davidova et al., (2002)

Large differences were also found in the capitalisation of farms. Polish farms have more assets per ha than farms in the other CEECs. This partially stems from the long Polish tradition of independent farming, where despite being small farms each wanted to its have own machinery. However, farms in the EU are generally much better capitalised than farms in CEECs. The farms of S.E. England have assets per ha three times higher than that in Poland.

The farms differed considerably in terms of their reliance on external land and labour. Poland differed the most in terms of external land, with only 17% rented, while in the other countries this share ranges from 34% in S.E. England to 76% in the Czech Republic. The differences among CEECs seem to come from different initial conditions and farm reforms, but the difference between Poland and small farms in Navarra results rather from differences in the functioning of land markets and from the fact that in the Navarra region are located less favourable areas (mountains), so consolidation of farm land in order to achieve an optimal farm size is even more needed. All in all, family farms in Navarra have three times as much land per labour as in Poland although the average size of farm is twice of that in Poland.

While the Polish and Navarran farms almost entirely use family labour (in 94% and 90% respectively), the Hungarian, British and Czech farms hire on average 31%, 50% and 53% off-farm labour respectively. This is largely determined by ownership structure. Individual farms generally rely heavily on own family labour. There is a clear and obvious difference in average annual wages of off-farm workers between the countries, with wages much higher in the EU member states than in the three accession countries (Table 6-20).

The number of full-time working people (family and hired combined) on the farm also differs significantly between individual farming and other farms, where the former uses on average less than 2 full-time work units (in Poland 1.85 and in Spain 1.49), while in other farms in other countries it ranges from 6 to 32 full-time work units). These figures reveal the scale of hidden unemployment, as for example in Poland, farming required almost 2 full-time working units, while on average there were about 3 people working on each farm (so almost every third family member was not needed and could work out of the farm).

All these differences in characteristics must have determined the differences in productivity performance among the farm discussed below.

One should recall that TFP scores calculated by the Tornqvist-Thail index are expressed in relation to the average farm in the sample (as discussed in the methodological section of this chapter and in Chapter 4). As in each country the average farm is different, one cannot compare the farms directly based on the level of their productivity indices. However, one can compare internationally the shares of farms with high TFP scores and profiles of the most productive farms in each country.

Among all three candidate countries Poland has the lowest share (35%) of productive farms, compared to 46% in the Czech Republic and 44% Hungary. If all countries are compared, Navarra has the smallest share of productive farms, with only 29%. The share of land in the hands of the most productive farms in Poland (63%) is almost the same as in Hungary (64%) and larger than in the Czech Republic (53%). In contrast, the share of output in the most productive farms in Poland is much lower than that in Hungary (and close to that of the Czech Republic, as indicated in Table 6-21.

In Poland, the most productive farms took up more than half of all subsidies, while in other countries this reliance on subsidies ranged from 26% in S.E. England to 49% in Hungary. However, one should bear in mind that the absolute level of subsidies per farm was much smaller in Poland than in other countries, so in fact the most productive farms actually had smaller amounts of subsidies than other countries.

Table 6-21 Farm Productivity in the CEEC and EU countries (TFP with estimated own factors' costs)

	Czech R	Hungary	Poland	Spain	S.E. England
No of productive farms (TFP>1)	381	488	346	106	86
Share of productive farms (as % of total number of farms)	46	44	35	29	47
Share of land in hands of productive (as % of total land)	53	64	63	29	38
Share of sample output in productive farms (as % of total output)	60	85	56	37	69
Share of sample subsidies in productive farms (as % in total amount of subsidies)	46	49	52	33	26

Source: Based on Davidova et al. (2002)

As there are such significant differences in the structures of farms between the countries it is not surprising that there is no single, unique, profile of the most productive farms which would suit all the countries together. Generally, one can say that the line of similarities between profiles of the best performers in productivity is linked with ownership structure, in other words, the profile of the most productive farms is similar in Poland and Navarra (Spain) and differs from that in the Czech Republic and Hungary.

One similar feature of all productive farms in each country is their large size (Table 6-22). For the Czech Republic and Hungary their almost total reliance on rented land and hired labour as well as on external financing (crediting) is similar. Subsidies seem not to determine the productivity of the farms in these two countries, as they are close to the average.

Table 6-22 Profiles of the most productive farms, the international comparison of farm clusters

	Czech Republic	Hungary	Poland	Spain
Size	Large	The largest	Large	Large
Management form	Co-operatives	Corporate	Individual	Individual
Specialization	Not specialised	Mixed	Crop	Crop
Rented Land	97%	95%	14%	32%
Hired labour	100%	100%	13%	29%
External Indebtedness	Large	Large	Average	Below average
Reliance on subsidies	Close to average	Above average	Average	Above average

Source: Based on Davidova et al. (2002)

Family farming in Poland and Spain proved more productive in case of farms specialised in crop production. Reliance on off-farm and hired labour in these two countries was much smaller than in the previous two countries, although in Poland both shares (of rented land and hired labour) were two times smaller than in Spain.

In all the countries, except Poland, the most productive farms were also profitable. As was explained earlier, profitability is conceptually close to competitiveness and is also strongly combined with productivity, so it is not surprising they tend to go together in these countries, given that this is a normal and long-term relationship. The Polish outcome, however, is difficult to explain. Generally, a situation when farms are productive but not profitable may occur only in the short to medium term as in the longer run it is unsustainable. As was discussed earlier, this situation could result from farms' decisions to invest and develop farm production (and productivity) even if it does not bring immediate profitability. Such behaviour seems justifiable in times of crises, when there is an expectation of the nearby recovery. Polish farms are of course operating in a difficult (crisis) situation, and hope for recovery may stem from the upcoming accession to the EU and joining the Common Agricultural Policy. Nevertheless, other productive groups of farms (clusters) in Poland turned out to be profitable.

6.8 Conclusions

- This chapter has attempted to shed light on the productivity differences between individual farms in Poland. Utilising farm survey data, ratios of agricultural productivity and profitability have been estimated and clusters of farms with different profiles have been identified. Thus, two last hypotheses were verified.
- Evidence clearly indicates that there are significant differences in the characteristics of productive and unproductive farms. There are, however, no unique profiles of productive versus unproductive farms (we identified four clusters of productive farms and three,unproductive). However, productive farms are larger, use less-labour intensive techniques, are more specialised (especially in crop production) and have better quality labour and land.
- The relative importance of determinants of TFP differs to a large extent. Among the significant variables, those which have the largest impact on productivity are specialisation, quality of land, level of education, techniques of production and size. Fragmentation or share of rented and hired off-farm inputs had a much smaller impact. Subsidies and financial indebtedness were insignificant. The latter appeared to be especially telling because it reveals one more obstacle to productivity, as insignificance of credit financing (which should be highly significant) indicates problems with credit markets.
- Productivity results are generally not optimistic, as the percentage of productive farms is still strikingly low. Those variables which turned out to significantly and importantly hamper TFP will be very difficult to remove as they are usually not only costly and time consuming but also depend on other sectors' policy. Such an example is education. No agricultural education hampers productivity, while high education improves it. But given the overall low level of farmer education in Poland, one can see that it is a long-term impediments to productivity growth and highly dependent on overall education reform.
- For many of farmers, due to the current structure of their farms, small and often operating on bad quality soils, the main question might be how to transfer out of the sector or at least diversify into non-agricultural activities (either through employment or enterprise diversification).

Appendix 6-1 Shadow prices for profitability and productivity indicators

The initial data did not include a national rent for owned land and wages for non-paid labour input. However, since own factors of production are important in farm production, these factors should also be evaluated according to the rule that they should bring returns at opportunity costs. Therefore, for non-paid land and labour input a set of shadow prices was estimated using different regional averages derived from the sample. Family labour was valued using the average farm unit labour costs in each voivodship, which served as an approximation of the local labour market. The results are presented in Table A. 6-1.

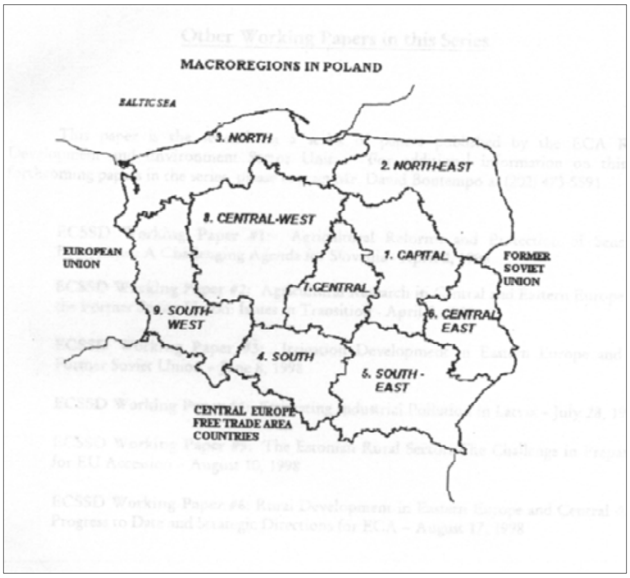
Table A. 6-1 Wages (per hour) of working units for calculating shadow prices for own labour

Voivodships	2000	1999	1998	1997	1996	Average
Dolnośląskie	9.1	11.1	9.6	7.9	7.8	9.1
Kujawsko-pomorskie	10.9	9.0	9.1	8.4	6.8	8.8
Lubelskie	11.3	9.5	7.3	6.9	5.9	8.2
Lubuskie	10.1	8.4	9.3	9.6	6.1	8.7
Łódzkie	9.8	11.5	7.9	7.6	6.5	8.7
Małopolskie	12.7	11.1	10.7	9.5	7.3	10.3
Mazowieckie	9.3	8.0	9.8	7.0	6.4	8.1
Opolskie	9.2	8.0	7.0	7.4	7.5	7.8
Podkarpackie	10.3	10.1	8.8	10.0	6.3	9.1
Podlaskie	8.1	8.7	9.0	7.2	5.5	7.7
Pomorskie	9.0	8.6	7.8	6.6	6.5	7.7
Śląskie	13.5	12.9	13.0	10.1	9.3	11.7
Świętokrzyskie	9.4	9.1	11.3	8.7	5.2	8.7
Warmińsko-mazurskie	9.9	9.6	10.3	8.7	6.5	9.0
Wielkopolskie	9.7	9.2	8.5	8.0	6.8	8.4
Zachodniopomorskie	10.5	12.4	8.5	8.0	7.5	9.4

Source: Author's calculations based on the IERiGŻ sample

As far as own land was concerned, shadow prices depended on whether or not the farm rented additional land or only used its own. If a farm had a mix of rented and owned land, the rent paid was imputed to owned land, as it was assumed that rented and own land were in close proximity, thus, were of a compatible quality and unit value. If a farm did not rent land, then the average regional rent was applied to the owned land. For the land, unlike for the labour, the macroregions of fairly homogenous land quality were selected, and not voivodships, for regional averages. The macroregions were distinguished by the Polish Institute of Agricultural and Food Economics (IERiGŻ) according to natural conditions for farming, such as soil, water, and climate, as well infrastructure development and sociological profiles. The regions are depicted in Table A. 6-1.

Map A. 6-1 Macroregions and voivodships in Poland



Source: IERiGŻ

The averages for factors based on macro-regions are found in Table A. 6-2.

