Swedish University of Agricultural Sciences
Faculty of Natural Resources and Agricultural Sciences
Department of Economics

Efficiency of pig farm production in the Republic of Macedonia

- "Data Envelopment Analysis" approach

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Building Capacity for Macedonian Higher Education, Research and Policy Analysis in Agriculture - with a focus on Agricultural Economics

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Marina Petrovska

Abstract

Pig production is one of the most important agricultural sub-sectors in the Republic of Macedonia, with a long tradition of production and a constant level of consumption. Starting from the farms, the livestock is sold on the market for consumption as fresh pork and for use in the processing industry and slaughterhouses for production of meat and different meat products.

In recent years the country has experienced a continuous decline of the number of pig farms and pork supply. There are many reasons for this: high feed costs, small land area available for production, traditional technology and equipment used to perform the activities, lack of education of farmers and increased utilization of inputs for pork meat production. In order to increase the profitability and to be more competitive in the market, the farmer has to focus more on the production efficiency and sustainability of the sector. This study aims to analyse the (technical) efficiency of production activities of pig farms in the Republic of Macedonia.

The empirical approach is based on collecting quantitative data through a questionnaire and establishing direct interviews with farmers. Pig farm data are analysed by using *Data Envelopment Analysis* (*DEA*) model. It estimates technical efficiency of production where the level of used inputs and produced outputs are the main subjects of analysis. Analysis give explanation of the efficiency from input-oriented and output-oriented perspectives by comparing the larger and smaller pig farms in the country.

The results show difference between constant and variable return to scale. Technical efficiency analysed from the aspect of constant return to scale is always lower and average technical efficiency is 75%. According to the variable return to scale, average technical efficiency from input perspective is 90%, and from output perspective is 87%. The ratio between constant and variable return to scale gives average scale efficiency.

However, technical efficiency does not depend on the input-output relationship only, but also, environmental and manager factors influence it as well. Accordingly, there is a difference between big and small pig farms in terms of the location, accessibility and size of the economic yard. The education of managers depends on the use of new technology of production that positively influences the increase of the number of obtained piglets per sow, and the decrease of the mortality and consumption of feed for kilogram growth.

Key words: constant and variable return to scale, *Data Envelopment Analysis*, efficiency of production, input, output, pig farms, technical efficiency

Апстракт

Свињарското производството, во Република Македонија, е еден од најважните потсектори во земјоделството, со долга традиција на производство и константно ниво на потрошувачка. Започнувајќи од фармите, добитокот се продава на пазарот за свежо свинско месо и за употреба во преработувачката индустрија и кланиците, како суровина за производство на месо и различни производи од месо.

Во последниве години, во нашата земја, се забележува константно намалување на бројот на свињарски фарми и понудата на свинско месо. За оваа состојба на свинско месо на пазарите, постојат многу причини: високите трошоци за добиточната храна, мала површина достапна за производството, традиционалните технологии и опрема коишто се употребуваат при извршување на активностите, недоволното образование на фармерите и друго. За да го зголеми профитот и да биде поконкурентен на пазарот, фармерот ќе мора да биде позаинтересиран за ефикасноста на производството и одржливоста на секторот. Затоа, цел на оваа студија е да се пресмета (техничката) ефикасност на производните активности во свињарските фарми во Република Македонија.

Емпирискиот метод се базира на собирање квантитативни податоци преку примена на прашалник и директно интервју со фармерите. Податоците од свињарските фарми се анализирани со примена на моделот *Data Envelopment Analysis* (*DEA*). Со него се пресметува техничката ефикасност на производството каде што главен предмет на анализа се конкретното количество на употребени материјали за производство и одреденото количество на краен производ. Анализите даваат објаснување на ефикасноста на производството од перспектива на употребените материјали за производство и од перспектива на добиениот производ, преку споредба на големите и малите свињарски фарми во нашата држава.

Резултатите покажаа разлика помеѓу константните и варијабилните приноси на обем. Техничката ефикасност анализирана од аспект на константен принос на обемот е секогаш пониска и просечната техничка ефикасност изнесува 75%. Во однос на варијабилните приноси на обем, просечната техничката ефикасност - од перспектива на употребени материјали за производство, изнесува 90%, а од перспектива на добиениот производ - изнесува 87%. Односот помеѓу константните и варијабилните приноси на обемот, ја претставува просечната ефикасност на обемот.

Техничката ефикасност не зависи само од инпут-аутпут односите, туку влијание имаат и факторите на животната средина и менаџерот. Според тоа, постои разлика помеѓу големите и малите свињарски фарми, во однос на локацијата, пристапноста и големината на стопанскиот двор. Едукацијата на менаџерот е во пропорционална зависност со користењето на нова технологија на производство, која позитивно влијае врз зголемување на бројот на добиени прасиња од маторица, намалување на морталитетот и консумацијата на храна за килограм прираст.

Клучни зборови: константни и варијабилни приноси на обем, *Data Envelopment Analysis*, ефикасност на производство, инпути, аутпут, свињарски фарми, техничка ефикасност

Abbreviations

CRS	Constant return to scale
DEA	Data Envelopment Analysis
DEAP	Data Envelopment Analysis Programme
DMUs	Decision Making Units
DRS	Decreasing return to scale
EU	European Union
FADN	Farm Accounting Data Network
FFTC	Food and Fertilizer Technology Center
IAP	Individual Agricultural Producer
IPARD	Instrument for Pre-Accession for Rural Development
IRS	Increasing return to scale
JSC	Joint Stock Company
kg	kilogram
km	kilometre
LLC	Limited Liability Company
MAFWE	Ministry of Agriculture, Forestry and Water Economy
MASA	Macedonian Academy of Sciences and Arts
MKD	Macedonian denar
NAERLS	National Agricultural Extension and Research Liaison Services
NARDS	National Agricultural and Rural Development Strategy
No.	Number
RM	Republic of Macedonia
SE	Scale efficiency
SSO	State Statistical Office
TE	Technical Efficiency
VEF	Vienna Economic Forum
VRS	Variable return to scale

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1 Introduction

Pork production has great significance in the total output of meat production for many countries in the world. In fresh and processed condition it is one of the most favourable products in the foreign market. Its advantages over other livestock products are numerous because of the quality, economical production and possibility for fully industrialised technology, which makes the pig production sector to be very important for the slaughterhouses and meat industry.

The globalization of markets has caused structural changes, especially in the agricultural sectors. The Republic of Macedonia, as a small developing country, has a less competitive industry and low production efficiency. As in many other countries, the domestic market is under increasing pressure by imports from more efficient countries that have lower costs of production. Some studies have already addressed the fact that highly efficient countries can dominate in the pig production market (www, FFTC, 2011).

In regards to the above stated, this chapter gives a short overview of the Macedonian pig breeding sector including the challenges that have appeared in recent years. This leads to an explanation of the purpose of delimitations in this study of production efficiency. At the end, an outline is provided as a clear explanation of the study.

1.1 Problem background

Livestock production, slaughterhouses and processing industry are key contributors to the agricultural and the domestic economy. Especially pork production is very important for consumption by domestic and foreign population (NARDS, 2007-2013). Unfortunately, during the period of economic transition, pig production was low and inefficient. As a result, at the end of this period, many of the existing industrial pig companies were closed, while some of them have changed their structure to private pig farms.

The production structure in the agricultural sector consists mainly of small family holdings and due to the support to agriculture the number of commercial family farms in this sector is constantly growing (NARDS, 2007-2013, www, CeProSARD, 2011). Companies that have an organized way of reproduction and pig production comprise around 40% of the total number of pigs in the country. The other 60% are owned by individual producers (NARDS, 2007-2013, www, CeProSARD, 2011).

Considering 2009 and 2010, pig production takes the third place in terms of number of heads as compared to other livestock in the country. The highest number of animals goes to sheep, while the second and fourth place belongs to cattle and goat respectively. These figures are represented in Figure 1.

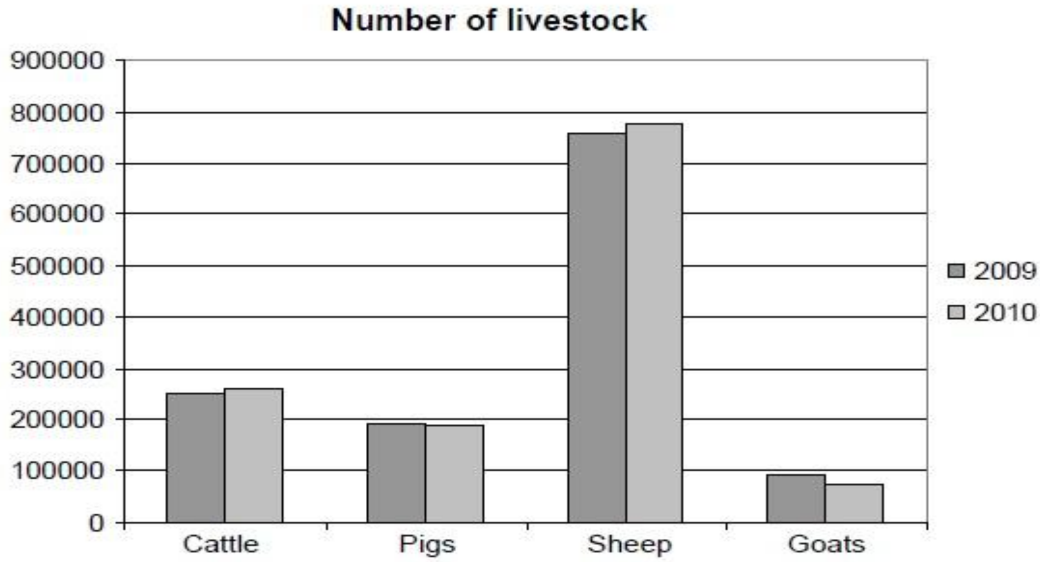

Figure 1: Number of livestock in the last two years in RM
Source: www, SSO, 7, 2011

The number of pigs in the Republic of Macedonia is fluctuating over the years. The statistical data are given below in Table 1.