Table A. 6-2 Averages of factor prices for calculation shadow prices

	2000			1999			1998			1997			1996			Average		
Macro-regions	Wage	Interest Rate	Land Rent	Wage	Interest Rate	Land Rent	Wage	Interest Rate	Land Rent	Wage	Interest Rate	Land Rent	Wage	Interest Rate	Land Rent	Wage	Interest Rate	Land Rent
Capital	9.9	19.0%	0.131	8.1	17.2%	0.129	10.8	25.9%	0.109	6.9	13.9%	0.119	6.5	9%	0.087	**8.5**	**17%**	**0.115**
(St Deviation)	7.1	0.2676	0.116	2.5	0.2488	0.097	12.2	0.4699	0.078	1.5	0.1578	0.100	2.3	0.050	0.050	**5.1**	**0.239**	**0.088**
North-East	9.3	29.8%	0.105	9.4	14.2%	0.097	9.9	14.3%	0.100	8.2	17.8%	0.083	6.2	18%	0.081	**8.6**	**19%**	**0.093**
(St Deviation)	3.0	0.5402	0.073	2.7	0.1253	0.084	3.9	0.1188	0.080	2.3	0.3881	0.068	1.9	0.211	0.063	**2.7**	**0.277**	**0.074**
North	9.6	18.6%	0.092	10.8	15.6%	0.116	8.1	13.3%	0.102	7.2	16.1%	0.111	7.1	39%	0.084	**8.6**	**20%**	**0.101**
(St Deviation)	2.5	0.2158	0.064	10.8	0.1813	0.147	4.2	0.0854	0.112	3.1	0.3241	0.111	6.0	0.720	0.068	**5.3**	**0.305**	**0.100**
South	12.2	16.0%	0.134	10.8	36.9%	0.130	10.4	12.9%	0.134	9.2	17.5%	0.111	8.4	23%	0.095	**10.2**	**21%**	**0.121**
(St Deviation)	5.2	0.1644	0.107	4.2	0.8527	0.104	4.3	0.0980	0.092	3.3	0.1826	0.086	2.9	0.283	0.099	**4.0**	**0.316**	**0.098**
South-East	10.7	18.5%	0.157	10.3	18.3%	0.138	10.3	34.9%	0.140	9.4	16.9%	0.142	6.6	18%	0.140	**9.5**	**21%**	**0.143**
(St Deviation)	4.5	0.1894	0.121	3.7	0.2724	0.084	3.5	1.2057	0.079	3.4	0.1652	0.094	2.2	0.266	0.104	**3.5**	**0.420**	**0.096**
Central-East	11.3	42.5%	0.153	9.5	15.5%	0.138	7.5	13.5%	0.162	6.9	11.6%	0.155	5.9	30.8%	0.161	**8.2**	**23%**	**0.154**
(St Deviation)	12.9	1.0063	0.103	8.1	0.1955	0.096	2.8	0.1273	0.108	3.4	0.1097	0.120	2.3	0.6533	0.109	**5.9**	**42%**	**0.107**
Central	9.2	20.3%	0.112	10.4	25.4%	0.119	7.8	21.4%	0.124	7.5	21.6%	0.096	6.4	20.6%	0.106	**8.3**	**22%**	**0.111**
(St Deviation)	2.8	0.2654	0.092	11.3	0.4743	0.102	2.2	0.2401	0.114	2.0	0.2287	0.065	3.0	0.2295	0.076	**4.3**	**29%**	**0.090**
Central-West	10.2	45.7%	0.208	9.1	16.7%	0.207	8.6	24.2%	0.205	8.0	12.1%	0.201	6.8	14.0%	0.155	**8.5**	**23%**	**0.195**
(St Deviation)	4.7	1.5278	0.135	2.8	0.2526	0.152	4.0	0.8930	0.140	3.0	0.1050	0.139	2.3	0.1332	0.116	**3.4**	**58%**	**0.136**
South-West	9.4	36.7%	0.166	9.9	17.8%	0.157	9.2	14.4%	0.159	8.3	14.7%	0.147	7.3	13.8%	0.128	**8.8**	**19%**	**0.152**
(St Deviation)	2.9	0.6470	0.162	7.9	0.1521	0.168	4.0	0.1159	0.155	3.0	0.1458	0.138	3.4	0.1173	0.127	**4.2**	**24%**	**0.150**
National Average	**10.2**	**29.3%**	**0.146**	**9.8**	**18.7%**	**0.143**	**9.1**	**20.5%**	**0.143**	**8.0**	**15.5%**	**0.134**	**6.8**	**20.2%**	**0.119**	**8.8**	**21%**	**0.137**
(St Deviation)	5.7	0.8204	0.119	6.6	0.3398	0.125	5.1	0.6107	0.117	3.0	0.2237	0.113	3.1	0.3622	0.102	**4.7**	**47%**	**0.115**

Source: Author's calculations based on the IERiGŻ sample

Table A. 6-3 Selected main ratios derived and calculated base on the IERiGŻ database

Labels of variables	Explanations
AWU	annual working units = number of hours spent on farming/2200, where 2200=275 working days * 8hours
BAL_CURR	current subsidies
CostRev	(interm consumption+cost of labour+depreciation+rents+interest)/total output
CostRevS	(interm consumption+cost of labour+depreciation+rents+interest)/total output+subsidies
DEBTOAS	liabilities / total assets
DEPAWU	depreciation / awu
DEPAWU	depreciation per awu
FWU	family working units (FWU=number of hours spent by family on farming / 2200)
GROSSOUT	gross output
HERFINDAHL (*)	[(crop output)^2+(livestock output)^2+othe output^2)] / (tot outp^2)
INTERM_C	intermediate consumption (total phisical inputs)
LAB_COST	annual cost paid to hired labour
LANDAWU	total utlised agricultural area per awu
LANDRENT	rents / rent_uaa
LEVERAGE	liabilities / networth
Liabilities	liabilities - own capital
NetWorth	total assets - labilities + own capital
OUTSTR	crop output / total output
P_CB	intermediate cons.+depreciation+labour costs+rents+cost of own labour and land / total output
PaidAWU	awu-fwu
PORPALAB (% of paid labor)	(awu-fwu)*100/awu
PORRESAU (% of rented land)	rented land*100/util_uaa
RENGM	rental/(grossout-bal_curr-interm_c)
RENGO	rental/(grossout-bal_curr)
Rent_UAA	rented utilised agricutlural area
SUBOUTP	subsidies*100/grossoutput
TOTAS	total assets
UTIL_UAA	utilised agricultural area

(*) Note: the Herfindahl Index is constructed as proposed by Tanic (1999), and Goodwin and Schroeder (1994), measuring a concentration of production:

$$SI = \sum_{i=1}^{n} \left[\frac{S_i}{\sum_{i=1}^{n} S_i} \right]^2$$

where SI is the specialisation index and S_i is the share of the i^{th} activity in total activities of the farm. The index varies between 0 and 1, with higher values indicating higher specialisation. For example, a value of 1 of the index indicates single type of activity (the highest specialisation), while a value of 0 means no production.

Appendix 6-2 Steps in Factor Analysis

The method of factor extracting adopted here is Principal Components with varimax rotation. Before coming up with the result of 7 factors (as presented in Table A. 6-11) the analysis was carried out several times, in an iterative procedure combined with cluster analysis, therefore, some feedback from the latter affected the factors, as will be seen below. Different sample sizes (with gradually deleted outliers), variable sets (those which were insignificant were deleted), and intermediate solutions were analysed before a final satisfactory solution was obtained (as presented in Section 6.6.1 in the main body of the text). The procedure was carried out as follows.

A number of assumptions and practical considerations underlying the application of Principal Components were taken into account during the process. Among them were required: minimum sample size, normality, linearity, elimination of outliers among cases, factorability of the correlation matrix, elimination of outliers among variables. The above statistical assumptions impact factor analysis to the extent that they affect the derived correlations, e.g. departure from normality, and linearity can diminish correlations between variables. Therefore they were verified one by one in the analysis.

Sample size

A minimum of five subjects per variable is required for factor analysis. A sample of 100 is acceptable, but sample sizes of 200+ are preferable. Since we have 1001 observations per variable, this assumption is satisfied without any problems.

Normality

Factor analysis is robust in terms of assumptions of normality (i.e. that data are from a normally distributed population). However, if variables are normally distributed, then the solution is enhanced. In order to check for normality first we visualised the analysed variables in various graphs, namely histograms, normal Q-Q plots and boxplots. At first glance it seemed that all distributions were only similar to normal but not ideally normal. There were obviously skeewness and kurtosis in all of them, but they looked quasi normal in the sense that they were unimodal and in most cases grouped in the centres and fewer in extreme cases. However, some variables were much more like normal than others, e.g. the most normal appeared to be distribution of labour (AWU), total assets (TOTAS), specialisation in crop production (OUTSTR), and capital per labour (DEPAWU) while far less normal appeared to be: share of rented land and hired labour (PORRESAU and PORPALAB), net subsidies (BALL_CURR) and subsidies per output (SUBOUTP). Graphs were helpful, but did not answer the question if distributions were close enough to normality, therefore we needed to use various tests. The suggested test, for large samples which is also available in SPSS, is the Kolmogorov-Smirnov test (Field, 2000). This test compares the set of scores in the sample to a normally distributed set of scores with the same mean and standard deviation. If the test is non-significant (p>0.05) it tells us that the distribution of the sample is not significantly different from a normal distribution. The results for our variables in interest are presented in Table A. 6-4, where one can see that all variables are actually significantly different from normality (even those which looked quite normal from visual interpretation).

Table A. 6-4 Test of normality

	Kolmogorov-Smirnov a)	
	Statistic	Sig.
UTIL_UAA	0.269	0.000
GROSSOUT	0.245	0.000
TOTAS	0.181	0.000
AWU	0.089	0.000
PORPALAB	0.311	0.000
PORRESAU	0.225	0.000
BAL_CURR	0.521	0.000
SUBOUTP	0.516	0.000
OUTSTR	0.109	0.000
MYHERFIN	0.207	0.000
LANDAWU	0.225	0.000
DEPAWU	0.163	0.000
DEBTOAS	0.277	0.000
LEVERAGE	0.309	0.000
RENGO	0.271	0.000
EDUD1	0.435	0.000
EDUD234	0.406	0.000
SOILQD1	0.535	0.000
SOILQD2	0.493	0.000
LANDRENT	0.269	0.000

a Lilliefors Significance Correction

Source: Author's calculations

In order to asses further the size and nature of this deviation from normality skewness and kurtosis z-statistics (which standardises the results) and other descriptive statistics were analysed together. Standardisation is needed because our data are measured in different units which make them difficult to compare in terms of their distributions. The z-scores are calculated for skewness (Sk) and kurtosis (K) in the following way:

(6-8) $$Z_{Sk} = \frac{Sk - mean}{SE_{Sk}} \quad , \quad Z_K = \sqrt{\frac{K - mean}{SE_K}}$$

where: $mean$ is a distribution mean, SE_{Sk} is a standard error for the skewness, and SE_K is a standard error for the kurtosis.

Values of skewness and kurtosis should be zero if the observed distribution is exactly normal, and z-statistics should be less than 1.96 (a critical value for alpha level of 0.05). Therefore, the further our results are from these, the higher non-normality of our data. The results are presented in Table A. 6-5.

Table A. 6-5 Descriptive statistics for the variables used in factor analysis, sample 1999

Number of	Minimum	Maximum	Mean	Std. Dev.	Skewness			Kurtosis		
obs. 979	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Z-score	Statistic	Std. Error	Z-score
UTIL_UAA	0.00	587.00	25.11	39.17	5.77	0.078	73.94	55.40	0.156	18.85
GROSSOUT	0.97	1065.47	75.91	107.11	4.01	0.078	51.38	21.82	0.156	11.83
TOTAS	22.00	2755.00	362.12	356.51	2.84	0.078	36.44	10.93	0.156	8.37
AWU	0.09	10.04	1.85	1.09	1.54	0.078	19.73	5.05	0.156	5.69
PORPALAB	0.00	88.87	6.28	12.73	2.98	0.078	38.14	10.21	0.156	8.09
PORRESAU	0.00	100.00	16.83	22.30	1.44	0.078	18.40	1.49	0.156	3.09
BAL_CURR	0.00	2.00	0.02	0.12	7.77	0.078	99.59	66.69	0.156	20.68
SUBOUTP	0.00	1.65	0.02	0.13	9.21	0.078	118.06	93.60	0.156	24.50
OUTSTR	0.02	1.00	0.49	0.21	0.72	0.078	9.22	-0.18	0.156	1.07
MYHERFIN	0.45	1.00	0.59	0.12	2.03	0.078	25.97	3.66	0.156	4.84
LANDAWU	1.09	253.71	12.76	14.70	6.57	0.078	84.19	81.79	0.156	22.90
DEPAWU	0.27	59.73	5.47	4.83	3.30	0.078	42.28	21.41	0.156	11.72
DEBTOAS	0.00	0.52	0.03	0.06	3.07	0.078	39.31	12.76	0.156	9.04
LEVERAGE	0.00	1.10	0.04	0.08	5.01	0.078	64.17	40.51	0.156	16.12
RENGO	0.00	0.39	0.02	0.03	4.65	0.078	59.59	34.92	0.156	14.96
EDUD1	0.00	1.00	-	-	-	-	-	-	-	-
EDUD234	0.00	1.00	-	-	-	-	-	-	-	-
SOILQD1	0.00	1.00	-	-	-	-	-	-	-	-
SOILQD2	0.00	1.00	-	-	-	-	-	-	-	-
LANDRENT	0.00	0.67	0.07	0.11	2.36	0.078	30.29	6.53	0.156	6.47

\- Statistics which do not have sense for dummies

Source: Author's calculations

The deviation from normality differs among the variables, and is similar to our expectations from the previous, visual, assessment of the data. The closest to normality are OUTRSTR, AWU and PORRESAU. Generally, the non-normality is quite high. Skewness is in all cases positive (i.e. pile-up of scores is on the left of the distribution) and kurtosis also differs from that of normal and is also positive (leptokurtic), which means that there are mostly 'pointy' distributions.
To summarise, as was mentioned at the beginning, the analysis of factors is not crucially dependent on normality of the data. Normality helps to obtain the results more easily, but if they are obtained without fulfilling the assumption there is not a problem. Of course, there are some other techniques which are far more sensitive to the non-normality of data, and then the problem is more serious. This is the case with ANOVA, which will be discussed in the next section.

Linearity

Because the factor analysis is based on correlations, linearity is important. Linearity here was assessed by viewing scatter plots of pairs of all variables in our set. Only those variables were selected whose associations were linear or approximately linear with most of other variables in the sample. As there is no universal test for assessing linearity we had to rely on graphical assessment.