Table 1: Number of pigs in the Republic of Macedonia (in heads)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Piglets up to 20 kg	54,584	61,353	53,127	52,909	47,917	49,023	49,746	90,115	82,373	69,247	71,144
Pigs 21-110 kg	107,986	92,109	104,422	82,778	75,924	73,526	81,879	108,708	115,955	90,681	83,996
Pigs over 110 kg	10,436	7,332	6,507	7,870	8,151	6,391	5,477	10,802	11,778	4,865	6,203
Sows	29,247	26,541	29,999	31,508	23,960	24,809	28,148	42,533	34,973	27,993	28,279
Male pigs	1,882	1,958	2,168	3,985	2,279	2,004	1,866	2,988	1,795	1,054	930
Total pigs	**204,135**	**189,293**	**196,223**	**179,050**	**158,231**	**155,753**	**167,116**	**255,146**	**246,874**	**193,840**	**190,552**

Source: MAFWE, 2010; www, SSO, 7, 9, 2011; IPARD, 2008, pp.80

In the last decade, the number of pigs was constantly decreasing. This negative trend existed until 2007 when there were 255,146 pigs, which is the highest number of total pigs in the country (MAFWE, 2010; www, SSO, 7, 9, 2011). The same year, the number of sows was also bigger than other years, and perhaps, that is the reason of such a big production. In 2008 and 2009 the number of pigs, as well as the number of sows was reduced again (MAFWE, 2010; www, SSO, 9, 2011 and NARDS, 2007). In 2010, the number of pigs in agricultural enterprises and agricultural cooperatives as compared to 2009 has increased for 4.4%, but in individual agricultural households the number of pigs has decreased for 5.3% (www, SSO, 7, 2011). However, some studies express that recently the number of pigs in RM is around 260,000 heads which is the biggest number of pigs in the period 2000-2009 (Vukovik and Andonov, 2010).

Since 2007, pork contributes with more than 40% of the total domestic production of meat and is becoming the leading meat sub-sector (Dimitrievski *et al*, 2010). The condition of Macedonian meat production sector in the last two years is comparatively given in Figure 2.

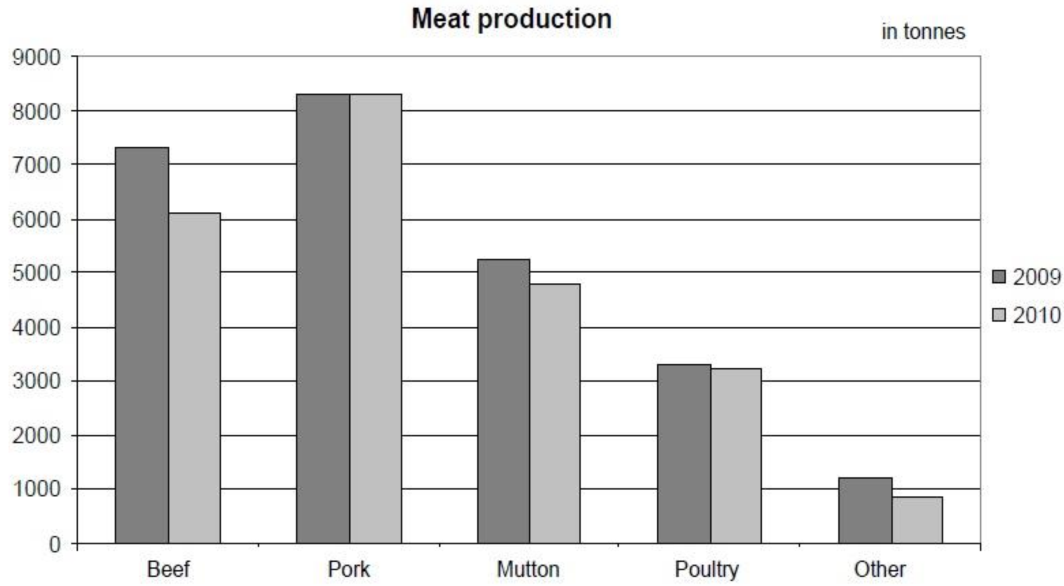

Figure 2: Meat production in the last two years in the Republic of Macedonia
Source: www, SSO, 8, 2011

However, pork production over the years presented in Table 2 confirms that the total production of pork in 2009 is lower than previous years and compared to 2008 decreased for 4.7% (MAFWE, 2010). In 2010 the production of pork is the same as 2009 with the production index (2010/2009) of 100% (www, SSO, 8, 2011).

Table 2: Production and consumption of pork in the Republic of Macedonia

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Production of pork (in tonnes)											
Pork	9,323	8,413	10,626	9,609	9,373	8,897	8,633	8,856	8,703	8,291	8,292
Consumption of pork - annual average per household (in kg)											
Total	28.9	38.8	28.7	24.9	29.9	28.7	27.2	24.1	23.2	22.4	26.1
With bones	16.1	28.0	17.6	16.3	19.9	17.6	16.1	13.5	12.8	10.9	13.1
Without bones	12.8	10.8	11.1	8.6	10.0	11.1	11.1	10.6	10.4	11.5	13.0
Consumption of pork - annual average per household member (in kg)											
Total	7.4	7.8	7.3	6.3	7.6	6.5	6.8	6.1	6.0	5.9	7.0
With bones	4.6	4.9	4.5	4.1	5.1	4.0	4.0	3.4	3.3	2.9	3.5
Without bones	2.8	2.9	2.8	2.2	2.5	2.5	2.8	2.7	2.7	3.0	3.5

Source: www, SSO, 2, 3, 4, 5, 6, 8, 2011; SSO, 2001-2007

The consumption of pork was constantly decreasing until 2010. In 2010, there is a significant increase in the annual consumption of pork both average per household and average per household members. Also, the consumption of pork with bones and without bones marks an increase in the last year. According to Vukovik and Andonov (2010) the increased consumption of pork in the last few years helps to improve and to increase the production of pig farms. They explain that in order to be more competitive on the market, both big and small farms in the country have included modern zoo-technical measures in the production process, started using the available biological capacities more efficiently by increasing the genetic capacities, selecting the most qualitative types of animals and better reproduction systems.

Macedonia is net importer of meat and different meat products. Around 90% of the domestic demand for fresh pig meat is satisfied by the domestic production, while the remaining 10% represent a lack of raw pork in the country that is fully satisfied by import (NARDS, 2007-

2013). Also, the meat-processing industry fully depends on import of raw, cooled and frozen pork. The major markets providing imported meat are EU with 62%, Brazil with 11% and 4% come from Poland. In 2005 the imported pig meat was 5,567 tons or 18% of the total import of agricultural products (NARDS, 2007-2013). In 2008, the import increased and according to Vukovik and Andonov (2010) imported pig meat was 9,452 tons and 3,087 tonnes processed pork. In 2009 the total import of raw pork was 11,878 tons (MAFWE, 2010). Today, the need of fresh and processed pork is estimated at around 20,000 tonnes per year.

1.2 Problem formulation

There are many problems and weaknesses in the Macedonian livestock production. Significant characteristics are reduced number of farms, insufficient production of meat and increased import. According to Dimitrievski *et al* (2003) Macedonian agriculture has the following main weaknesses: unsatisfactory technical-technological equipment and inadequate organisational-economic position to meet the requirements of market economy, low level of management, bad organization of marketing, and very high production costs, which cause high prices on the domestic market.

Livestock production in Macedonia is still traditional with low quality and quantity of pig meat. Usually farms work with classical breeding systems that do not allow animal's commodity. According to IPARD (2008, pp.84) problems that usually appear refer to "waste treatment and disposal, hygiene and animal welfare and in meeting environmental standards in the farm". Livestock breeding in unprofessionally built farms, which is not according to today's breeding standards, is one more reason for increased animal health problems, increased mortality and lower farm profitability. To increase the production under these conditions, farmers have increased costs for feed, but animals remain in stress condition and production remains significantly lower than expected. This situation represents a violation of the law for animal protection and welfare (Official Gazette, 113/2007).

In NARDS (2007-2013) it is said that a very common situation in the country is absence of agreement for cooperation between farmers, slaughterhouses and meat processing industry, which further complicates the pork production process. Without market institutions Macedonian companies may be less competitive.

The reduction of number of pigs and insufficient production of pork is mostly due to high prices of animal feed. This represents the biggest problem for the private sector. According to NARDS (2007-2013) the country highly depends on importing animal feed, like wheat, soybean, sunflower and complete mixtures and additives (proteins, minerals and vitamins). In 2003 imported feed included 25,500 tons of oil seeds products, 7,800 tons of mixtures and 3,800 tons of additives.

Another problem is low average productivity as a result of low level of production management, low use of artificial insemination, slow introduction of superior and productive genetic types of animals. Low technical knowledge of individual producers contributes to this low production efficiency (NARDS, 2007-2013).

1.3 Aim

This study aims to identify technical efficiency of pig farm production in the Republic of Macedonia. The objective is to analyse the way the management activities affect the efficiency of the production process in pig farms, considering the level of inputs used, and the quantity of output produced on the farm.

In order to meet the purpose of the study, the research should answer the following questions:

- Are the operating activities in average Macedonian pig farms efficient?
- What is the efficiency from the input perspective?
- What is the efficiency from the output perspective?
- Are bigger pig farms more efficient than smaller farms?
- What other factors influence the efficiency?

1.4 Delimitations

This study focuses on pig farms in the Republic of Macedonia, where small, medium and large farms are the subject of analysis. Only commercial farms would be studied, because there are no data for organic or other farms to be included in calculations.

The data analysed in this study cover the period of one calendar year. In this respect, 2010 was chosen as the most appropriate year for emphasis on the current situation regarding efficiency of farm production.

To be taken into account, pig farms must meet certain conditions in terms of capacity and size of farm. Only farms that have more than 10 sows for intensive production intended for market have been analysed.

The country has insufficient number of available data and statistical information that can be used for the analysis. Therefore, additional data were collected directly by interviews with farmers. Because of the small number of pig farms in the country a questionnaire was prepared and distributed to all commercial and individual pig production family farms. The response rate depended on the acceptance of farmers to respond to the prepared questionnaire and to share their data obtained on the basis of real evidence of production activities realized in the previous year.

The purpose of the study is to estimate the technical efficiency of pig production farms. This emphasises incoming raw materials for production (inputs) and produced outputs. All outputs have been reduced to the same unit value in order to estimate a sum useful for further calculations. This approach has helped avoiding the risk to provide unrealistic data due to a lack of some products in different farms.

In the Republic of Macedonia there are many types of studies for measuring the production of pig farms, like efficiency according to biological and reproductive characteristics of pigs, genetic inheritance or selection of more productive sorts of pigs (www, University of Ljubljana, 2011; www, MAFWE, 2011). This study does not include the above stated types of analysis. Also, the characteristics of market, number of slaughterhouses and formulation of pork price like a ratio between supply and demand are not a subject of the analysis. This study is the first in Macedonia to analyse the production efficiency of pig farms and farmer's management characteristics.

1.5 Outline

The thesis is divided in 7 chapters. The outline below (Figure 3) illustrates the arrangement of chapters.

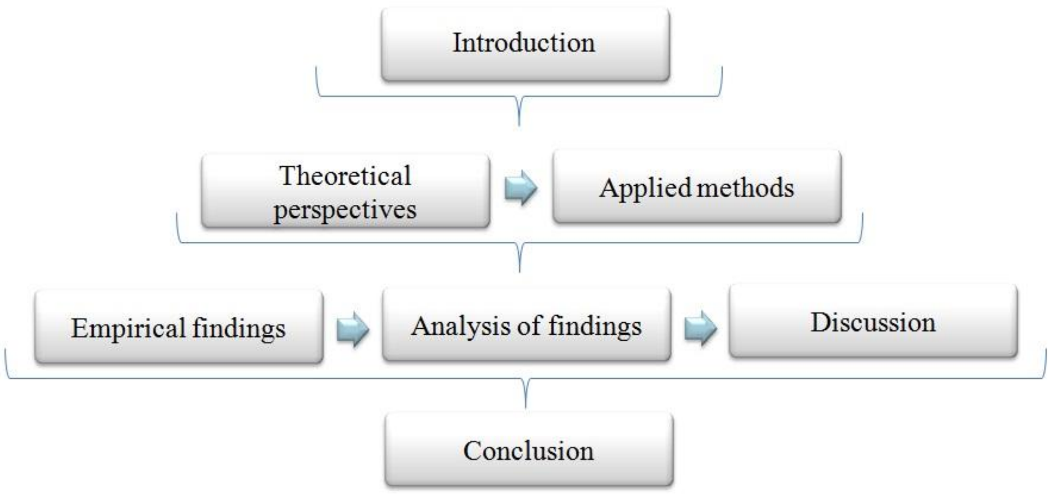

Figure 3: Illustration of the outline of the study

Firstly, an introduction chapter gives an explanation of the background of the study and the problems that appear in terms of pig farms production in the Republic of Macedonia. The aim, delimitations and outline of the study are given afterword.

The theoretical perspectives are provided as a literature review from the research and analysis of previous studies. This part is divided in three related topics: a theoretical part of data envelopment analysis approach, technical efficiency theory and a concept of the analysis in two stages. The emphasis is put on Data Envelopment Analysis (Coelli *et al*, 2005), which allows analysis of three types of efficiency: economic, allocative efficiency, and technical.

The third chapter covers the applied methods of the study and gives an explanation of all research activities related to data collecting and estimating the efficiency. This part includes analysis of the data availability, data collecting and data procedure.

Chapter four contains the information of the empirical findings regarding the data collected and their procedure for further analysis.

The fifth chapter gives the results from estimating the efficiency. Here, the analysis concerns the results and comparison between bigger and smaller pig farms.

Chapter six gives an overview of the efficiency from input and output perspective and the results are compared to the reviewed literature. In this chapter, the obtained data are discussed.

Finally, a conclusion is given to answer the research questions stated in the aim of the study.

2 Theoretical perspectives

This chapter of the thesis covers a previous research and literature review, applicable to give an answer of the research questions in the aim of the study. It gives a basis for the choice of method and data collecting. The chapter is divided in three parts:

- Data Envelopment Analysis approach is used to explain the way of estimating efficiency of production and production frontier function;
- Technical efficiency approach describes a correlation between inputs and outputs with emphasis on rational utilization of inputs;
- The last part describes the inputs and outputs of production, where inputs are based on two stage analysis according to their structure and the way that can be used in technical efficiency measurement.

2.1 Data Envelopment Analysis framework

This part is an overview of the method that gives an explanation of the background and method characteristics. Hence, the analysis is divided in three sub-titles. The first one considers production frontier as a base for analysing efficiency of production. The second one is an overview of the history and the third one divides the efficiency in three types which are explained separately afterwards.

2.1.1 DEA background and definition

One of the most important issues in each firm is the efficiency in working. It comprises of the efficient working with production resources (inputs), and the process of production by itself through finalizing the most economically beneficial products (outputs).

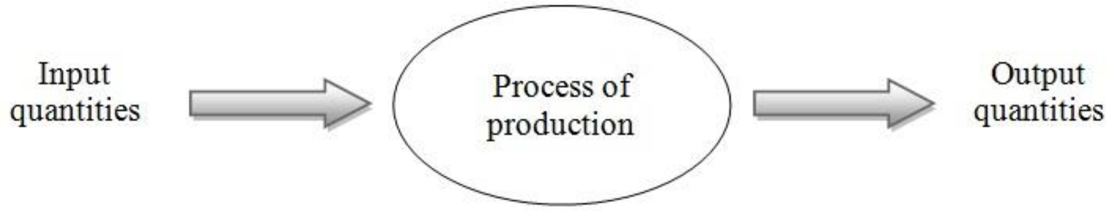

Figure 4: Relationship between inputs, outputs and the process of production
Source: Own version developed for the thesis

Also, measuring efficiency is very important issue for increasing farm productivity. By knowing the level of productivity a farmer can influence managerial decisions in terms of rational use of inputs and improvement in management practices for increasing the efficiency of production. According to Johansson and Ohlmer (2007) the efficiency of production would increase if the manager used inputs more intensively or by making combination of inputs and output. They explain that the manager decision making can influence efficiency in the long-term, but especially in the short-term due to the frequent changes that are possible to appear every day in the production field like the agricultural is.

Data Envelopment Analysis (DEA) model uses the exact level of inputs and the certain output level to estimate the efficiency of production. It is a non-parametric method that uses linear programming in the analysis. Linear programming is used as many times as there are observations for analysis, for each individual farm separately (Coelli *et al*, 2005).

> *"DEA models are non-parametric linear programming methods that estimate a frontier production function of a set of decision making units and evaluate the relative efficiency of each unit, thereby allowing a distinction to be made between efficient and inefficient DMUs"* (Galanopoulos *et al*, 2006; Hartwich and Kyi, n.y.).

According to the definition, DEA uses "the best unit" to estimate the efficiency of production. The best unit has a ratio equal to 1. All other units that are not equal to 1 are not the most efficient in their operational activities. Therefore, the inefficiency is estimated as a difference between the frontier and the individual producers (Coelli *et al*, 2005; Farrell, 1957; Galanopoulos *et al*, 2006; Sharma *et al*, 1996). As it is already mentioned, DEA analyses are based on the frontier theory where the most efficient firms lie on the frontier production function. Hartwich and Kyi (year) say that the focus is not on the average production function measurements, but the idea is to identify the best DMUs that make the best DMU frontier and each unit is analysed by this frontier. For better explanation and more clear understanding of the background of the efficiency analysis by DEA the frontier theory is explained in the separate chapter below.

2.1.2 The productivity and production frontier

An important issue in everyday working is the firm to be familiar with its productivity. The productivity depends on different combinations of inputs and outputs used in the production. To measure farm performances, the manager could use the *Productivity ratio* which is actually relationship between outputs and inputs (Coelli *et al*, 2005).

$$\text{productivity} = \frac{\text{outputs}}{\text{inputs}}$$

If the firm has better performance its ratio has higher values (Coelli *et al*, 2005). The basic productivity ratio consists of one output and one input. However, in many cases when the term productivity is used it means that all factors influencing the production are included in measurements (all outputs and all inputs). Additionally, the term *Total factor productivity* is used when all resources are included in the production. The equation is represented by the production function below (Coelli *et al*, 2005):

$$y = f(x), \text{ and } x = (x_1, x_2,..., x_n)$$

In the equation, y represents the output that is impossible to happen without using even one input. Then, f(x) is non negative real number which represents a sum of inputs. Variables x_1, x_2 and until x_n are different inputs used in the production *i.e.* feed, labour and energy respectively. The analysed inputs are managed by the decision maker (in this study the farmer). Also, there are other inputs that cannot be controlled directly like the occurrence of natural disasters, the governmental policy and legislation in the country etc.

According to Coelli *et al* (2005, pp.12) the term production function explains the relationship between inputs and outputs of a certain production, which is also the case with the production frontier meaning that these two terms are both used for the same area of study and can be used alternately. The definition of production frontier follows:

> *"Production frontier describes the relationship between inputs and outputs, with the emphases on maximum possible output obtained by using certain level of inputs"* (Coelli *et al*, 2005).

Also, Production frontier and the relationship between inputs and outputs can be elaborated graphically. Therefore, they are represented in the following figure.

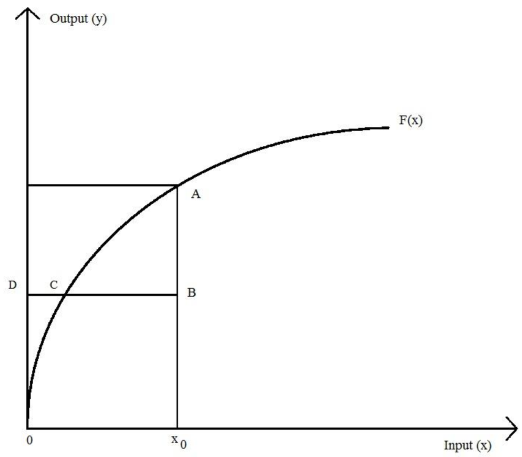

Figure 5: Production frontier
Source: Coelli *et al,* 2005, pp.55

According to the figure, Production frontier line is represented by the curve OF. The theory explains that points A and B represent certain level of productivity that a firm has by using x_0 level of inputs. If the firm operates at point A it is efficient, because it has high level of output for the inputs used. If the firm operates in point B it has lower productivity and is not efficient because with the inputs already used, the firm can produce higher output (Coelli *et al*, 2005). In other words, if the firm that operates in point B brings the productivity at point A, by using the same level of inputs and increasing the output, it will have higher production efficiency.