Outliers among the cases

Because factor analysis is sensitive to outlying cases, they were identified and deleted. This was carried out together with procedures for identifying the number of clusters (as was mentioned before, the factor analysis was combined with cluster analysis, so to some extent the outcomes from the latter affect the former). The more precise description of the procedure will be presented in Appendix 6-4, where steps in cluster analysis are described.

Factorability of the correlation matrix

A correlation matrix that is appropriate for factor analysis need to have several sizeable correlations. There are several stages to verify them. The first step is a visual examination of the correlations in a simple correlation matrix, and identifying those that are statistically significant. Usually, correlations in excess of 0.3 are acceptable for further analysis. If none of such are found, then the PC is no longer a suitable method.

Table A. 6-6 shows the correlation matrix for 16 characteristics of farms. An examination of the matrix indicates that a considerable number (more than 50%) of correlations exceed 0.3 and thus the matrix is suitable for factoring and provides an adequate basis for proceeding to the next step, which is the empirical examination of adequacy for factor analysis on both an overall basis and for each variable.

Table A. 6-6 Correlation Matrix

Correlations

		AWU	UTIL_UAA	RENT_UAA	TOT_OUTP	BAL_CURR	TOTAS	GROSSOUT	TFPII	SOILQ	SUBOUTP	PORPALAB	PORRESAU	LANDAWU	DEPAWU	RENGO	MYHERFIN	AGE	PLOTS
AWU	Pearson Correlation	1.000	.642**	.476**	.700**	.167**	.736**	.701**	.237**	-.016	-.008	.544**	.223**	.083**	-.016	.079*	.034	-.003	-.052
	Sig. (2-tailed)	.	.000	.000	.000	.000	.000	.000	.000	.615	.812	.000	.000	.008	.603	.012	.284	.926	.098
	N	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001
UTIL_UAA	Pearson Correlation	.642**	1.000	.880**	.816**	.142**	.780**	.816**	.565**	.000	-.003	.542**	.396**	.646**	.326**	.281**	.257**	.008	-.040
	Sig. (2-tailed)	.000	.	.000	.000	.000	.000	.000	.000	.999	.935	.000	.000	.000	.000	.000	.000	.793	.211
	N	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001
RENT_UAA	Pearson Correlation	.476**	.880**	1.000	.652**	.071*	.567**	.652**	.503**	-.004	-.010	.460**	.591**	.646**	.287**	.347**	.239**	.016	-.025
	Sig. (2-tailed)	.000	.000	.	.000	.025	.000	.000	.000	.909	.747	.000	.000	.000	.000	.000	.000	.617	.425
	N	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001
TOT_OUTP	Pearson Correlation	.700**	.816**	.652**	1.000	.158**	.889**	1.000**	.436**	.060	-.010	.617**	.331**	.421**	.316**	.164**	.199**	.016	-.020
	Sig. (2-tailed)	.000	.000	.000	.	.000	.000	.000	.000	.058	.763	.000	.000	.000	.000	.000	.000	.623	.534
	N	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001
BAL_CURR	Pearson Correlation	.167**	.142**	.071*	.158**	1.000	.205**	.164**	.068*	.022	.784**	.084**	.028	.074*	.193**	.139**	.039	-.010	.046
	Sig. (2-tailed)	.000	.000	.025	.000	.	.000	.000	.032	.478	.000	.008	.381	.019	.000	.000	.220	.744	.142
	N	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001
TOTAS	Pearson Correlation	.736**	.780**	.567**	.889**	.205**	1.000	.889**	.442**	.092**	.040	.562**	.244**	.400**	.431**	.198**	.231**	-.001	-.014
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.	.000	.000	.004	.211	.000	.000	.000	.000	.000	.000	.964	.647
	N	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001
GROSSOUT	Pearson Correlation	.701**	.816**	.652**	1.000**	.164**	.889**	1.000	.436**	.060	-.005	.617**	.331**	.421**	.317**	.165**	.199**	.015	-.019
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.	.000	.058	.878	.000	.000	.000	.000	.000	.000	.625	.540
	N	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001
TFPII	Pearson Correlation	.237**	.565**	.503**	.436**	.068*	.442**	.436**	1.000	.271**	-.010	.402**	.303**	.655**	.397**	.311**	.629**	.003	-.012
	Sig. (2-tailed)	.000	.000	.000	.000	.032	.000	.000	.	.000	.758	.000	.000	.000	.000	.000	.000	.913	.697
	N	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001
SOILQ	Pearson Correlation	-.016	.000	-.004	.060	.022	.092**	.060	.271**	1.000	-.004	.024	-.016	.016	.102**	.060	.121**	.026	.053
	Sig. (2-tailed)	.615	.999	.909	.058	.478	.004	.058	.000	.	.887	.456	.622	.607	.001	.059	.000	.417	.093
	N	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001
SUBOUTP	Pearson Correlation	-.008	-.003	-.010	-.010	.784**	.040	-.005	-.010	-.004	1.000	-.011	.036	.052	.296**	.305**	.038	-.012	.057
	Sig. (2-tailed)	.812	.935	.747	.763	.000	.211	.878	.758	.887	.	.728	.262	.101	.000	.000	.235	.698	.073
	N	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001
PORPALAB	Pearson Correlation	.544**	.542**	.460**	.617**	.084**	.562**	.617**	.402**	.024	-.011	1.000	.224**	.277**	.212**	.142**	.264**	.006	-.034
	Sig. (2-tailed)	.000	.000	.000	.000	.008	.000	.000	.000	.456	.728	.	.000	.000	.000	.000	.000	.851	.276
	N	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001
PORRESAU	Pearson Correlation	.223**	.396**	.591**	.331**	.028	.244**	.331**	.303**	-.016	.036	.224**	1.000	.376**	.199**	.402**	.122**	.013	.015
	Sig. (2-tailed)	.000	.000	.000	.000	.381	.000	.000	.000	.622	.262	.000	.	.000	.000	.000	.000	.681	.646
	N	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001
LANDAWU	Pearson Correlation	.083**	.646**	.646**	.421**	.074*	.400**	.421**	.655**	.016	.052	.277**	.376**	1.000	.610**	.372**	.447**	.000	.004
	Sig. (2-tailed)	.008	.000	.000	.000	.019	.000	.000	.000	.607	.101	.000	.000	.	.000	.000	.000	.995	.902
	N	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001
DEPAWU	Pearson Correlation	-.016	.326**	.287**	.316**	.193**	.431**	.317**	.397**	.102**	.296**	.212**	.199**	.610**	1.000	.499**	.426**	-.020	.097**
	Sig. (2-tailed)	.603	.000	.000	.000	.000	.000	.000	.000	.001	.000	.000	.000	.000	.	.000	.000	.532	.002
	N	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001
RENGO	Pearson Correlation	.079*	.281**	.347**	.164**	.139**	.198**	.165**	.311**	.060	.305**	.142**	.402**	.372**	.499**	1.000	.326**	-.013	.016
	Sig. (2-tailed)	.012	.000	.000	.000	.000	.000	.000	.000	.059	.000	.000	.000	.000	.000	.	.000	.691	.615
	N	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001
MYHERFIN	Pearson Correlation	.034	.257**	.239**	.199**	.039	.231**	.199**	.629**	.121**	.038	.264**	.122**	.447**	.426**	.326**	1.000	-.019	-.014
	Sig. (2-tailed)	.284	.000	.000	.000	.220	.000	.000	.000	.000	.235	.000	.000	.000	.000	.000	.	.549	.655
	N	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001
AGE	Pearson Correlation	-.003	.008	.016	.016	-.010	-.001	.015	.003	.026	-.012	.006	.013	.000	-.020	-.013	-.019	1.000	-.034
	Sig. (2-tailed)	.926	.793	.617	.623	.744	.964	.625	.913	.417	.698	.851	.681	.995	.532	.691	.549	.	.283
	N	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001
PLOTS	Pearson Correlation	-.052	-.040	-.025	-.020	.046	-.014	-.019	-.012	.053	.057	-.034	.015	.004	.097**	.016	-.014	-.034	1.000
	Sig. (2-tailed)	.098	.211	.425	.534	.142	.647	.540	.697	.093	.073	.276	.646	.902	.002	.615	.655	.283	.
	N	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001	1001

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Source: Author's own calculations

The overall significance of the correlation matrix is verified using the Bartlett test of sphericity. This indicates, as in Table A. 6-7, that the correlations, when taken together, are significant at the 1% level and also the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy far exceeds the threshold of 0.6 (before we ended up with this level, some variables for which KMO did not meet threshold value were deleted). In addition, each of the variables also exceeded the threshold value, indicating that the reduced set of variables meets the fundamental requirements for factor analysis, which means that factorability is assumed. Also communalities shown in Table 6-8 indicate that total amount of variance that each variable shares with all other variables exceeds the threshold value of 0.5.

Table A. 6-7 KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.718***
Bartlett's Test of Sphericity	Approx. Chi-Square	14694.554***

*** significance at 1% level

Source: Author’s calculations

Table A. 6-8 Communalities for selected variables

Communalities	Initial	Extraction
UTIL_UAA	1	0.804
GROSSOUT	1	0.867
AWU	1	0.751
TOTAS	1	0.861
BAL_CURR	1	0.94
SUBOUTP	1	0.941
PORPALAB	1	0.535
PORRESAU	1	0.597
OUTSTR	1	0.601
MYHERFIN	1	0.595
LANDAWU	1	0.705
DEPAWU	1	0.702
DEBTOAS	1	0.926
LEVERAGE	1	0.912
RENGO	1	0.668
EDUD1	1	0.94
EDUD234	1	0.943
SOILQD1	1	0.823
SOILQD2	1	0.811
LANDRENT	1	0.751

Extraction Method: Principal Component

Source: Author’s calculations

Deriving Factors and Assessing Overall Fit

The correlation matrix which we finally obtained is then transformed through estimation of a factor (component) model to obtain a factor (component) matrix. The next step then is to decide on the number of factors to be retained for further analysis.

Table A. 6-9 contains the information on total variance explained by all factors and each separately, as it shows initial factor eigenvalues, percentage of variance explained and the cumulative percentages. The table suggests choosing 7 factors, because individual eigenvalues for each factor (component) exceed 1 up to the 7th factor, all other eigenvalues are below 1. This number of factors explains the satisfactory (over 50%) level of total variance, which is here 78.4%, of all 20 variables.

Table A. 6-9 Total Variance Explained by Factors

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variar	Cumulative %
1	5.842	29.212	29.212	5.842	29.212	29.212	3.729	18.647	18.647
2	2.106	10.532	39.743	2.106	10.532	39.743	2.663	13.315	31.962
3	1.874	9.37	49.113	1.874	9.37	49.113	2.398	11.991	43.954
4	1.741	8.705	57.818	1.741	8.705	57.818	1.902	9.511	53.465
5	1.587	7.933	65.751	1.587	7.933	65.751	1.892	9.462	62.927
6	1.354	6.772	72.524	1.354	6.772	72.524	1.615	8.075	71.002
7	1.17	5.848	**78.371**	1.17	5.848	78.371	1.474	7.37	78.371
8	0.858	4.29	82.661						
9	0.678	3.392	86.053						
10	0.521	2.605	88.658						
11	0.517	2.586	91.244						
12	0.455	2.273	93.517						
13	0.387	1.934	95.451						
14	0.273	1.365	96.816						
15	0.227	1.134	97.949						
16	0.123	0.615	98.564						
17	0.109	0.547	99.112						
18	8.69E-02	0.435	99.546						
19	7.26E-02	0.363	99.909						
20	1.82E-02	9.08E-02	100						

Extraction Method: Principal Component Analysis.

Source: Author's calculations

Interpreting the factors

After a satisfactory factor solution is derived, it is usually useful to assign some meaning to the factors. This process involves substantive interpretation of the pattern of factor loadings for the variables, including their signs, in an effort to name each of the factors. Before interpretation, a minimum acceptable level of significance for factor loading must to be selected. Here the cut-off point which was selected for all loadings was +/- 0.55 or above. All significant factor loading typically are used in the interpretation process, but variables with higher loading determine to a greater extent the factor.

Table A. 6-10, is a matrix of loadings or correlations between the variables and factors. 'Pure' variables should have loading of 0.35 or greater on only one factor. However, as we can see, variables such as the debt to asset ratio, leverage, annual work units (AWU) etc. have high loadings on more than one factor, and thus make interpretation of the output unclear. Therefore, we need to use a rotational procedure. Varimax rotation, where the factor axes are kept at right angles to each other, is the most frequently chosen, and therefore Varimax with Kaiser Normalization was applied here. The rotation should reduce or eliminate the number of complex variables and enhance interpretation. Indeed, the picture of factors is now much clearer (each variable is correlated above 0.35 with only one factor) as indicated in Table A. 6-11 and hence, allows for easier interpretation of the factors. Naming of the factors is carried out in Section 6.6.1 in the main body of the thesis.