2.1.3 The beginnings of measuring the efficiency

In 1951, Debreu and Koopmans started to estimate a firm efficiency by making combinations of various inputs. Koopmans (1951) believes that excellent combination of inputs would contribute for efficient production. Since then, the first beginnings of efficiency measurement have been recorded.

Then in 1956, Heady *et al* use the production function for analysing technical efficiency on the farm level. The next year, Farell (1957) followed the work of Debreu (1951) and Koopmans (1951) using the accounting system of multiple inputs and established the bases for measuring production efficiency by using production frontier methods. He wanted to solve the problem concern in how much one industry can increase its output by increasing the efficiency while using the same quantity of inputs. Since then, many studies have tried to use programming methods to estimate production efficiency. Coelli *et al* (2005) discuss about the beginners who use mathematical programming methods: Boles (1966), Shephard (1970) and Afriat (1972). However, the first who emphasizes the use of Data Envelopment Analysis Programme for estimating efficiency of production were Charnes, Cooper and Rhodes (1978).

Until today, there have been many studies that have used production frontier and DEA in the analysis of different kinds of efficiency in working. For example, in DEA home page (www, 2011) it is discussed that today DEA is accepted for economic analysis of production units with many studies increasing daily, which consider farm efficiency, banking, education, health care, benchmarking, management evaluation, restaurant working etc. Hence, many researchers analyse the influence of managerial activities and decisions for production efficiency with DEA (Coelli, 1996; Coelli *et al*, 2005, Johansson and Ohlmer, 2007; Zonderland and Enting, 2003; Galanopoulos *et al*, 2006; Hartwich and Kyi, n.y.; Sharma *et al*, 1996).

2.1.4 Types of efficiency

In respect to DEA analysis and input-output relationship, there are three types of efficiency that the programme used in its measurements: technical, allocative and economic efficiency (Coelli *et al*, 2005). An overview of each efficiency type is given in this part of the chapter.

Table 3: Technical, Allocative and Economic efficiency

Types of efficiency		
Efficiency measure	Symbol	Definition
Technical efficiency	TE	Ability to produce a certain level of outputs with minimum inputs
Allocative efficiency	AE	Ability to choose optimal combinations of inputs given their respective prices
Economic efficiency	EE	Can be achieved after the realization of technical and allocative efficiency

Source: Farrell, 1957; Coelli *et al*, 2005, Sharma *et al*, 1996 and Matthews *et al*, n.d.

On the other hand, the individual producer can face inefficiency in operating activities. There are three types of inefficiency: technical, allocative and scale inefficiency (Sharma *et al*, 1996):

- If the inefficiency comes from failure in achieving maximum output quantities from a given set of inputs, the producer faces technical inefficiency.
- If the producer uses inputs in wrong proportion in regards to inputs prices, he operates under the allocative inefficiency.
- If the producer fails to get the production to the optimal scale of operation, he faces scale inefficiency.

- **Technical efficiency**

In 1957, Farrell (1957) estimated the efficiency of production as an empirical approach including inputs and outputs in the analysis. He found out that a change of the level of inputs used influenced the efficiency of production. Measurement of inputs and outputs quantities covered in the production gives a basis for estimating technical efficiency. Therefore, technical efficiency takes into account only the technology of production. The level of technical efficiency of a firm represents a relationship between the actual production and an ideal or potential production (Greene, 1993). The measurement of a specific technical efficiency of the individual firm is a ratio of an obtained output and the output of the firm that operates on the efficient production frontier. If the obtained output lies on the frontier, the firm is perfectly efficient. If it lies below the frontier then it is technically inefficient (www, Herrero and Pascoe, 2011). According to Figure 6 (below in this chapter) technical efficiency has the following formula: TE = 0Q/0P.

Prices are used to estimate profit and costs functions, and considering the efficiency measurement they are used in estimating allocative and economic efficiency. Output prices are received of each product excluding transport and marketing costs. Input prices consist of all costs paid for each input including taxes. Usually, the price of one unit of input is an average price taken from the whole production of that input in the country (Farrell, 1957).

- **Allocative efficiency**

Allocative efficiency is used when measurement takes not only the production technologies but also their prices. In respect to the prices, Farrell (1957) analysed this efficiency under the name *price efficiency*. The advantage of the allocative efficiency is the possibility to analyse the efficiency from cost minimization and revenue maximization perspectives due to involved costs in the analysis. Both cost minimization and revenue maximization are assumed from the profit maximization perspective which can also be analysed by the allocative efficiency (Coelli *et al*, 2005). On the other hand, this efficiency is very sensitive to introduction of new observations and errors in measurement of factor prices (Farrell, 1957). Therefore, a firm will face best price efficiency if its inputs are adjusted to future or past prices, because this efficiency measures the adaptation of a firm to certain prices and will have good measures in completely static situation (Farrell, 1957). Allocative efficiency is equal to AE = 0A/0Q, see Figure 6 on page 13.

- **Economic efficiency**

With a combination of technical and allocative efficiency, the analysis shows total economic efficiency of a firm (Farell, 1957). Technical efficiency is a basis for estimating economic efficiency because the firm must have a technical efficiency in order to be economically efficient. Also, allocative efficiency must be reached if the firm is to meet economic efficiency. Profit maximisation requires a maximum output produced by the right set of inputs (www, Herrero and Pascoe, 2011).

However, this study focuses on technical efficiency of production due to considering the further analysis only on input-output relationship excluding prices, and as a result does not contain account of the other efficiency. In Figure 6, economic efficiency is:
EE = 0A/0P = (0Q/0P) x (0A/0Q) = TE x AE.

2.2 Technical efficiency according to the scale

According to Farrell (1957) a firm has reached technical efficiency if it gets the maximum output by a given set of inputs. This is the case of output oriented production. In respect to the input oriented production, technical efficiency can be achieved by a firm that gets a maximum feasible reduction of inputs without reduction in output quantities (Galanopoulos *et al*, 2006). Technical efficiency measurement displays only values from 0 to 1. If the value is closer to one the firm operates more technically efficient, if it is closer to 0, the input-output relationship must be changed in order to increase the firm's efficiency of working. The fully efficient firm has technical efficiency 1 (Coelli *et al*, 2005).

Not only the input-output relationship, but the operating environment is also important in a relation to constant and variable return to scale. *"Returns to scale refer to increasing or decreasing efficiency based on size"* (www, DEA home page, 2011). From one side, all DMUs are using a certain level of inputs in order to produce specific level of output. If they increase the quantity of utilised inputs, there is a possibility to get that much increased quantity of output. They face constant return to scale efficiency. According to Fare and Lovell (1978) in the case where the constant return to scale exists the input oriented production is equivalent with the output oriented production.

> *"Constant return to scale (CRS) means that the producers are able to linearly scale inputs and outputs without increasing or decreasing efficiency"* (www, DEA home page, 2011).

On the other hand, imperfect competition, finance constraints etc. may cause a change in the operational scale of DMUs. This is especially important and frequent in the agricultural production which depends on the environmental conditions. "*These increasing return to scale (IRS) and decreasing return to scale (DRS) which appear in the production coursed by external factors represent the variable return to scale, VRC"* (Coelli, 1996; www, DEA home page, 2011). Moreover, Coelli (1996) explains that if the DMUs are not operating on the constant return to scale (CRS) than TE measurements are affected by scale inefficiency. Accordingly, measurement of scale efficiency may be done by analysing the difference of two TE scores (TE_{CRS} and TE_{VRS}) upon the same data of DMUs. He gives the scale efficiency (SE) equation as follows:

$$SE = TE_{CRS}/TE_{VRS}$$

If there is a difference, it indicates that DMUs are operating under VRS and there is an increasing or decreasing inefficiency scale. To estimate the inefficiency scale the convexity constraint $N'\lambda=1$is substituted with the constraint $N'\lambda\leq 1$ which includes CRS and DRS in the same name NIRS (non-increasing return to scale). If NIRS and VRS are equal it means that the farm is operating under DRS, while if they have different values it means that a farm is operating under IRS (Calanopoulos *et al*, 2006). Otherwise, if TE scores show the same value, then the DMUs are operating under CRS (Coelii, 1996). Also, CRS usually lower the efficiency scores, while VRS increase the efficiency scores of operating activities (www, DEA home page, 2011).

The most efficient point of production is known as an *optimal scale*. In this point a firm has the biggest productivity and maximum level of efficiency. The optimal scale is determined by drawing a tangent of the *Production frontier* (Coelli *et al*, 2005). It is a subject of analysis of a theory named *Scale economics*. The theory gives a definition of the meaning of the term:

> *"The optimal scale is a point where technical efficiency of a firm and the production frontier intercept between each other"* (Coelli *et al*, 2005).

The following part goes more deeply in analysis of technical efficiency. It gives an explanation of the constant and variable return to scale models. Technical efficiency analysis are considered from both input and output oriented perspectives which are divided according to constant and variable return to scale.

2.2.1 Input oriented perspective

Input perspective, in the analysis considers the materials included in the production. This perspective gives an answer to the question:

> "*By how much can input quantities be proportionally reduced without changing the output quantities?*" (Coelli, 1996, pp.7; Coelli *et al*, 2005, pp.54).

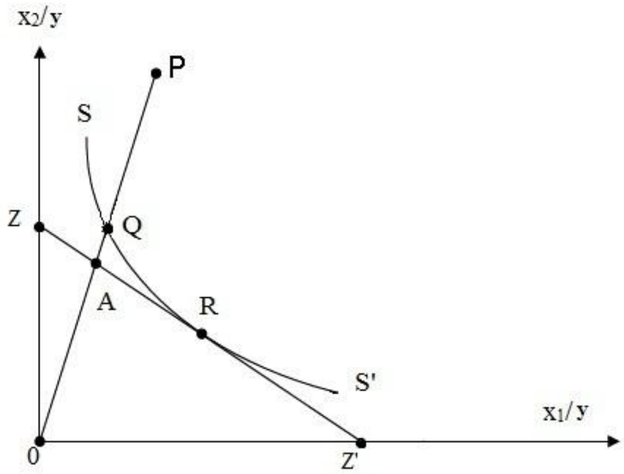

Figure 6: Input oriented technical efficiency
Source: Farrell, 1957; Coelli *et al*, 1996 and 1998; Coelli, 2005

P - an inefficient unit

Q - technically efficient unit

R - an allocative efficiency unit

A - a hypothetical point on the isocost line equal to R costs
ZZ' - isocost line

SS' - isoquant of efficiency

Figure 6 elaborate technical efficiency from input orientation. The isoquant SS' consists of all inputs that a *fully efficient firm* uses in its production. However, these kinds of data are not known while measuring technical efficiency. Therefore, the measurement request values to be given by the most productive efficient firm from a sample of firms which are taken to be a subject of analysis. Point P is the output obtained by a certain level of inputs (Coelli *et al*, 2005). Therefore, technical efficiency (TE) of the firm is the distance QP which represents the amount of inputs that can be reduced without requiring the firm to change the quantity of output. In percentage the reduction of all inputs is the ratio QP/0P. Moreover, technical efficiency of the firm is measured from the input orientation with the following formula (Coelli *et al*, 2005): TE = 0Q/0P which is equal to TE = 1 - QP/0P.

- Input oriented - constant return to scale

When firms are working at an optimal scale and the environment face constant return to scale (CRS) inputs orientate technical efficiency can be solved by using the following equation (Coelli *et al*, 2005; Galanopoulos *et al*, 2006):

$$\begin{aligned} &Min_{\theta,\lambda}\theta, \\ &subject\ to\ -y_i + Y\lambda \geq 0, \\ &\qquad \theta x_i - X\lambda \geq 0, \\ &\qquad \lambda \geq 0, \end{aligned}$$

or

$$\begin{aligned} &Min_{\theta,\lambda}\theta, \\ &subject\ to\ y_i \leq Y\lambda, \\ &\qquad \theta x \geq X\lambda, \\ &\qquad \lambda \geq 0, \end{aligned}$$

The equation explains that technical inefficiency has a firm that produces smaller output than can be expected or the level of utilized input is bigger than it should be for the firm to get the same level of output. A constant is bigger or equal to one. Here, θ is the value of efficiency that a firm obtain and $\theta \leq 1$. If $\theta = 1$ the firm operates on frontier considering full technical efficiency. If θ is less than 1 the firm is technically inefficient. y_i is a value of the produced output for i-th firm and x_i is the value of inputs used in the production by i-th firm. Y represents the outputs data of all I firms included in the sample. Y vector is actually (M x 1) output matrix. X represents inputs included in all I firms and its vector is (N x 1) input matrix. Finally, the model must be solved I times, one time for each firm in the sample (Coelli *et al*, 2005; Galanopoulos *et al*, 2006).

- Input oriented - variable return to scale

CRS is not the case when there is an imperfect market competition or governmental regulations. Within this condition, the appropriate model is Variable return to scale (VRC). The formula of CRS can be easily adapted in VRC conditions, by adding $I1'\lambda=1$ convexity constraint where I1 is I x 1 vector at ones. The constraint ensures that the inefficient firm which is subject of analysis is compared with the other firms that are with similar size. Also the firm that operates on frontier is a convex combination of the other observed firms. The equation for VRS technical efficiency is represented below (Coelli *et al*, 2005; Coelli, 1996):

$$\begin{aligned} &Min_{\theta,\lambda}\theta, \\ &subject\ to\ y_i \leq Y\lambda, \\ &\qquad \theta x \geq X\lambda, \\ &\qquad I1'\lambda = 1 \\ &\qquad \lambda \geq 0, \end{aligned}$$

The equation shows that minimum efficiency has a firm that obtains small output quantity, but uses more inputs than the efficient firms. This model identifies technical inefficiency of a firm and suggests a proportional reduction of inputs assuming that output level is fixed.

2.2.2 Output oriented perspective

Output efficiency perspective is important for analysing the quantity of production and income received (Farrell, 1957). The analysis gives an answer of the question:

> "*By how much can output quantities be proportionally expanded without altering the input quantities used?*" (Coelli, 1996, pp.7; Coelli *et al*, 1998 and 2005, pp.54).

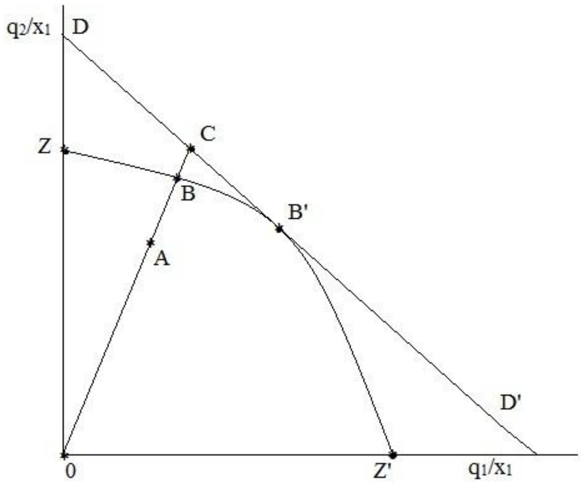

Figure 7: Output oriented technical efficiency
Source: Coelli *et al*, 1998 and 2005, pp.55; Coelli, 1996

In Figure 7 the curve ZZ' gives the efficient production cases (Coelli *et al*, 2005). Hence, the point A is inefficient production, and AB is the distance where the output can be increased without involving extra inputs. According to Coelli *et al* (2005) the technical efficiency from the output orientation perspective is measured as the ration: TE = 0A/0B.

- Output oriented – constant and variable return to scale

Output oriented technical efficiency identified technical inefficient firms under the consumption that their operating activities provide a constant level of inputs, but the output level can increase. It has the same level of technical efficiency with the input oriented under the constant return to scale conditions. According to Coelli *et al* (2005) the difference in input and output oriented TE in VRC conditions is that output oriented TE has ϕ-1 proportional increase in output and the output is bigger than one $(1 \leq \phi < \infty)$. The ratio 1/ϕ is the level of TE between 1 and 0. The equation of output oriented TE is the following (Coelli *et al*, 2005):

$$Max_{\phi,\lambda}\phi,$$

$$subject\ to\quad \phi y_i \leq Y\lambda,$$

$$x_i \geq X\lambda,$$

$$I1'\lambda = 1$$

$$\lambda \geq 0,$$

According to Coelli *et al* (2005), the most suitable measures are related with input oriented models. This happens to be so because firms have bigger influence on the input quantities that can be used in the production. The output is very sensitive issue since there is a risk in the production and the output quantity can vary, sometimes depending on the natural conditions, especially in the field of agriculture. Therefore, most studies are directed towards input oriented measures.

2.3 Technical efficiency according to stage

This part of the chapter explains technical efficiency from inputs and outputs measurements point of view more deeply. Coelli *et al* (2005) provide the analysis in two stages (first and second) while making technical efficiency analysis by dividing them in three categories: traditional inputs and outputs of production, environmental variables and managerial characteristics.

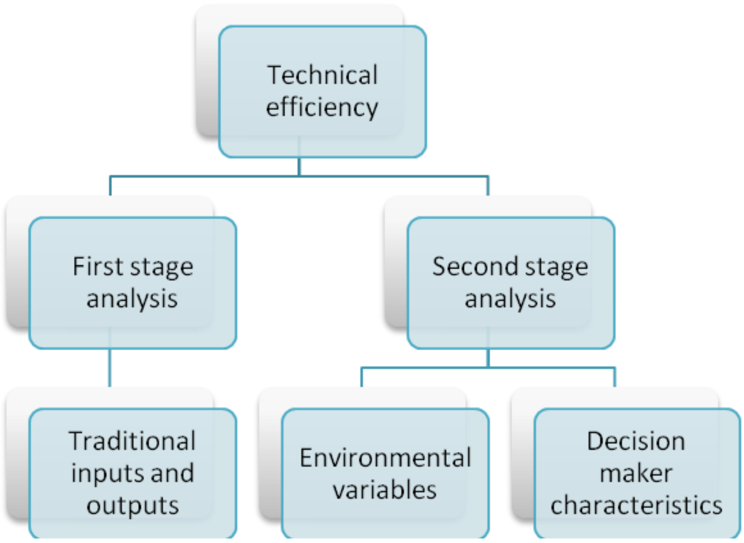

Figure 8: Technical efficiency from two stage analysis approach
Source: Own version adopted for the theory

2.3.1 First stage analysis

In the first stage analysis traditional inputs and outputs are included. The term traditional includes material resources that the production needs for processing and the output obtained by the same production.

- ✓ **Input measurement characteristics**

In pig production, inputs are divided in four categories: feed, labour, resources of production (other variable inputs) and fixed inputs (Sharma *et al*, 1996).

Feed is the most important for normal growth and reproduction of pigs (Sharma *et al*, 1996). Seen from another point of view, feed is the most expensive input in pig production since over 50% of the total farm costs go to the feed (www, NAERLS, 2011). It determines the quality of meat and intensification of the production system. Pig feed should contain: proteins, carbohydrates, lipids, minerals, vitamins, water and energy (www, NAERLS, 2011). Growing of piglets should consist of high level of protein diet since the insufficient protein causes lack of nutrient in manure. Manures are usually put on a field for crop production, so the composition of feed is indirectly related to the economic benefits of farmer (Campos Labbe, 2003).

Labour can be measured in different ways. The most common is the number of hours of utilised labour input. According to Sharma *et al* (1996) the labour in pig production includes both family and paid workers and the measurement is assumed to have eight working hours per day. This kind of measurement includes both full-time and part-time workers and the total work hours. The other measurements are: the number of people employed the number of full-time and part-time workers and salary paid for labour. When the measurement is focused on the number of workers then it must consider whether they are full-time or part-time workers and how many hours they spend working. If the labour input considers a total salary paid during the analysed period and if the measurement is a comparison between more than with one firm, it must consider the area of working. Considering that the labour payment is not the same in rural areas or big cities, the differences must be taken into account (Coelli *et al*, 2005). According to Farrell (1957) when the prices for labour are known or when the labour is measured in number of hours spend on working, they both affect allocative efficiency. Otherwise, when the labour input is measured in number of man employed, it affects the technical efficiency of a firm.