Table A. 6-10 Unrotated component analysis factor matrix

	1	2	3	4	5	6	7
UTIL_UAA	**0.88**	0.07	0.02	-0.06	0.11	-0.10	-0.07
GROSSOUT	**0.81**	0.28	-0.01	-0.22	0.16	-0.25	-0.03
TOTAS	**0.80**	0.23	-0.05	-0.11	0.18	-0.35	0.00
DEBTOAS	**0.74**	-0.12	0.12	-0.14	-0.09	**0.51**	-0.25
LANDAWU	**0.72**	-0.34	-0.04	0.24	-0.03	-0.10	-0.04
LEVERAGE	**0.71**	-0.14	0.13	-0.13	-0.09	**0.53**	-0.27
PORPALAB	**0.63**	0.16	0.06	-0.18	0.07	-0.23	-0.14
DEPAWU	**0.59**	-0.30	-0.10	0.32	-0.02	-0.38	0.07
AWU	**0.57**	**0.50**	0.02	**-0.37**	0.20	-0.03	-0.06
RENGO	**0.56**	-0.28	0.15	0.11	-0.04	0.39	0.29
PORRESAU	**0.53**	0.06	0.13	0.00	0.02	0.29	**0.47**
BAL_CURR	0.17	**0.61**	0.30	**0.64**	-0.15	0.05	-0.08
SUBOUTP	0.08	**0.59**	0.29	**0.68**	-0.21	0.05	-0.06
EDUD1	-0.24	-0.20	**0.88**	-0.14	0.19	-0.15	0.05
EDUD234	0.13	0.23	**-0.90**	0.12	-0.17	0.16	-0.02
MYHERFIN	**0.46**	**-0.46**	-0.02	**0.35**	-0.02	-0.13	-0.19
OUTSTR	0.34	**-0.57**	-0.05	*0.34*	-0.07	-0.17	0.09
SOILQD2	0.09	0.05	0.16	**-0.34**	-0.80	-0.12	-0.05
SOILQD1	-0.16	0.03	-0.08	0.22	**0.82**	0.25	-0.11
LANDRENT	0.29	0.16	-0.07	-0.03	0.00	0.03	**0.80**
Extraction Method: Principal Component Analysis.							
a 7 components extracted.							

Source: Author's calculations

Table A. 6-11 Varimax rotated component analysis factor matrix with Kaiser Normalization

	1	2	3	4	5	6	7
GROSSOUT	**0.89**	0.15	0.15	0.06	0.03	0.04	0.15
TOTAS	**0.87**	0.27	0.05	0.07	0.04	0.00	0.15
AWU	**0.79**	-0.26	0.19	0.06	0.05	-0.02	0.12
UTIL_UAA	**0.74**	0.34	0.34	0.05	0.05	0.00	0.14
PORPALAB	**0.69**	0.16	0.15	-0.02	0.03	0.09	0.00
DEPAWU	0.32	**0.76**	-0.03	0.07	0.04	0.04	0.12
OUTSTR	-0.07	**0.76**	0.07	-0.01	-0.08	0.02	0.09
MYHERFIN	0.10	**0.73**	0.21	0.01	0.02	-0.04	-0.12
LANDAWU	0.33	**0.70**	0.31	0.06	0.02	0.03	0.10
LEVERAGE	0.29	0.16	**0.89**	0.04	0.00	0.06	0.02
DEBTOAS	0.33	0.16	**0.89**	0.05	0.00	0.07	0.04
RENGO	0.04	0.34	**0.57**	-0.06	0.01	-0.02	0.47
EDUD234	0.03	-0.01	-0.01	**0.97**	0.00	-0.01	0.03
EDUD1	-0.09	-0.08	-0.05	**-0.96**	-0.01	-0.01	-0.02
SUBOUTP	0.01	-0.01	-0.01	0.01	**0.97**	0.02	0.03
BAL_CURR	0.11	-0.01	0.02	0.00	**0.96**	-0.02	0.04
SOILQD2	0.04	-0.09	0.11	-0.03	0.00	**0.89**	-0.05
SOILQD1	-0.04	-0.11	0.02	-0.02	0.00	**-0.90**	-0.08
LANDRENT	0.16	0.00	-0.09	0.09	0.00	0.04	**0.84**
PORRESAU	0.22	0.09	0.36	-0.03	0.09	-0.01	**0.64**
Extraction Method: Principal Component Analysis.							
Rotation Method: Varimax with Kaiser Normalization.							
a Rotation converged in 6 iterations.							

Source: Author's calculations

Validation of Factor Analysis

Validation of the results is particularly important when one attempts to define underlying structure among the variables, as is wanted here. Optimally, it is based on another (confirmatory) factor analysis which can assess the stability of the results. One way is to make structural equation modelling, but this is rarely feasible. Another way is to carry out analysis on the same sample but split it into groups or on a similar sample. We have chosen the latter option, and carried out the factor analysis for another year, 2000. There were also 7 factors consisting of the same variables. This justified the stability of the results.

Appendix 6-3 Steps in ANOVA analysis

For the purpose of this analysis, a one-way ANOVA was selected as the appropriate technique to assess the significance of differences in characteristics between farms which differ in productivity and profitability. We are interested if structural variables such as size, specialisation, financial conditions etc. significantly discriminate between productive versus non-productive farms, and profitable versus non-profitable farms. We will use two measures for productivity and two for profitability. The farms are classified as productive if productivity measures are larger than 1 and unproductive otherwise, and for profitability, farms with results below 1 are profitable and non-profitable otherwise.

In ANOVA the null hypothesis states that all population means associated with each group or condition under investigation are the same. The hypothesis is verified based on the significance of the F-ratio[48], which like the t-test, measures the ratio of systematic variance to unsystematic variance. If the F-ratio is significant we reject the null hypothesis and assume that there are significant differences between the means of structural variables between the groups of productive versus non-productive farms, and the same with groups of profitable and nonprofitable farms.

Assumptions

Before we can carry out the analysis we have to check the assumptions. The assumptions under which ANOVA is reliable are the same as for all parametric tests, so data should be from a normally distributed population, the variance in each experimental condition should be fairly similar, observations should be independent and the dependent variable should be measured on at least an interval scale. Some of them were addressed in the previous section on Factor Analysis, although here we analyse again those which are crucial for the method (for which the methods is sensitive).

Normality

ANOVA requires the normality assumption, but as stated earlier, the distribution of our variables is not normal (only close to normal). In the literature it has been shown that the power of parametric tests is not affected by a violation of the normality assumption if the non-normality is solely due to skewness (Sharma, 1996). However, this is not the case, as it was shown in Section 6.6.3, because kurtosis causes problems to normality as well. Kurtosis affects the power of test statistics and this is even more severe for platykurtic (peaked or positive) distributions, as it is the case for our data. There is a problem then, but it is unclear how serious. Many studies have found that violation of the normality assumption does not have an appreciable effect

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48 $F = \frac{MS_M}{MS_R}$, where MS_M is a model mean squares and MS_R is a residual means squares.

on the Type I error[49] in ANOVA (Glass, Peckham, and Sanders 1992, Everitt 1979, Hopkins and Clay 1963, Marida 1971, and Olson 1974 – for precise references see Sharma, 1996). However, the problem will arise if an error of Type II occurs, then we will be suspicious as to the results in cases when tests indicate insignificance of variables.

One should mention here that one of the suggested solutions for non-normal data distribution is transformation of the data such that the distribution is normal. In general, the square root transformation works best for data based on counts, the logit transformation for proportions and the Fisher's Z transformation for correlation coefficient (Sharma, 1996), however we wanted to avoid the transformation in our ANOVA because it would complicate the interpretation of the results. Instead we tried a non-parametric test to check if our ANOVA results were reliable (as we will see further on in this section).

Homogeneity of variance

For ANOVA to be correct, the scores in each group should have homogenous variances, or in other words, equal covariance matrices (variance of the dependent variable should be the same for all the cells). In order to test if the assumption is satisfied we can apply the Levene's[50] test (Coakes and Steed, 1999) that is recommended for the univariate analyses for two measures of productivity and two of profitability (which we want to use in ANOVA). Each of the measures (TFP2 (all costs), TFP1 (paid costs), P_CB, C_Rs) divide the groups into productive versus non-productive as well as profitable and non-profitable, exactly as in the core idea of our ANOVA analysis. The Levene's test is similar to a t-test in that it tests the hypothesis that the variances in each of the two groups for all four measures are equal. Therefore, if Levene's test is significant at $p<0.05$ then we can conclude that the null hypothesis can be rejected and that the variances are significantly different.
As we can see in Table A. 6-12, the Levene's statistics are significant for all productive variables. Therefore, for these groups the assumption of homogeneity of variances has been violated.

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[49] Two types of errors are commonly made while testing hypothesis: Type I and Type II errors. 1/ The Type I error (usually labelled as the significance or alpha level of a given test statistics) is the probability of a false rejection of the null hypothesis due to chance. There are, however, two types of Type I error rate, the error rate in a single comparison (per comparison error rate) and cumulative effects of doing many separate tests (familywise error rate). 2/ The Type II error, usually represented by β, is the probability of failing to reject the null hypothesis when in fact it is false. The power of a test is given by $1- \beta$ and it is the probability of correctly rejecting the null hypothesis when it is false. If the power is low, then the probability of finding statistically significant results decreases. We want to have small alpha and a highly powerful test, therefore we have to be aware how violations of assumptions affect the two types of errors.

[50] The Levene test is a homogeneity-of-variance test which has the advantage that it is less dependent on the assumption of normality than most tests. For each case, it computes the absolute difference between the value of that case and its cell mean and performs a one-way analysis of variance on those differences (SPSS Help).

Table A. 6-12 Test of Homogeneity of Variances for productivity and profitability groups

	TFP2	*TFP1*	*P_CB*	*C_Rs*
	Levene Statistic	*Levene Statistic*	*Levene Statistic*	*Levene Statistic*
UTIL_UAA	162.443***	210.568***	223.078***	0.34
AWU	15.991***	30.7***	19.403***	0.073
GROSSOUT	56.456***	112.846***	36.925***	16.191***
BAL_CURR	7.678***	10.968***	8.42***	3.001*
TOTAS	64.786***	121.639***	77.103***	4.506**
PORRESAU	81.278***	109.808***	59.773***	0.126
PORPALAB	75.937***	136.812***	82.667***	0.079
OUTSTR	229.463***	211.31***	0.365	0.02
MYHERFIN	379.61***	432.916***	191.684***	2.979*
SUBOUTP	6.471***	6.589***	2.379	1.528
DEPAWU	84.767***	126.247***	61.482***	39.744***
LANDAWU	148.877***	166.163***	221.795***	6.923***

2 =paid costs
1=all costs

* significance at 10%, ** significance at 5%, *** significance at 1%, others - not significant

Source: Author's calculations

As for profitability, the situation is better because the assumption was not violated in the case of such variables as specialisation in crop production (OUTSTR) and share of subsidies in total output (SUBOUTP) for private cost benefit ratio (P_CB), and for all variables except gross output (GROSSOUTP), total assets (TOTAS), depreciation and land per annual work units (DEPAWU and LANDAWU respectively) in the case of the cost revenue ratio (C_Rs).

Violation of the equality of covariance matrices assumption affects Type I and Type II errors. However, simulation studies have found that the effect is much more severe for a Type I error than for the Type II error. The consequences depend on the significance of the influence. Research has shown that for equal group sizes the significance level is not appreciably affected by unequal covariance matrices, but this is not the case here (numbers of farms in each group are presented in Table A. 6-13). So for unequal group sizes, as ours, the consequences differ and depend on some features of the variance within the groups. From simulation analysis by Holloway and Dunn (1967), Hakstian, Road, and Linn (1979) sited in Sharma (1996), the findings are that the problem does severely affect the results if the test (here F-ratio) is conservative[51] and at the same time indicates a significance of variables, because the results would still become significant after transforming these variables to achieve equality of covariance matrices, and consequently the conclusions of the study will not change. However, the problem is when the test is conservative but at the same time indicates insignificance because then we cannot be sure if after assuring homogeneity it is still insignificant (it may become significant after data

[51] The test is conservative if the variability of the larger group is more than that of the smaller group.

transformation). There is also not a problem if the test is liberal[52] and at the same time indicates an insignificance, because even after transforming the data, the results will still be insignificant (Sharma, 1996). However, the analogous problem arises if the test is liberal but indicates significance (then we cannot be sure if after assuring homogeneity it is still significant, as it can become insignificant).

As presented in Table 6-13, for two indicators of productivity (TFP with paid costs only and TFP with all costs appraised) smaller groups have more variability than the larger groups. So the F- tests presented in Table A. 6-14 for the productivities and different farm characteristics are all liberal. This means that all insignificant variables, i.e. subsidies per output (SUBOUTP) and net subsidies (BALL_CURR) would stay insignificant even if the data were transformed to adjust for variance inequality. As for all significant variables in this case we cannot be sure if the results are significant due to the actual differences or due to chance because of the effect of the inequality of covariance matrices. However, it must be noticed that the level of significance generally is very high, more than 1%, so one can expect that even after adjusting for equal variances most of the results would stay significant. The chance of committing the Type II error is small.