Fixed inputs usually refer to material assets that firms use in the production for more than one year. They are classified as taxes, depreciation, insurance, and owners' capital, like buildings, small and heavy machinery for production, computers, transport equipment etc. (Coelli *et al*, 2005; Sharma *et al*, 1996). Particular attention should be paid here to the service life of the asset due to estimating productive capital that takes the age efficiency over the assets lifetime into account. On the other hand, productivity of two different sets of equipment may experience big difference according to the amount of other inputs (Farrell, 1957). Farrell (1957) explains that capital measurement may present a difficult problem and it can be solved by measuring homogeneous sorts of capital in physical units or their prices.

Resources of production include utilized energy and variable material inputs (except feed and labour). They have the main influence in the amount of production costs, especially in the agricultural sector. Resources of production can be estimated in quantity of utilized input or the total cost for using the input, when the price is available. Variable material inputs consist of veterinary and medicine, insemination material (if applicable), fuel and gas used for transport, disposal of manures and ecology, hygiene and disinfection assets etc. (Coelli *et al*, 2005; Sharma *et al*, 1996).

- ✓ **Output measurement characteristics**

Output production can consist of single or multiple products. Measurement of a single product is the easiest part. In this case, output is measured by a number of units produced during the analysed period. The problem may appear when a firm produces multiple outputs. It is important not to aggregate different products, but different variable of the same product. If a firm has a lot of products, firstly they must be aggregated in the same unit and then to be summarized in units number of one product (Coelli *et al*, 2005). In pig production, outputs can be measured as physical quantities for instance, total live weight of pigs, and as a monetary value, total revenues (Sharma *et al*, 1996).

2.3.2 Second stage analysis

Second stage analysis is used to distinguish traditional inputs from other variables that influence the efficiency: environmental variables and various management factors. The first stage results in efficiency scores for all farms in the sample, and the second stage aims to analyse what factors influence the efficiency. Measurement of second stage variables is done by making a regression of coefficients that are adjusted to the efficiency scores that corresponds to the analysed factors (Coelli *et al*, 2005).

The term environmental variable is used to describe factors that influence the efficiency, but are not under the manager's control. Also, there are management characteristics that are not directly correlated with inputs, but still have an important role in determining the efficiency. Some examples of environmental and management factors related to pig production are presented in the table below (Coelli *et al*, 2005).

Table 4: Variables of second stage analysis

Second stage analysis	
Environmental factors	Management factors
Governmental regulation and legislation	Formal education of farmer
Location of the farm	Informal education of farmer
Technology and design of buildings	Age of farmer and years of experience
Technological process of production	Participation in association and cooperation
Ownership structure	Providing suggestions and innovations
Pig breeds and type of feed	Bookkeeping or accounting

Source: Adopted for the thesis according to Coelli *et al*, 2005; Sharma *et al,* 1996

More detailed review of the environmental inputs and manager characteristics which are significant for pig production follows.

- **Legislation and animal welfare**

Pig production strategies play a significant role in meeting consumers' demands and increasing the consumption on the domestic market, and even more on the foreign market. Indirectly, they are responsible for the improvement of the agricultural production. They comply with the legal framework in the country and influence the production environment. In this part of the study, the legislation and animal welfare established in the Republic of Macedonia are elaborated and are compared to the legislation and animal welfare in the European countries.

To fulfil a general need of food in the country a lot of standards were established in the period when R. Macedonia was a part of Yugoslavia (MAFWE, 2003; Todorovski, 1969, pp.269). For instance, the Official Gazette (16/1960) constituted a standard that concerned all pigs in the country regardless the gender, type, breed, real value and quality of meat.

After the independence, agricultural progress in the country was going slowly because of the political and economic reasons. In 1997, the Government of RM adopted a *Law on livestock breeding* (Official Gazette, 61/1997). It refers to commercial livestock and determines objectives, ways and conditions for livestock breeding. A *Veterinary Health Act* (Official Gazette, 28/1998) is established in 1998 and *Law on animal identification and registration* in

2004 (Official Gazette, 69/2004). They tend to satisfy the domestic market with cheap and quality livestock products and to increase the export of fresh and processed meat products (MASA, 1997).

A new *Law on animal protection and welfare* adopted in 2007 set up the rules for meeting minimum requirements for protection and welfare of different types of animals in the Republic of Macedonia (Official Gazette, 113/2007).

> "*Animal welfare is physical and social condition of animals that is achieved by satisfaction of certain living conditions, like: accommodation, environment, animal feeding, medical care and social contact" (Official Gazette, 113/2007, pp.1).*

The law has special provisions for protection of farm animals and separately for pigs. The aim is to provide the best treatment of animals concerning their needs, exposure to pain, suffering, physical injury and fear. Seen from this point of view, the farmer is obliged to meet breeding conditions in the farm, to keep the environment healthy, to provide a regular veterinary medical care and to use objects that allow accommodation of animals (Official Gazette, 113/2007, pp.5-8). Also, the microclimate should provide optimum level of temperature, especially for piglets that need additional heating (Official Gazette, 113/2007, pp.12-13).

During the last few years a strategic orientation of the Republic of Macedonia has been to enter the European Union. This is a reason for harmonization of the existing legislation with the legislation in EU countries. Hence, the Government of RM has adopted a new *Law on livestock breeding* in 2008 (Official Gazette, 7/2008). Despite previously established regulations, the Law provides a sustainability of the sector, protection of genetic variability and domestic breeds, animals' registration and environmental protection. Additionally, in 2009 the Government has established a *Regulation on conditions and ways of protection of farm animals* (Official Gazette, 140/2009).

- **Location of the farm**

Before building a farm, analysis should be made in terms of climate conditions (temperature, raining and water presence) and a location regarding near settlements.

Knowing the temperature is of great importance, especially in big production. The air temperature has significant value not only for the pigs' health, but for economical production, as well (Donevska, 2006). The best temperature for farrowing pigs is 15 to 20^{0}C, and the optimal is 16-18^{0}C in both winter and summer period (Todorovski, 1969).

Another important characteristic is the quantity of rain during the hotter part of the year, spring and summer. Also, climate indirectly influences the pig sector through livestock feed. The emphasis is put on farms that have their own production. According to Galev and Lazarov (1968) pig farms should be built in the area where the biggest cereal fields are located due to reduction of feed delivery costs.

According to Galev and Lazarov (1968) small pig farms can be built together with the other livestock farms. At the same time, big pig farms with more than 10000-30000 fattening pigs per year should be in separate objects. They explain that farms should be located at least 1km far from living places, but closer to the main roads and slaughterhouses due to reduction of transport costs.

Also, it is very important the location of buildings within the farm to be set properly, so the production process continues uninterrupted from one phase into another. For instance, the farrowing house should be located near sows and boars' house, then breeding house should follow the farrowing house and the fattening house should be at the end. The fattening house should be the closest to the road so that easier transport could be provided (Galev and Lazarov, 1968).

In Figure 9 (www, SSO, 1, 2011) the total available land of pig production farms is compared to the other livestock farms in different regions in the Republic of Macedonia. Therefore, the biggest area under pig farms is in the East part of the country, which includes Northeast, East and Southeast region. Here, most of the farms have from 1 to 5ha of land available for production. On the other side, West Macedonia has less pig farms, especially in Polog and Southwest regions. In these regions, most of the pig farms have less then 1ha available land. According to the total land available for production pig farms are in the third place, just behind the sheep and the cattle farms.

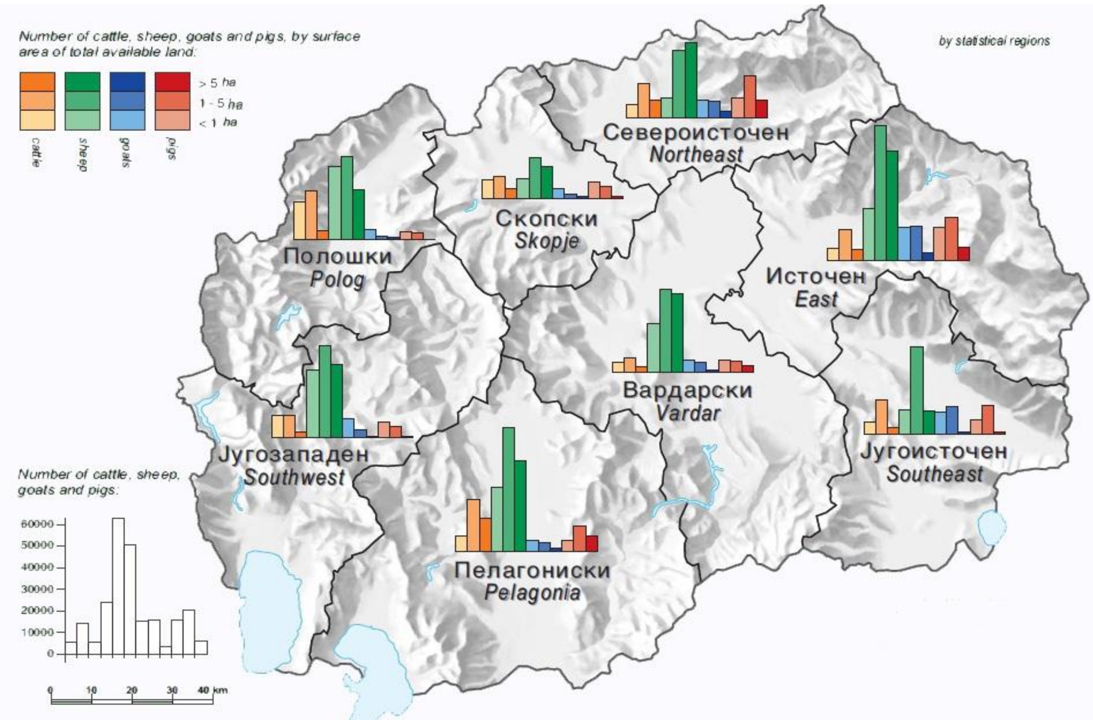

Figure 9: Pig farms by surface area of total available land for production
Source: www, SSO, 1, 2011

- **Management activities provided on the farm**

By different combination of resources, and with rational use of inputs, farmers aim to increase the production quantities and to get the quality output. Farmers must provide adequate animals care in order to expect the maximum production capacity (www, NAERLS, 2011). Johansson and Ohlmer (2007) find out that the production depends on the managerial activities and by rational and planned use of inputs in a production system the manager can determine farm profit.