Table A. 6-13 Variation of variables between the two size groups

	Farms 601	TFP2	Farms 378	Farms 633	TFP1	Farms 346	Farms 894	P_CB	Farms 85	Farms 591	C_R	Farms 338
	Std. Deviation	Sign	Std. Deviation	Std. Deviation	Sign	Std. Deviation	Std. Deviation	Sign	Std. Deviation	Std. Deviation	Sign	Std. Deviation
UTIL_UAA	16.91	<	56.01	14.91	<	57.89	24.92	<	90.46	33.54	<	46.46
AWU	0.9574	<	1.2471	0.9269	<	1.3047	1.0252	<	1.5805	1.0244	<	1.1199
GROSSOUT	86.49985	<	127.32991	71.53313	<	141.24097	98.07975	<	153.69115	114.51455	>	90.36856
BAL_CURR	0.11	<	0.14	0.11	<	0.15	0.12	<	0.16	0.13	>	0.11
TOTAS	270.47	<	439.27	237.34	<	466.91	310.96	<	574.56	373.64	>	327.13
PORRESAU	18.3966	<	26.4378	17.9421	<	27.2453	20.6493	<	31.5996	22.112	<	22.5272
PORPALAB	10.0994	<	15.4811	9.2982	<	16.3143	11.2523	<	20.7386	12.3453	<	13.3029
OUTSTR	0.13192	<	0.24581	0.13433	<	0.2463	0.18368	>	0.16388	0.21069	>	0.20846
MYHERFIN	6.10E-02	<	0.1547	6.08E-02	<	0.158	8.93E-02	<	0.1818	1.13E-01	<	0.1258
SUBOUTP	0.1041	<	0.1563	0.1045	<	0.1598	0.1229	<	0.1634	0.129	>	0.1236
DEPAWU	3.1997	<	6.292	2.9358	<	6.4038	4.197	<	7.2014	3.6196	<	5.9775
LANDAWU	5.889	<	20.8166	5.5298	<	21.1734	8.2734	<	33.7892	12.5124	<	17.4772

TFP2 =paid costs
TFP1=all costs

Source: Author's calculations

As for profitability measures, the situation is almost the same if it is measured by the P_CB however it is much different in case of the C_R. Then, the situation is much more conclusive because we have more variables for which (i) the F-tests is liberal and results are insignificant and those for which (ii) test is conservative and results are significant (see Table A. 6-13 and Table A. 6-14). In these cases we can be sure that the result of ANOVA, presented in Table A. 6-13, would not change even after solving the problem of heterogeneity of variance. Besides, there are many variables which satisfied the condition of homogeneity of variance as i was shown before. So

[52] The test is liberal if the variability of the smaller group is more than that of the larger group.

specialization in crop production (OUTSTR) and subsidies per output (SUBOUTP) would remain insignificant for the private cost benefit ratio (P_CB) because in these cases the assumption was satisfied. For the cost revenue ratio (C_R) the results of ANOVA as expressed in Table A. 6-13 are reliable for most of the variables because they satisfied the condition of homogeneity (see above), only gross output (GROSSOUTP), depreciation and land per labour (DEPAWU and LANDAWU) did not satisfy them. However, the former will remain significant because the test is conservative in that case, so only DEPAWU and LANDAWU remain inconclusive because they are significant and the test is liberal.

Generally, the variables which were significant and for which the test was liberal could become insignificant after solving the problem of unequal variances and, those which were insignificant under the conservative test could become significant later on. However, the positive thing is that the results are very strong in the sense that both insignificant or significant results are at high levels (below or above 1%, respectively), so there is a high chance that they will indicate the same results even after rearranging the data.

Table A. 6-14 Results of ANOVA for productivities and profitability, 1999

	TFP1 (estimated costs)			TFP2 (paid costs)			PC_B			C_R		
Mean	<1	>1	F	<1	>1	F	<1	>1	F	<1	>1	F
No. Farms	633	346	-	601	378	-	85	894	-	591	388	-
UTIL_UAA	14.4	44.7	153.92***	15.4	40.5	105.43***	77.8	20.1	203.50***	26.1	23.7	0.876
AWU	1.7	2.1	21.715***	1.7	2	16.487***	2.1	1.8	5.947**	2	1.6	44.983***
GROSSOUT	12.1	28.7	106.68***	13.2	25.5	57.084***	37.7	16.1	59.733***	21.4	12.7	29.017***
BALL_CURR	0.014	0.029	3.035*	0.015	0.027	2.111	0.039	0.018	2.332	0.023	0.015	0.878
TOTAS	65.1	123.2	118.95***	69.1	112.1	64.184***	164	78.2	87.558***	90.1	78.9	4.11**
PORRESAU	13	23.9	57.108***	13.3	22.5	41.547***	32.1	15.4	45.758***	17.8	15.3	3.109*
PORPALAB	3.7	11	80.225***	4.2	9.6	44.741***	16.3	5.3	60.887***	6.5	5.9	0.53
OUTSTR	0.4	0.6	347.14***	0.4	0.6	311.8***	0.8	0.5	345.16***	0.5	0.5	18.534***
HERFINDAH	0.5	0.7	242.02***	0.5	0.7	208.8***	0.8	0.6	370.88***	0.6	0.6	0.09
SUBOUTP	0.014	0.026	1.886	0.014	0.025	1.801	0.029	0.017	0.703	0.02	0.015	0.477
DEPAWU	4.1	7.9	159.58***	4.4	7.1	80.125***	10.9	5	131.79***	4.6	6.9	56.113***
LANDAWU	8.2	21.1	209.61***	8.6	19.4	144.02***	36.9	10.5	337.82***	12.1	13.8	3.447*

* significance at 10%, ** significance at 5%, *** significance at 1%, others - not significant

Source: Author's calculations

All in all, although there is a rather small chance that the results of the ANOVA analysis are incorrect, nevertheless the problems with fulfilling the assumptions force us to treat some of the results with caution, especially in the case of productivity. We will not try to solve these problems by rearranging the data because after that we would have problems with interpretation of the changed data. Instead, we will employ other statistical techniques in order to check if they confirm the results of ANOVA or not (for example non-parametric tests presented further in this Appendix). If they give similar results we will treat the ANOVA's results as reliable.

Independence of observations

The independence assumption has a substantial effect on the significance level and the power of tests, and the larger the sample ,the more serious are the consequences

(Scariano and Davenport, 1986). Therefore, it is important to check if the data hold this assumption. Two observations are said to be independent if the outcome of one observation is not dependent on another observation (Sharma, 1996). This implies that the response of one subject (i.e. farm in our case) should be independent of the responses of other subject (farm). There are no sophisticated tests available to check if the independence assumption is violated so only common sense is of help. As we know the whole process of collecting the data (presented in Section 6.3), we can be almost sure that the independence assumption does hold. First of all the questionnaires were carried out separately at each farm, and besides, the bookkeeping collects facts not opinions of farmers, so the risk that the answers could be dependent on other respondents is practically zero.

Dependent variable

As for the last assumption, that the dependent variable has to be on an interval scale, in our analysis we consider the dichotomous dependent variables (farms are either productive or unproductive, and either profitable or unprofitable) which are not measured in intervals. This means that the assumption is violated. However this problem was addressed in the literature already long ago by Lunney (1970) who proved that this assumption can be violated if there is a sufficient number of degrees of freedom, i.e. more than 20 if the smallest category contains at least 20% of all responses, and more than 40 if the smaller response category contains less than 20% of all responses. In our case the number of degrees of freedom is much higher than that (we have 979 observations and 12 explanatory variables).

Since, some of the assumptions for a parametric test were not fully satisfied, we can check if the obtained results also hold if we apply a more appropriate non-parametric test (to see if the results of ANOVA are consistent with it). The suggested nonparametric test, comparing the means, is a Mann-Whitney test *U*, which however is not exactly the same as ANOVA, but similar in the way that it assesses the significance of differences in mean ranks between the groups[53]. It is expressed by the following equation:

(6-9) $$U = N_1 N_2 + \frac{N_1(N_1+1)}{2} - R_1$$

where: N_1 and N_2 are the sample sizes of groups 1 and 2, and R_1 is the sum of ranks for group 1.

If the Mann-Whitney test is insignificant, then it means that the differences between the means of structural variables such as farm size, specialization, etc. in the analysed groups of productive and nonproductive farms (as well as profitable and nonprofitable ones) are not significant, and the opposite if it is significant. Therefore, we would like to check if the results obtained by applying this test will be consistent

[53] For more details see Field (2000).

with our results of ANOVA. If so, we can assume that data problems did not substantially influence our analysis and the ANOVA results are reliable. The results of the Mann-Whitney U test are presented in Table A. 6-15.

Table A. 6-15 Results of nonparametric test of Mann-Whitney for productivities and profitability

	TFP1 (estimated costs)			TFP2 (paid costs)			PC_B			C_R		
Mean ranks	<1	>1	U test (i)	<1	>1	U test (i)	<1	>1	U test (i)	<1	>1	U test (i)
No. Farms	633	346	-	601	378	-	85	894	-	591	388	-
UTIL_UAA	403.6	648.07	54815.5***	414.7	609.72	68335***	743.39	465.91	16456.5***	522.67	440.23	95343.5***
AWU	465.42	534.97	93948***	464.35	530.78	98175.5***	527.31	486.45	34824	550.95	397.17	78635.5***
GROSSOUT	260594	219116	59933***	420.55	600.42	71848.5***	698.34	470.19	20286***	565.83	374.49	69836***
BALL_CURR	483.95	501.07	105677.5**	484.68	498.46	110391.5***	504.87	488.59	36731	496.39	480.26	110876**
TOTAS	266271	213439	65610***	432.59	581.28	79087***	698.02	470.22	20313***	505.34	466.64	105590**
PORRESAU	453.07	557.56	86134***	455.87	544.27	93075.5***	621.98	477.45	26776.5***	510.32	459.05	102645.5**
PORPALAB	428.5	602.52	70578***	437.14	574.04	81821***	672.75	472.62	22461***	505.77	465.98	105334**
OUTSTR	395.4	663.08	49624.5***	391.82	646.1	54582.5***	870.18	453.85	5679.5***	455.95	541.86	94531.5***
HERFINDAH	412.79	631.25	60636***	410.2	616.87	65631***	793.63	461.13	12186.5***	507.17	463.85	104508**
SUBOUTP	484.02	500.94	105723**	484.72	498.39	110417***	504.49	488.62	36763	496.4	480.26	110874**
DEPAWU	411	634.53	42637***	432.65	581.18	60357***	759.26	464.4	15108***	432.34	577.82	80578***
LANDAWU	384.36	683.27	59500***	401.43	630.83	79124***	821.44	458.49	9823***	480.18	504.96	108848.5

(i) Mann-Whitney test

Source: Author's calculations

As is clear, the results obtained by the non-parametric test of Mann-Whitney are very similar to those of ANOVA (compare the Table A. 6-14 with Table A. 6-15) [54]. First of all, all the differences between the means of variables which were significant in ANOVA are significant in non-parametric analysis. What is more, generally even some differences between the means of variables which were not significant before, such as SUBOUTP in TFP1 groups and BALL_CURR and SUBOUTP in TFP2 groups, and all variables in C_R groups are now significant. Only variables such as GROSSOUT, BALL_CURR, and DEPAWU, which were significantly different between the groups of profitabilities measured by P_CB are now insignificant and were significant in ANOVA. Besides, in both analysis all the differences between the means indicate the same direction, for example farm size was on average larger in productive farms, labour force was also on average larger in productive farms etc. The only exceptions were GROSSOUT, and TOTAS in groups measured by TFP1, which indicated larger values for unproductive farms on average if assessed by a non-parametric test, and the opposite in ANOVA. However, for productivities groups measured by TFP2 there were not such differences in direction.

Generally, it seems that we can trust the results of ANOVA analysis because they were strongly confirmed by the non-parametric test of Mann-Whitney. However, in a few cases there are some doubts. For example, measures of subsidies (BAL_CURR and SUBOUTP) are insignificant in ANOVA and in the non-parametric test but for different groups, in the former for productivities measured by TFP2, and in the latter

[54] Please note, that we cannot compare the mean ranks of non-parametric test with means form ANOVA but only the significance of differences between the variables, and this is what we need.

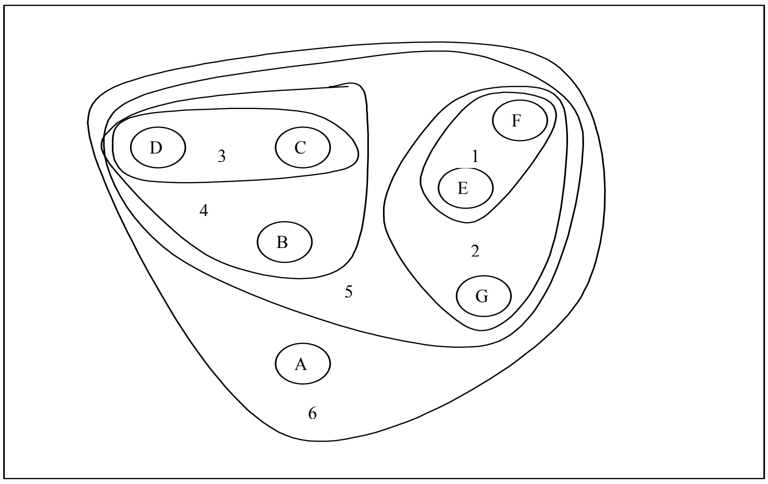
for profitabilities in P_CB groups. Besides, both subsidy measures are generally very low, because Polish farms do not count much on subsidies. Therefore, we will bear it in mind to pay attention in further analysis if those variables are significant or not. Besides, in groups of C_R in ANOVA many variables showed non-significant differences between the means between the groups but all of them were significant in the non-parametric test. As such, one should also watch them more carefully in further analysis, because we are not sure if this is due to the fact that the ANOVA was more restricted because of the data problems, or because the non-parametric test is not totally comparable (because it compares the means ranks), so we still cannot be sure about the significance of differences between the means of these variables in the profitable groups. Therefore, despite the fact that ANOVA is pretty reliable we apply other techniques (clusters and pooled regression) which will give us more insights into the doubtful variables.