Despite the short run management activities that are more directed on managing the variable inputs in the production (like involving feed, cooling and heating energy, additional labour and other additional costs), managerial activities are very important in decision making in long term activities like using certain technology and process of production, choosing the location, preferring different breeds with various characteristics, utilisation of fixed assets, environmental performance etc.

- **Construction and design of buildings and technology of production**

Construction of buildings is a very important part in efficient pig farming. It is related to the temperature level of the farm, ventilation system, and dust appearance. Climate conditions have a direct impact on pig health and its performance (Campos Labbe, 2003). Inadequate conditions can lead to diseases, increased consumption of feed and reduced weight grows that directly affects farmers gain. Usually pigs are kept indoors in boxes without access to outdoor conditions, normal movement and activities. In such circumstances, it is necessary that the farmer keeps the environment clean and to provide good hygiene practices. That helps in the reduction of diseases appearance and infections risks and indicates pig welfare (www, Compassion in world farming, 2011).

From one side, public is concerned about the negative environmental impact of pig farms and animal welfare (Zonderland and Enting, 2003). On the other hand, farmers are interested in profitable production and reduction of all additional costs. Both sides influence the changing of the managerial activities for more healthy and natural production and make the management process an important issue when analysing farm efficiency.

- **Technological process of production**

Technological process covers a few phases by utilization of a specific technology in production. It consists of two separate, but also connected systems, reproduction and fattening system. For effective management, every system consists of different buildings where pigs are grouped according to the age and weight. Each house should be washed, disinfected and left empty for one or two weeks before new pigs are to be brought in (www, NAERLS, 2011). The production process in Figure 10 elaborates the recommended way of production:

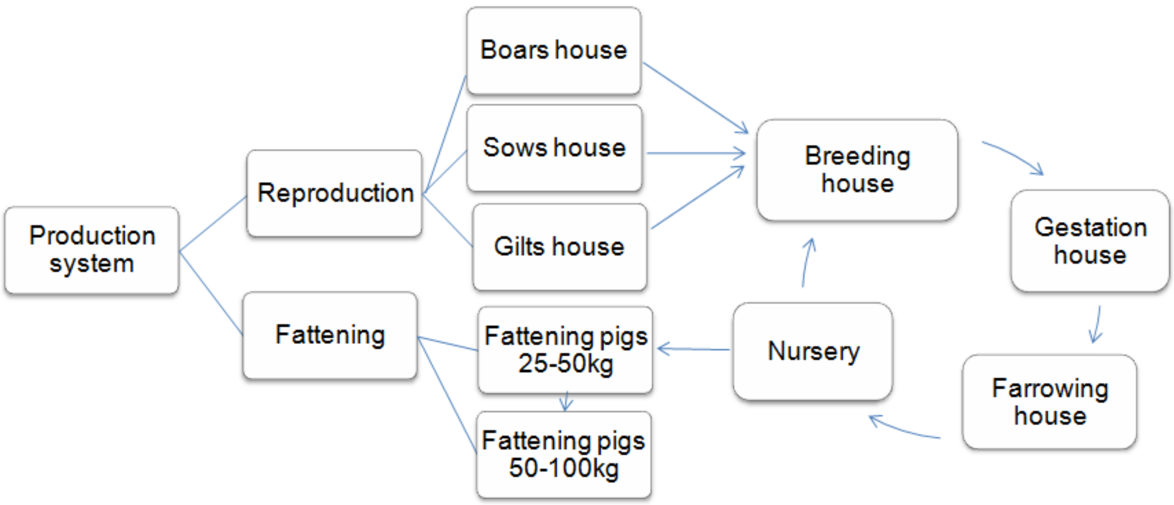

Figure 10: Technological process of production in pig farms
Source: Figure adopted for the thesis

In the ***reproduction system*** farmers make different combinations of male and female breeds in order to get the best characteristics in piglets, or they just make artificial insemination of sows with already prepared reproductive material. Boars, sows and gilts are bred separately and then put together only for reproduction needs. Then, this system unfolds in four chronological phases of reproduction provided in separate objects (Todorovski, 1969; CeProSARD, 2010; Bar-Ece, 2006; Vukovik, n.d.; www, NAERLS, 2011):

- ***Breeding house*** – This is a building where the insemination is performed on sows and gilts. In breeding farms this process is done by matching pigs and in producing farms the insemination is done by the veterinary officer. Sows are here 21 to 30 days, depending on the efficiency of insemination. If the insemination process succeeds, sows are transported into the gestation house.

- ***Gestation house*** – In this object sows are staying for 110 days or 5 days before farrowing. Here, sows are able to move freely. They need to be kept into small groups to have access of feed. A feeding quantity is given according to the time when sows are farrowed. In this phase, every produced stress can result in losing pregnancy or decrease the number of piglets.

- ***Farrowing house*** – Sows are staying in the farrowing house for 35 days, 5 days before farrowing and 30 days while they are in a lactation period. Here, sows are accommodated in individual boxes together with piglets. The farrowing should be supervised by the farmer in case of any farrowing problems. Management is important especially 72 hours after piglet's birth. A special care can minimise piglets' loss for 95% (www, NAERLS, 2011). The breeding process should be provided on friendly flooring systems made by a high quality and easy to clean plastic slats (Big Dutchman, 2011). The aim is to ensure dry place for the piglets to be safe from diseases. At the end of this phase, piglets are brought into the nursery and sows are turned back into the breeding house.

- ***Nursery*** – This phase undergoes two sub phases where the piglets are bred until they become 25 or 30 kg, around 40 – 45 days. In B–phase pigs are separated due to the sex and size. In this period piglets are still early separated from sows and are consuming a lot of food.

A ***fattening system*** also undergoes two sub phases. In the first sub-phase pigs are bred to reach from 25 to 50 kg and the second sub-phase consists of pigs fatten until they get 50 to 100 kg. After this phase pigs are ready for transport in the slaughterhouses or to be sold at the market as live weight.

- **Prevalent breeds of pigs**

During the time when Macedonia was a part of Yugoslavia the pig production sector consisted of few domestic breeds spread around the Balkans region. The most famous domestic breed is called *Shishka*. This pig is very similar to the European wild pig and until the 19th century it was dominant not only in the Balkans, but in middle Europe, as well. Today, it is represented in very small numbers and is treated as a historical breed. *Shishka* is bred in primitive conditions as it was in the past and can be seen in the forests in semi-wild condition with clearly expressed maternal characteristics. Due to the natural conditions of the environment, this breed has very good health, resistance and humility, but is developed in a small and low productive breed. The breed is not competitive compared to the other modern breed and will disappear in the near future. The remaining domestic breeds are more represented in the other parts of Yugoslavia and their attitude in pig production sector in RM is insignificant (Todorovski, 1969).

Today, pig production in the Republic of Macedonia is represented with three major breeds. One of them is *Landrace*, imported in the country from Belgium, Denmark, Sweden and Germany. The others are *Yorkshire* and *Duroc* (IPARD, 2008, pp.80). To avoid inbreeding and to increase the production farmers provide a process of reproduction with new genetic materials by importing boards from the foreign countries. However, farmers increase breed performances and meat characteristics by making different combinations and cruising of primary breeds (IPARD, 2008, pp.80).

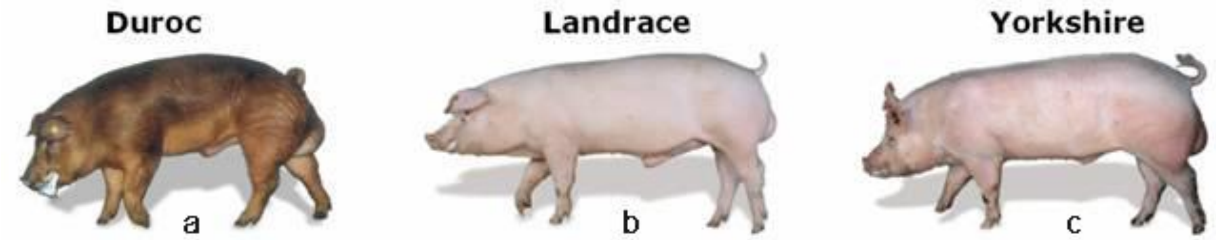

Figure 11: The three breeds used in RM
Source: www, Mark and Ostersen, 2011

<u>*Yorkshire*</u> (also called *Large white*) is formed in the late 1700s in England, but prominence in the 19th century. It plays a significant role in creating other breeds of pigs, not only from the historical aspect, but in the modern production programs, as well. This makes her the major breed in all pig producing countries in the World. It has white skin and is large-framed (see Figure 11c). Its ability for adaptation in different living conditions makes it withstand a wide range of climatic conditions. It is produced for the market to meet consumer's requirements of low amount of fat and high level of quality meat. Its fertility is high, with 10-12 live births piglets and expressed maternal instincts on the breeding piglets which are the reason why the pig is also called *Fertility breed* (www, Taylor *et al*, 1, 2005; Todorovski, 1969, pp.63-68; www, NAERLS, 2011).

<u>*Landrace*</u> breed is spread in many countries in Europe. It originates from the *Danish Landrace* which was partially created by crossing the native pig with the *Yorkshire*. It is adaptable to the intensive housing production systems, but with lower ability for adaptation than the *Large White*. It is a lop-eared pig with a long middle and with white coloured skin (Figure 11b). It has solid muscles especially in the back side of the significantly long body. Like *Yorkshire*, it expresses maternal characteristics and big fertility, early and rapid growth and a big quantity of high quality meat (www, Taylor *et al*, 2, 2005; Todorovski, 1969, pp.80-85; www, NAERLS, 2011).

<u>*Duroc*</u> is modern breed produced in the USA by crossing the old *Duroc* from New York and the Jersey Red from New Jersey. *Duroc* has reddish colour of the skin, varying from gold to dark (Figure 11a). In the country, it is used to provide a third breed as a terminal sire by combination of male pigs with *Large White* and *Landrace* sows. They do not have good maternal characteristics, but have lower litter than the other breeds. Pig performance depends on the genetic characteristics and the environment of breeding (www, Taylor *et al*, 3, 2005; Todorovski, 1969, pp.92-93; www, NAERLS, 2011).

There are many cross-breeding programs that make different combinations of breeds, especially of Yorkshire and Landrace. They are all intended for increasing the efficiency and make intensive pig production. One of them is the breed F1 which is one of the most popular pig breed in the World (www, Taylor *et al*, 1, 2, 2005).