Appendix 6-4 Steps in Cluster Analysis

Cluster analysis is the name for a group of multivariate techniques whose primary purpose is to group objects based on the characteristics they possess. Cluster analysis classifies objects so that each object is very similar to others in the cluster with respect to some predetermined selection criterion. The resulting clusters of objects should then exhibit high internal (within-cluster) homogeneity and high external (between-cluster) heterogeneity (Hair et al., 1998). In our analysis, clusters of farms should gather farms with the same structural characteristics (size, financial situation, production techniques, etc.) but each cluster should be significantly different in terms of these characteristics from the others. Analysis will help us identify the maximum number of such farm clusters. Then we will be able to analyse the TFP performance and profitability of farms within each cluster.

There are several methods available for forming clusters. Here the hierarchical clustering process was adopted, one of the most popular. This is a stepwise procedure involving a combination (or division) of the objects into clusters. It works in the way that the two most similar (closest) observations are identified and are combined in the common cluster. This procedure is repeated starting with each observation in its own cluster and combining two clusters at a time until all observations are in a single cluster. This is termed a hierarchical procedure because it moves in a stepwise fashion to an entire range of cluster solutions. It is also an agglomerative method because clusters are formed by the combination of existing clusters. The process is portrayed graphically in Figure 6-5.

Figure 6-5 Graphical portrayal of the hieratical clustering process – a nested groupings



Source: Hair et al. (1998)

Firstly, the two closest observations E-F are combined into a cluster. This reduces the number of clusters from 7, which was the initial number of all observations, to 6. Then the next closest pairs are identified, and in this example three pairs have the same distances: E-G, C-D, and B-C. G is a single cluster but E was combined in the prior step with F, so the cluster formed at this stage has three members G, E and F.

Next, B is combined with the two-member cluster C-D. So there are three clusters now: the first with A only, the second with B,C,D, and the third with E,F, and G. The procedure goes on until all observations are in one cluster.

The whole clustering process is usually viewed from the six-stage model-building approach starting with research objectives and research design of the cluster analysis, then verifying assumptions, partitioning the data set to form clusters and assessing the overall fit, finally interpreting the clusters, and validating the results. The portioning process determines how clusters may be developed. The interpretation process involves understanding the characteristics of each cluster and developing a name or label that appropriately defines its nature. The final process involves assessing the validity of the cluster solution.

Objective of Cluster Analysis

Our objective is to segment farms into groups with similar structural characteristics and then analyse their performance in terms of productivity and profitability, and finally formulate strategies with different appeals for the separate groups. The variables used to formulate the clusters are the same as those used earlier in factor analysis, so we have already tested their normality, linearity, etc. and hence know that these variables have sufficient predictive power to justify their use as the basis for segmentation.

Research Design of the Cluster Analysis

The first step is to identify any outliers in the sample before partitioning begins. At first, we did not find strong candidates for deletion, but later on in the process of examining cluster solutions some outliers emerged and were deleted. On three occasions new outliers occurred during the clustering procedure and had to be deleted, and the whole clustering procedure has to be repeated again three times. From all sample of 1001, 22 observations (farms) were deleted, ending up with a final sample of 979 farms. More details on deleting decision of the farm cases will be addressed later on in the subsection on identifying outliers in cluster solutions.
The next issue in this step involves the choice of a similarity measure. Given that the set of our variables is metric, squared Euclidean distances were chosen. Another possibility was Mahalanobis distance (D^2)[55], which is usually more appropriate if there is a serious problem with multicollinearity, however, because the factors used here were free of this problem the first method was deemed more appropriate. Also, correlation measures are not employed because the derivation of segments should consider the magnitude of the characteristics and pattern, which is best accomplished with a distance measure of similarity. Also standardisation was avoided, because the magnitude of the farm characteristics is an important element of the segmentation objective.

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[55] Mahalanobis distance is a standardized form of Euclidean distance. Scaling responses in terms of standard deviations that standardises the data, with adjustments made for inter-correlations between the variables (Hair et al, 1998).

Assumptions in Cluster Analysis

Cluster analysis has no essential assumption to be met prior to undertaking analysis. Only that one must be aware of the impact of multicollinearity on the implicit weighting of the results and choose an appropriate method of clustering. However, as stated above, this problem was solved by the construction of factors which assures no multicollinearity between them, and so we assume no data problems.

Deriving clusters and assessing overall fit

Here we employ a mix of hierarchical and non-hierarchical methods together. The former is to identify outliers, number of clusters and profile the cluster centres. This is followed by observations of clusters using a non-hierarchical method with the cluster centres from the hierarchical results as the initial seed points. This combined procedure allows one to benefit from the advantages associated with hierarchical and non-hierarchical methods, while at the same time minimising the drawbacks (Punj and Stewart, 1983).

1 - Hierarchical Cluster analysis:

Algorithm: There are different algorithms for clustering however, the most popular Ward's method was chosen here to minimise the within-cluster differences and to avoid problems with 'chaining' of the observations found in the single linkage method. The final result (coming from the final iteration) is presented in Table A. 6-16, where only last 25 rows are presented (979 rows would be too long, and besides only the last ones are essential for further analysis).

Table A. 6-16 Ward linkage agglomeration schedule and two selection criteria for number of clusters

	Cluster Combined		Agglomeration	Cluster First Appears		Next	Sigma2*	Simple	Number of
Stage	Cluster 1	Cluster 2	Coefficients	Cluster 1	Cluster 2	Stage	% change	Change**	Clusters
963	126	496	2066	946	941	967	69.8	1.2	16
964	95	180	2148	956	905	967	68.6	1.2	15
965	56	359	2240	952	951	972	67.3	1.4	14
966	1	2	2336	953	945	970	65.9	1.4	13
967	95	126	2448	964	963	975	64.2	1.6	12
968	6	14	2566	959	954	973	62.5	1.7	11
969	84	360	2700	961	929	972	60.6	2	10
970	1	17	2843	966	955	976	58.5	2.1	9
971	77	176	3016	948	933	977	55.9	2.5	8
972	56	84	3273	965	969	973	**52.2**	**3.8**	**7**
973	6	56	3670	968	972	974	46.4	5.8	6
974	6	26	4126	973	960	975	39.7	6.7	5
975	6	95	4630	974	967	977	32.4	7.4	4
976	1	31	5352	970	962	978	21.8	10.6	3
977	6	77	6097	975	971	978	10.9	10.9	2
978	1	6	6846	976	977	0	0	10.9	1

* Sigma2 = percentage change between the last agglomeration coefficient and the one at a certain stage

** Change = first difference between Sigmas2 for each stage

Source: Author's calculations

The table includes cases combined at each stage of the process (the first three columns) and the agglomeration coefficient (the fourth column), which is the within-cluster sum of squares, and the next three columns are stages for the cases which first time enter the clusters[56].

Number of clusters: here the manageable number of clusters has to be selected. Usually it is between 2 and 5. The higher the number of clusters, the more difficult the analysis, so there should not be more than 10 clusters. To decide on the appropriate number of clusters, the criteria suggested by Fiegenbaum and Thomas (1993) were applied, focused on the simultaneous analysis of the overall fit obtained within each grouping and the marginal change in this fit with the inclusion of an additional group. Thus, the number clusters selected was determined when two conditions are satisfied simultaneously, i.e.: (i) the percentage of intra-group variance explained with the obtained grouping was higher than the minimum percentage which was placed at 50% and (ii) that the percentage increase in the explanation of the intra-group variance, obtained with the inclusion of an additional group, did not exceed 5. Here such criteria are satisfied for the 7 cluster solution, as indicated in the last three columns in Table A. 6-16.

Identifying outliers in the cluster solution: Agglomeration schedule also provide a means of identifying outliers in the sample. At the sixth column in the Table A. 6-16 the stage at which each cluster was formed is presented. An observation that has never been joined into a cluster has a stage of 0. The outliers are those farms, which joined very late in the clustering process, and have 0s in the last rows of column six. In our example we cannot see 0s in the column because the data were cleaned of outliers, identified just this way. So previous agglomeration schedules indicated cases which entered clusters at very last stages e.g. at 976 stage, etc. However, after three iterations of the clustering process carried out up to this point all potential outliers were deleted and a final solution was obtained. From 1001, 22 cases were deleted, with the final sample including 979 observations.

It is also important that clusters have a reasonable number of cases included. It seems that 7 cluster solution satisfies this requirement as opposed to 9 cluster solution, which has one very small cluster of 7 cases - see Table A. 6-17. This additionally convinced us that a 7 cluster solution is the maximum number of clusters.

[56] Zero in the seventh column indicates that at this stage the case entered the cluster first time.

Table A. 6-17 Ward method frequencies tables in hierarchical method

	Clusters	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	279	28.5	28.5	28.5
	2	366	37.4	37.4	65.9
	3	53	5.4	5.4	71.3
	4	72	7.4	7.4	78.7
	5	146	14.9	14.9	93.6
	6	23	2.3	2.3	95.9
	7	40	4.1	4.1	100
	Total	979	100	100	

	Clusters	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	279	28.5	28.5	28.5
	2	366	37.4	37.4	65.9
	3	53	5.4	5.4	71.3
	4	72	7.4	7.4	78.7
	5	82	8.4	8.4	87
	6	16	1.6	1.6	88.7
	7	64	6.5	6.5	95.2
	8	40	4.1	4.1	99.3
	9	7	0.7	0.7	100
	Total	979	100	100	

Source: Author's calculations

2 - Non-hierarchical Cluster analysis:

This step uses non-hierarchical techniques to adjust results from hierarchical procedures. In performing the cluster analysis, the initial seed points[57] from the previous analysis were taken. The result indicates that the 7 cluster solution from this analysis matches quite well the one from hierarchical analysis (see frequency and other indicators of resulted groups and compare 7 cluster solution from Table A. 6-17 with solution in Table A. 6-18). The correspondence and stability of the cluster solutions between hierarchical and non-hierarchical methods confirms the results subject to theoretical and practical acceptance.

Table A. 6-18 Frequencies tables in non-hierarchical method

	Clusters	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	252	25.7	25.7	25.7
	2	377	38.5	38.5	64.2
	3	67	6.8	6.8	71.1
	4	79	8.1	8.1	79.2
	5	135	13.8	13.8	93
	6	19	1.9	1.9	94.9
	7	50	5.1	5.1	100
	Total	979	100	100	

Source: Author's calculations

[57] Initial seeds are cluster initial centroids or starting points for clusters. These values are selected to initiate non-hierarchical clustering procedures, in which clusters are built around these prespecified points.

Table A. 6-19 Cluster results for the 1999 sample

Cluster	1	2	3	4	5	6	7	Mean	F [i]
	252	377	67	79	135	19	50		
UAATOT	14.55	15.17	52.99	17.19	38.85	65.93	75.91	**25.11**	41.931
TOTASSET	62.85	63.54	147.75	56.67	142.54	160.51	148.03	**85.66**	40.027
GROSSOUT	11.39	12.17	26.56	8.65	34.7	38.6	44.81	**17.96**	37.224
PORPALAB	4.11	4.05	13.12	2.73	9.46	14.99	18.59	**6.28**	20.198
TOTALAWU	1.7	1.72	1.36	1.72	2.36	3.05	2.68	**1.85**	19.992
LANDAWU	8.17	9.06	35.79	9.48	15.59	16.64	29.07	**12.76**	66.501
DEPAWU	3.85	4.29	14.65	3.76	7.33	6.4	7.42	**5.47**	83.195
PROCRO	0.45	0.45	0.91	0.4	0.53	0.38	0.61	**0.49**	82.768
HERFINDA	0.55	0.56	0.86	0.57	0.57	0.6	0.68	**0.59**	130.368
SUBNET	0	0	0	0	0.01	0.83	0	**0.02**	769.205
SUBOUTP	0	0	0	0	0.01	0.76	0	**0.02**	351.892
DEBTOAS	0.02	0.02	0.04	0.01	0.03	0.06	0.22	**0.03**	190.103
LEVERAGE	0.02	0.02	0.05	0.01	0.04	0.07	0.29	**0.04**	183.774
RENGO	0.01	0.01	0.03	0.02	0.04	0.03	0.08	**0.02**	48.835
PORREUAA	11.76	10.59	13.82	14.43	35.18	35.19	40.76	**16.83**	43.357
LANDRENT	0.04	0.03	0.03	0.03	0.27	0.09	0.07	**0.07**	181.202

[i] significant at 1%

Source: Author's calculations

Interpretation of the clusters

Information essential to the interpretation of clusters is covered in Table 6-13. For each cluster, the centroid on each of the variables is provided, and the univariate F ratios for assessing the significance of differences between the clusters means and levels of significance. The statistics indicate that the all clusters means differ significantly at the 1% significance level. This confirms heterogeneity between the clusters (which are internally homogenous). The clusters can be named or described according to their values of the entire farm structures. This was carried out in Section 6.6.3 in the main body of the thesis.

Appendix 6-5 Steps in Pooled regression analysis

Choosing the type of model

Since we have the panel data (five years 1996-2000 and 914 observations per year), we have to use pooled regression model which combines time series with cross-section data.

Before the regression model was specified a number of assumptions were checked:

Sufficient number of observations

The number of cases needed depends on the type of regression model. For all, however, the minimum requirement is five times more cases than independent variables, or ideally twenty times more. As we start with 16 explanatory variables (which were used in cluster analysis) we have many more cases than are needed, as we include into the analysis 914 observations for each year.

Outliers

The identification of outliers was carried out in the cluster analysis and out of the total of 1001 observations, 22 were deleted. Then we had to delete another 65 in order to obtain a balanced and robust sample (see data description in Chapter 5), ending up with 914 observations.

Multicollinearity and singularity

Thanks to the factor analysis we knew which variables could cause multicollinearity problems (those within the factors) and those which would not (those between factors). The correlation matrix was also examined before, so we did not allow variables causing this problem even to enter the regression.

Normality, linearity, homoscedasticity and independence of residuals

Again, all the assumptions were checked before the factor and cluster analyses were carried out, so there was no need to repeat it and the variables used here satisfy all the assumptions fairly well.

Selection of the model

Based on previous analyses we selected the most promising determinants of productivity and included them in the regression. We came up with representatives of the following groups:

1/ scale of production (value of total assets, or total output, or total land); 2/ technologies used (specialisation index, depreciation level and land per annual working unit; number of plots indicating fragmentation of production); 3/ quality of land and human capital (soil quality indicator, age, education level, percentage of paid labour and rented land); 4/ access to financial capital (financial indicators of indebtedness as leverage).

In order to test the relative significance of determinants of productivity among Polish farms and verify corresponding hypothesis the following pooled regression model was built and tested:

$$\ln(y_{it}) = \alpha_{it} + \beta'_{i} \ln(X_{it}) + \varepsilon_{it}$$

where: i = 1, 2, …. 914 is a number of cross-sections and t=1, 2, 3, 4, 5 is a number of years (1996-2000); α is a constant; $\ln(y_{it})$ is a logarithm of the TFP Tornqvist Index (including apprised value of own factors based on shadow prices), X = vector of independent explanatory variables (suspected determinants of TFP); α and β = vectors of parameters, and ε is an error. The logarithms of continuous variables were taken due to the large differences in size between them.

The parameters were estimated by means of Pooled Least Squares method. Firstly, the large set of variables was tested and then some of them were deleted, according to adequacy of fit and two information criteria (Shwarz and Akaike) of the consecutive models.

Interpretation of results

The results generated in Eviews are presented in Table A. 6-20. The interpretation of the coefficients is straight forward. As in any other type of regression, the beta coefficients indicate elasticities.

Table A. 6-20 Pooled regression analysis of TFP determinants

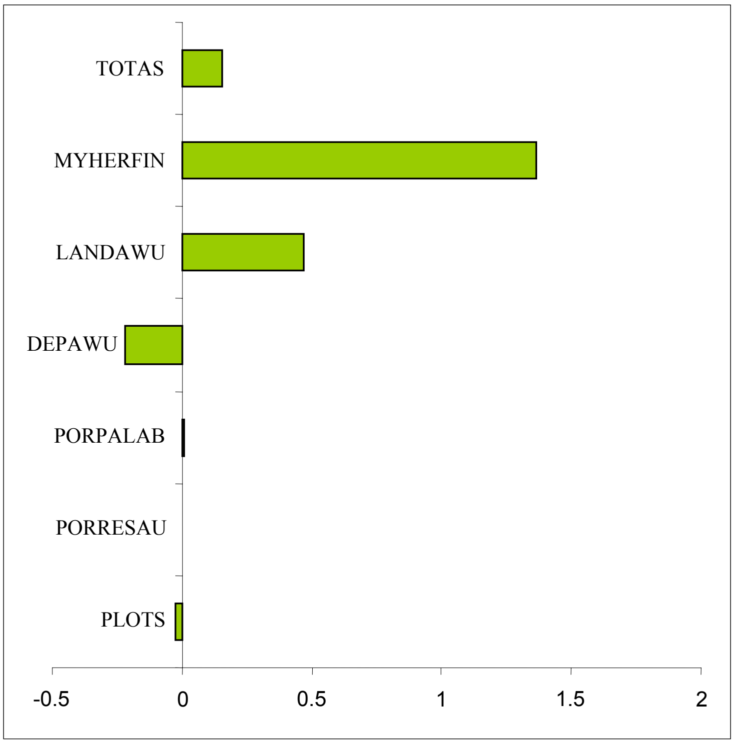
Dependent Variable: LOG(TFP)
Method: Pooled Least Squares
Date: 04/10/03 Time: 02:04
Sample: 1996 2000
Included observations: 5
Number of cross-sections used: 914
Total panel (balanced) observations: 4570

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-1.035092	0.105327	-9.827417	0.0000
SOILQD1	-0.402305	0.031507	-12.76865	0.0000
SOILQD3	0.340718	0.026903	12.66452	0.0000
EDUD1	-0.060221	0.019110	-3.151185	0.0016
EDUD3	0.100721	0.039884	2.525347	0.0116
LOG(TOTAS)	0.155789	0.015792	9.865304	0.0000
LOG(MYHERFIN)	1.366199	0.055607	24.56871	0.0000
LOG(LANDAWU)	0.468089	0.017073	27.41718	0.0000
LOG(DEPAWU)	-0.217089	0.018168	-11.94899	0.0000
LOG(LEVERAGE)	0.000494	0.000883	0.559468	0.5759
LOG(PORPALAB)	0.005630	0.000683	8.246866	0.0000
LOG(PORRESAU)	0.002339	0.000658	3.555400	0.0004
LOG(SUBOUTP)	-0.001967	0.001347	-1.460185	0.1443
LOG(PLOTS)	-0.026314	0.012482	-2.108182	0.0351

R-squared	0.457265	Mean dependent var	-0.278207
Adjusted R-squared	0.455716	S.D. dependent var	0.779035
S.E. of regression	0.574737	Sum squared resid	1504.952
F-statistic	295.2709	Prob(F-statistic)	0.000000

Source: Author's own calculations

Figure A. 6-1 Relative importance of significant determinants (continuous variables only)



Source: Author's own calculations

7 Summary, conclusions and recommendations

7.1 The research logic

Starting with a theoretical background on approaches to competitiveness (Chapter 2) and touching on previous research into the competitiveness of the Polish agricultural sector (Chapter 3) the author proposed an eclectic framework for assessing the competitiveness of Polish agriculture (Chapter 4) in order to analyse the issue from a broader perspective, linking macro- and microeconomic fundamentals.

The primary objective of the study was to assess changes in the competitiveness of Polish agricultural producers in the 1990s because it is important for Poland's successful competition in the EU Common Market. The period of the country's transition initiated strong pressure on all Polish sectors by opening the economy up to international competition (trade liberalisation) and domestic rivalry between sectors for the best production factors. Besides, Poland took on various international commitments by joining the World Trade Organization (WTO) and started negotiations with the EU, which also called for serious adjustments. Agricultural producers had to face declining relative (output-input) prices, deteriorating terms of trade, then declining incomes and profitability of production and in consequence declining agricultural production and trade. The size of these challenges was significant and difficult to alleviate by policy interventions (Chapter 5).

According to the theory of dynamic comparative advantage (presented in Chapter 4), agricultural producers can either (i) resist the pressure and positively respond to it by improving their productivity and adjusting factor allocation (towards more optimal proportions); or (ii) expose themselves to the pressure and bare the consequences of declining competitiveness in the sector. As the study revealed, the latter was the case - productivity during 1996-2000 declined (Chapter 5) and hence also the competitiveness of the farm sector. However, because the farm sector is far from homogeneous (a peasant type of farming coexists with market oriented farming) changes in the productivity of particular groups of farms differed in terms of the direction of the changes, their extent and underlying causes.

As productivity is a main offsetting force in the hands of producers (given that changes in factor proportions are limited) it was crucial to investigate the determinants of productivity differences and their relative importance in explaining productivity performance (Chapter 6). Various variables suggested by theory and previous studies were tested in order to find out if they are important in determining productivity. We selected determinants which drive (boost) productivity and those which are obstacles to productivity and competitiveness improvements and assessed their relative importance. Finally, we compared productivity results of Polish farms with their counterparts in other CEE and EU countries (Chapter 6) and can now attempt to identify areas for possible policy actions.

7.2 Main findings

We have tested four hypotheses which were complemented by additional research questions (see Table 7-1) and they led us to the following conclusions:

<u>Competitiveness of the farm sector declined over 1996-2000</u>

Many signals indicated a deterioration of the Polish agricultural sector: declining relative agricultural prices, deteriorating terms of trade, declining incomes, the persistence of a trade balance deficit, etc. These were warning indicators of revealed competitiveness, though our research showed that the potential competitiveness of the sector also declined during the analysed period. Earlier, producers were not able to resist the pressure stemming from the appreciation of the real exchange rate (which hampered sectoral terms of trade) and from international markets (low commodity prices put pressure on domestic output prices) and failed to accommodate them by improving their productivity (which would have allowed for a maintaining of profitability).

<u>Policy was able to reduce by half the pressure stemming from exchange rate appreciation and amplified by declining world agricultural prices</u>

Sectoral policy effectively offset part of this pressure, in the sense that it prevented a further (twice as large) decline in real producer prices. One might ask whether the policy could have been more effective and reduce the pressure even further at that time? Although the author did not analyse the policy itself at that time (this falls beyond the scope of this research), in the author's opinion it seems quite unlikely given the fact that such pressure was constant and of a fundamental (irreversible) character. Clearly, a combination of exchange rate appreciation, declining world prices and the overall course of trade liberalisation made it almost impossible. What is more, it is questionable if it would be desirable to engage larger resources in order to remove the pressure as the only sustainable solution is to improve factor productivity and, there is surely a positive role for policy to play here. This situation represents the usual dilemma for agricultural policy in finding a balance between direct protection and other types of support leading to sustainable solutions.

<u>Producers failed to improve their productivity mainly due to technical inefficiency and weak technological progress</u>

Clearly, adjustment mechanisms did not work, in the sense that producers did not respond to competitive challenge and the competitiveness of the sector declined. This would not have happened if technical efficiency had increased considerably and technological advancement been quicker. However, technical efficiency between 1996-2000 declined on average (annually by 2.1%) and technological progress was weak (1.2%). All in all, total factor productivity was declining by 1% annually. Only three groups of farms (large, crop oriented, and more specialised) were able to improve slightly in this respect. According to earlier studies by Brümmer, et al. (2002), productivity during 1991-1994 in the Polish farms sector also declined and even at a higher rate (5% annually), but due largely to technological regression and not technical inefficiency.

<u>The decline in technical inefficiency stemmed mainly from 'pure' technical inefficiency rather than scale inefficiency</u>

The decline in the technical efficiency of Polish farms was due mainly to the decline in 'pure' technical efficiency (2% annually) rather than scale efficiency decline, as the latter was negligible (0.1%). 'Pure' technical inefficiency can potentially be explained by the existence of X-inefficiency. This inefficiency may result from bad management practices, inappropriate work norms, distorted motivation (principal-agent dilemma), transaction costs, etc. Although analyses of the precise reasons for 'pure' technical inefficiencies in Polish farms falls beyond the scope of this analysis, in the light of our findings some reasons seem more probably than others. For example, bad management practices seem very probable given the low education of farmers, something which can cause labour management problems but also improper management of new technologies (introduction of technical, chemical, and biological technology requires special skills and education). A principal-agent problem is less probable given our finding of a positive correlation between productivity and off-farm resources, but it may occasionally occur in farms which rely more on off-farm labour. According to many studies, reliance on family labour is generally more efficient in transition sectors (Latruffe, et al. 203). Certainly, a more probable obstacle to 'pure' technical efficiency is high transaction costs, given the proved distortions in the functioning of agricultural input markets in transition countries, and Poland is not exempt (World Bank, 2001). Negative changes in scale efficiency also contributed to a decline in overall technical efficiency, although relatively by far less. In Poland, this most often means that farms size should increase because most Polish farms (and especially crop oriented) operate under increasing returns to scale (Latruffe, et al. 2003).

<u>The small size of farms and their fragmentation hamper productivity</u>

Our study confirms the existence of a significant and positive relationship between productivity and farm size. As was discussed earlier, various studies deny the significance or existence of a relationship between farm efficiency and size in Poland (van Zyl, et al, 1996) or show a negative relationship (Munroe, 2001). However our study confirms the positive returns to scale, like those by Davidova, et al (2002), Latruffe, et al. (2003) and Mech (1999). Generally speaking, potential gains from land consolidations are large because individual Polish farms are still very small (7 ha) and structural changes are very slow (the average size of individual farm increased by less than 1 ha over 10 years) (GUS, 2001a). However, the fragmented farm structure had historical causes (private ownership and the hereditary farming tradition), so increasing farm size was never going to be easy. Although fragmentation of land slightly but significantly contributes to a decline in productivity performance it causes waste of resources (fuel, time) and organisational problems.

Fragmentation of farm structure also hampers relative prices in the sector

The small size of farms implies high transaction costs in market operations and undermines farmers' bargaining position vis-à-vis up- and downstream industries (activities). This negatively contributes to relative prices in the sector and aggravates the problem of deteriorating sectoral terms of trade, although the effect is of a reversible character. This issue has not been the subject of an insightful analysis in this thesis, although the economic literature (theoretical and empirical) suggests its significance as well.

Specialisation does not help productivity unless it takes account of risk

Specialisation proved generally positive for productivity, although we observed that in the group of the most specialised farms (with single activity) changes in productivity were negative, while in the group of farms with slightly lower specialisation (farms with two or three activities) the changes were positive. This led to the conclusion that farms which specialise, but at the same time diversify the risk of production, perform better than those which depend solely on one type of production. The importance of risk management was probably amplified during the transition period because it was a time of rapid changes, but after EU accession, the more stable economic environment will further favour specialisation with its positive effects on productivity.

Poor land quality is another significant and strong impediment to productivity

Land quality has proved to be one of the most significant and influential determinants of farm factor productivity. Unfortunately, most of the farm land in Poland is of medium and poor quality and regional variations are considerable. However, poor land quality may be compensated by progress in biological (genetics) and chemical technology.

The relative insignificance of external financing in determining factor productivity indicates serious problems with crediting agricultural investments

In order to finance investments, farms need access to credits. The fact that credits for productivity in the sector were low does not mean that crediting investments is not generally important for productivity improvement, but that crediting of investments in the Polish agricultural sector does not work. In other words, it indicates a malfunctioning of the credit market. Due to lack of credits, investments are postponed, and this is unsustainable. It is also a serious obstacle for productivity improvement and, as stated earlier, the problems lie on both the demand and supply side of the market.

Low agricultural education restrains a rapid improvement in management and implementation of new technologies

Our study confirms findings from previous studies, which pointed to problems with the low education of Polish farmers. According to these studies, low education hampers technical efficiency (Latruffe, et al. 2003) so also productivity. In our study we also revealed problems with 'pure' technical inefficiency which usually results from low education. We showed that lack of agricultural education may have a more significantly negative impact on productivity than, for example, the fragmentation of land.

Reliance on labour-intensive techniques is generally less productive

Labour intensive types of production proved generally less productive than, for example, land intensive ones, although the techniques of production are correlated with farm size, certain types of production, etc. and therefore in this analysis with all the effects which make it an important determinant. What we have observed in the sector, however, is a switch from labour-intensive towards more capital- and land-intensive techniques. This indicator of productivity improvement contributes to an enlargement of the persistently excessive labour force in farm activities (indicated by registered and hidden unemployment, which is already much larger if we compare it with other countries), however. Policy will have to address the problem that improvement in productivity aggravates the problem of the excessively large labour force in the sector.

Compared to other CEECs, the productivity problems of Polish farms result from an excessively large labour force, the persistence of small farms and their overcapitalisation

The most distinct feature of Polish farms compared to other farms in the region (e.g. the Czech and Hungarian) which hampers their productivity is overcapitalisation of farms (given the relatively small size of farms, capital is used inefficiently and is mostly obsolete). Besides, the fact that the farms are much smaller means they cannot utilise economies of scale. Another distinct feature is also low labour productivity, which, to some extent, results from the fact that agriculture has played the role of a social 'safety net' for those who have become unemployed and migrated from the cities. Generally speaking, therefore, labour and capital productivities are lower than in other CEECs, but at the same time this means that the potential for improving productivity of Polish farm sector in that respect is larger, if the obstacles to both are removed.

Table 7-1 Summary of Hypotheses with evaluation

Hypothesis	*Evaluation* **Positive evaluation means that the Hypothesis**	*Chapter /Page*
Hypothesis 1: *Relative agricultural (output-input) prices deteriorated during the analysed period mainly due to the strong pressure stemming from macroeconomic adjustment which was too strong to be offset by sectoral policy interventions.*	*Positive*	CH.5 p.98
Research questions: Which pressure on relative prices was larger, that stemming from low international prices or real exchange rate appreciation? To what extent did intervention offset the pressure? In which periods was the policy successful (in the sense that it prevented a decline in real output prices)?	Real Exchange Rate appreciation had a stronger effect than declining world prices Only by half over the 1990s When international prices were increasing	
Hypothesis 2: *Changes in total factor productivity (TFP) did not offset the pressure of deteriorating relative prices during the analysed period and hence the competitiveness of the sector declined in the analysed period.*	*Positive*	CH.5 p. 108
Research questions: Were the changes in TFP positive or negative? Were the changes in TFP strong or weak? What were the primary causes of the TFP changes?	TFP declined over 1996-2000 The decline was weak 'Pure' technical inefficiency	
Hypothesis 3: *There are significant differences in characteristics between productive and unproductive farms and both have unique profiles (i.e. combination of features determining factor productivity).*	*Positive / Negative (profiles are not unique)*	CH.6 p.143
Research questions: Which factors had significantly positive and which negative influence on TFP?	Positive: farm size, specialization, high quality of land and education, land intensive techniques, some amount of hired labour and rented land Negative: Poor quality of land, low education, land fragmentation, capital-intensive techniques	
What is a profile of productive versus unproductive farms?	There are no unique profiles but productive farms tend to be on average larger, more specialized in crop production, less labour-intensive and owners have better agricultural education	
Hypothesis 4: *There are several significant determinants of TFP, but they differ largely in terms of the strength of their impact on TFP.*	*Positive*	CH.6 p.143
Research question: Which factors had the strongest impact on TFP?	Specialization, quality of land, level of education, techniques of production, and size	

7.3 Policy Recommendations

Policy aimed at increasing competitiveness of the agricultural sector should primarily focus on supporting improvement to factor productivity of farms…

Agricultural policy, especially during the transition period, seems to have been unable to effectively offset the external adjustment pressure faced by the sector. This pressure is of an irreversible character because it results from changes in the economy's fundamentals and to a large extent from long-term trends in international markets (important for a small open economy). So the policy aimed at sustainable and efficient solutions should focus on supporting the adjustment of the sector and not only offsetting pressure in the sector. Hence, policy should primarily focus on supporting improvement of factor productivity in the sector.

…which requires supporting land consolidation…

As economies of scale matter, policy should aim to facilitate land consolidation and aim at reducing land fragmentation. In the light of the newly enacted bill on the agricultural system (11th April, 2003), which established the range of individual farm size to be between 1 ha to 300 ha, it seems that additional measures may be needed in order to encourage the creation of farms with efficient scale within this range (as for example the measure called 'structural rents', introduced in 2001, imposed a minimum size of new or enlarged farms at 15 ha.

…facilitating access to higher education…

Revealed problems with education cannot be resolved solely at the level of sectoral policy. This calls for integrated action at the local, regional and central levels. Education reforms must remove 'invisible' barriers of entry to higher schools and universities. Better education is also a must if farmers are to benefit from various EU programmes that target structural problems (the second pillar of the CAP and structural funds) in the sector.

…and advisory…

Not only school knowledge, but also certain agricultural advisory services should be strengthened and integrated. There is an important question of the role to be played by Agricultural Extension Services (ODRy) and EU information points. It seems that there is also room for NGOs and other organisations which can carry out broadly defined advisory and training activities.

…supporting technological progress…

Various institutions may play a vital role in supporting technological progress as well, though the key is that they are well co-ordinated. Some studies, however, have shown aweakness in the co-ordination of various programmes aimed at supporting technological progress between institutions (OECD, 1995a,b). Strong links should be established and co-ordinated between research institutes (Research and Development), information centres and producers (Adoption and Diffusion). Policy can also help in supporting technological progress by facilitate the raising of capital for new investments in agriculture e.g. by delegating sources for co-financing certain EU programmes (oriented towards technology creation and diffusion).

…and capital productivity…

Overcapitalised and obsolete machinery are features of many Polish farms and both these problems should be addressed by policy as well. Land consolidation, promoting joint use of machinery (mechanisation circle) and supporting the development of mechanical services for the sector may help in the diminishing capitalisation per farm. Dealing with obsolete capital will require encouragement for farmers to replace at least some of it with new ones, but this will only be possible if incomes in the sector increase or prices of new machinery (expressed in agricultural output prices) decline.

…as well as an outflow of excessively large labour force from agricultural activity...

This is certainly one of the most serious and difficult problems which calls for an integrated strategy to resolve it. Development and quick growth of the whole economy will help in sucking out labour from agriculture, but at the same time there should be programmes proposing effective diversification of economic activities of farmers and rural areas, creating new jobs there, training people so that they can become competitive on the wider labour market. Given the size of registered and hidden unemployment, job creation in the non-farm sector seems vital.

Specialisation will bring positive effects if policy becomes more predictable and more effective in stabilising farm markets…

Generally, specialisation helps in gaining higher productivity, although this only holds if certain risks can be avoided. As such, policy should be predictable and effective in stabilising markets (i.e. effectively contribute to stabilisation of the relative prices floating around their long-term trends). Unfortunately, Polish intervention policy in farm markets generally has not met these standards very well, as it is usually backward looking, under strong pressure from lobbies and is therefore used to sending the wrong signals to the markets.

…and this will be possible under the Common Agricultural Policy….

Integration with the common EU market provides itself greater stability due to its size. In addition, the Common Agricultural Policy is more stable and predictable than the current Polish agricultural policy. CAP interventions, despite also being distorting, seem more transparent (the financial framework for policy is usually set for 6 years in advance and guidelines for future changes in policy interventions are publicly known), which allows for better decision making of farms because they can be based on longer term perspectives. This generally helps in better allocation of investments in the sector.

…which should also bring other opportunities for supporting productivity...

Apart from production support and market stabilisation, EU membership offers measures which are designed, more or less directly, for improvement in productivity. Already in the first years of membership, Poland will be allowed to choose from the broad offer of measures of rural development policy (the second pillar of CAP) and structural funds. These measures range from investment grants for farms and the processing sector in infrastructure to promotion of non-farm income sources, early retirement schemes, etc.

All in all, any policy actions aimed at solving the aforementioned problems should be integrated, in the sense that they must match the problems with competent institution(s), policies (if necessary) and appropriate instruments during implementation, because, as we have shown, many of those problems are very complex and are impossible to be solved at the sectoral level alone. The theory of integrated rural development suggests that integrated policy implies: territorial (engaging all levels of competence starting from local to central), sustainable, subsidiary (what can be done at a lower level of competence should not be shifted to the central level), based on partnership (all the agricultural stakeholders should be involved in policy, including farmers' organisation, government agencies, relevant ministries, etc.), integral (the policy should be integrated with other policies, e.g. educational reform, pension reform, etc.) (Marsden and Bristow, 2000; and Scott, 2002).

7.4 Scope for further research

This study touched many issues related to the competitiveness of the Polish farm sector, but has also certainly left much room for further empirical research which might be able to make the concepts presented here more insightful. For example, studies on particular reasons of X-inefficiency within different groups of Polish farms (groups of different farm size, specialisation, activity, etc.) would be invaluable. Precise studies on the barriers to technological progress in the agricultural sector, including the role of R&D, adoption and diffusion (A&D) as well as institutional components would also be interesting. As the Polish farm sector is relatively diversified it would also be interesting to carry out more insightful analyses on the particular farms which will actually be able to compete on the Common Market, and characterise problems with competitiveness of potential farm leaders. An insightful empirical study on competitiveness and structural changes in a regional context would also be particularly interesting and valuable. Lastly, it would be interesting to carry out empirical analysis on changes in factor proportions and find out whether they changed toward more or less optimal solutions and to what extent.

Besides this factual research, there is also scope for methodological research aimed at improvement of the concepts presented here. For example, one could carry out TFP decomposition with use of parametric approach in order to compare the results with those obtained in this thesis (which was based on the non-parametric TFP Malmquist index decomposition with use of DEA) and besides use confidence intervals for evaluating the efficiency estimates (by means of bootstrapping procedures). Furthermore, one could attempt to disaggregate the policy interventions in the Valdes' approach into more detailed policy actions.

The last suggestion concerns studies on an institutional approach to competitiveness, which would ideally lead to establishing the role of certain institutions and social partners in integrated efforts for constant improvement in the competitiveness of the sector.

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