- **Education of farmers**

Because of the increased costs of production which are not possible to be met by increasing the price of the output, farmers must invest to improve farm productivity and to increase the production quantities. By this farmers need to improve their managerial skills and with good decision making to contribute for increasing farm efficiency (Kilpatrick *et al*, 1999).

Farmers' education is divided into formal and informal. Formal education includes a college and university degree etc, while informal education includes experts, media, attending workshops, seminars, conferences and trainings. Farmers prefer to learn in the informal way, more than through a formal education. The main subject of interests is the technological process of production and management issues. In addition, the motivation for learning comes with a purpose to improve farm efficiency (Kilpatrick *et al*, 1999).

To increase the sustainability of farm, management skills and marketing farmers may need help from the Government and private experts that work in the field of agriculture. Moreover, a number of studies have confirmed that there is a positive link between using consultations from experts and adaptation to new and more profitable technologies of production (Miller, 1994; Fulton, 1995). Private consultants are usually used for getting advices according to the technical innovations in the area where a rapid change exists (Fulton, 1995).

On the other hand, consultations with other farmers, family members or the employees is very important for providing support in implementing new technologies (Kilpatrick *et al*, 1999). According to Fulton (1995) consultation with other farmers and family members is the major source of information and influence on the decision making. According to Millar and Curtis (1997) family members are usually consulted about the management activities, while the knowledge from other farmers means sharing local information and direct farm experience which is important for appropriate decision making. Also, very important source of information are media, especially the internet because it provides a considerable amount of information concerning technical, production and management topics. According to the (Kilpatrick *et al*, 1999) *"a 'successful' farm managers use a computer as a tool for providing management activities in the farm business"*.

Training and formal education are not favourable by farmers while seminars and workshops are more preferred. They both play a significant role in motivating farmers to implement a change (Kilpatrick, 1997) and give an opportunity to exchange farmers' experience and opinion with experts, neighbours, as well as to become familiar with new practices and develop new awareness of information. According to Woods et al (1993) seminars and workshops are useful for awareness raising, motivation and decision making especially in the field of technical, physical and financial management and marketing. According to (Kilpatrick *et al*, 1999) those farmers that have higher education are more flexible and willing to participate in education and training activities and are better in planning and providing good management practices, as well as innovation activities. They see that management activities are necessary for good decision making process. Therefore, they use different sources of information in their management like consultations, education and trainings, seminars, media etc. Also, a participation in an agricultural association was found to be very helpful in communication, obtaining new information and learning activities.

Regarding the involvement of women in an agricultural management provided on the farm, a lot of farms still have traditional roles (Reeve and Black, 1998). Indeed those women that are part of non traditional farms participate in educational activities and trainings more than women in traditional farms. According to Kilpatrick *et al* (1999) participation of women in the management and decision making processes is very important because of a certain knowledge and attitude that they bring to the farm. In addition, an Australian Standing Committee on Agriculture and Resource Management (1998) explained that "*women in business management have greater skills on research and passing of information*". Since they want to communicate more with other farmers or other persons involved in the same research area, and are more open to innovations, participation of women in management activities would contribute in increasing the farm technical efficiency (Kilpatrick *et al*, 1999).

- **Keeping of records**

Bookkeeping and accounting are very important activities for every successful pig farm. Bookkeeping is a procedure of keeping financial records (costs and revenues) that helps the management to deal with everyday financial activities of the company, while accounting is provided in order to analyse microeconomic activities of business (www, Difference Between, 2011; Milanov and Martinovska-Stojceska, 2002).

According to NAERLS (www, 2011) keeping of records can help in determination of the efficiency of farm production. Additionally, in the first 24 hours of birth piglets must be marked and identified in the herd records. Herd records should have data of piglet's birth, mortality, feed consumption, medication and veterinary treatments, and market sales (www, NAERLS, 2011).

- **Environmental performance**

The environmental performance of farms needs to meet public interests. Odum (1986) explains that pigs use concentrated feed intensively and produce organic waste in which there is unutilized energy that was entered by feeding. According to Grupce (1994), unutilized energy causes difficulties in maintenance of hygiene and quality of the environment. He elaborates that pigs use only 48% of feed to build their biomass and the remaining amount is thrown outside their body. That is why the production of manure consists of 2.5kg per pig daily. Anyway, manure organic waste that can be rationally used as an input for further production of energy or biomass.

Another problem is that traditional production of pig farms in Macedonia do not allow utilization of organic waste which causes farms not to be rational in using the entered energy and makes them intensive pollutants of the environment issues, especially waters, soil and air (Grupce, 1994). Jordanovski *et al* (1987, 1988) say that unutilized organic waste in alternative energy production is clear loss for farmers, because collected waste from farms not only allows better hygiene in them, but also makes production of new products like biomass, biogas, liquid waste for the agriculture and water for recycling available in quantities that can meet farm needs. According to Grupce (1994) Macedonian pig farms are built as linear systems (Figure 12) and their structure allows accumulation of manure into channels set up to bring the waste in tanks without production of economic valuable products. This causes difficulties in maintenance and management activities for waste utilization and big environmental pollution.

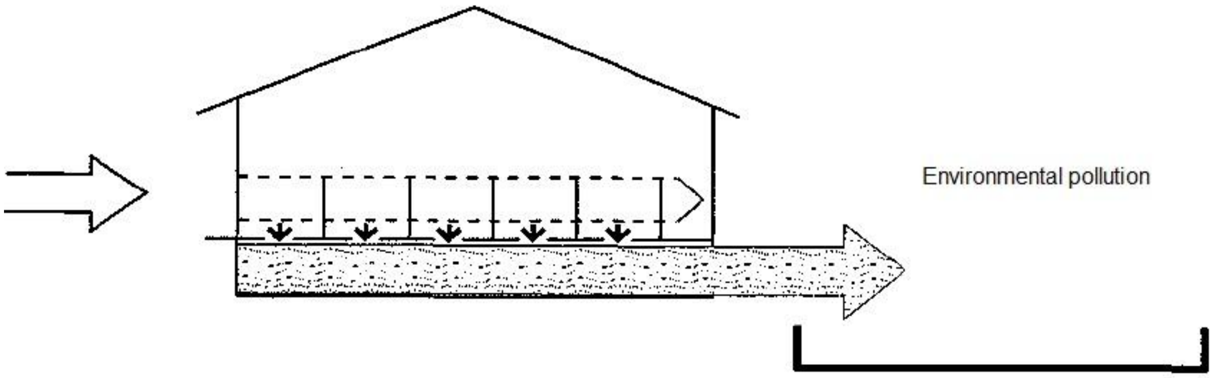

Figure 12: Linear organization of pig farms in RM
Source: Grupce, 1994, pp.53

In terms of environmental safety, traditional farms are not competitive in the world market because their structure requires high costs of electricity, labour and feed. Therefore, a pig production system needs another alternative that would take a greater care of human health, animal welfare, clean and safe environment, but at the same time economically profitable and efficient in their production activities (www, Agro-Soyuz, 2011).

3 Method

The third part of the thesis explains a working procedure under which a survey would obtain the needed answer. It comprises of methods used consequently by the following order:

- In the first part of the method chapter, a survey is made on the information needed and relevant for the research and the approach for its analysis on the thesis level. At the end, this part includes a survey on the number of pig farms in the country, their location and size.

- The second part shows the process followed according to data collecting by using direct and indirect sources of information. The survey has been done through a sampling procedure and preparation of the questionnaire.

- The third part of the method chapter includes processing of collected data. Therefore, the research is provided in three sections: by statistical analysis of the collected data and DEAP approach, where the data are used for estimating the efficiency on the farm level. In the last section it is decided for the data to be protected according to the letter of data collection (Appendix 2). Hence, the data for each farm are coded separately.

3.1 Initial research

The idea of this study begins after the analysis of pig production sector in the Republic of Macedonia. The analysis consists of a review of the statistical data available from the State Statistical Office web-site and statistical books, as well. The data show that the sector does not meet market demand and pig production is followed by frequent variations in the production quantities. More details are provided in the introduction chapter of the study. After the analysis the aim is developed, to make a research about the efficiency in production of pig farms in the country.

The research can be completed only if there is a suitable model for analysing the efficiency. For that reason Data Envelopment Analysis is confirmed to be the best way for analysing the efficiency on farm level. The model needs sensitive information in order to estimate the efficiency. For instance, data considering all inputs and outputs in the production should be collected. The background of DEA is analysed in the second chapter.

The need for relevant data that would be applied in the analyses initiate a survey of the way these data would be collected. The survey shows that there are no previous studies of the input-output related efficiency of pig farms in the country. Also, the database is still not developed, except FADN database which is in a preparation phase, but it still does not cover enough quantity of relevant data. Preliminary data are collected through organized survey of pig producers in the rural areas in the Republic of Macedonia. As a result, an analysis of the total number of pig farms and their location is made. The results show that the total number of pig farms in the country was 35 in 2007 (SSO, 2007), while in 2010 is around 50 (pers. com., Saklev, 2011), from which only 7 are big farms which are private organizations with a total capacity of 150,000 pigs per year (Vukovik and Andonov, 2010), and around 10 farms have less than 100 sows. The others are very small producers who have 10-50 sows per farm and their number is not yet determined.

3.2 The process of data collecting

Data are collected by few steps: using different ways of collecting the needed information, sampling procedure and preparation of the questionnaire.

3.2.1 Collecting approach

Data collecting process starts by contacting a few relevant institutions, The Faculty of Agricultural Sciences and Food in Skopje, Veterinary offices, several Municipalities where the majority of farms are concentrated, The Federation of Farmers in RM and The Association of Farmers. Their contribution is provided by giving contacts of pig producers that operate in their region. Faced with no appropriate and no available data it is agreed the data to be collected by three approaches: by making direct interviews with the decision maker, by a telephone call and searching the internet.

At first, for the interviews, each pig producer has direct contact with the researcher. This approach is found to be relevant for collecting the most sensitive data. The investigation is supported by a questionnaire that was previously prepared. The questionnaire is adapted to the research and questions are developed according to the literature searched, which makes the analysis of the collected data easier. In order to give a relevant data and the answers to fulfil the questionnaire requirements all face to face interviews are provided partially with the decision maker[1] and with the accountant of the farm.

The second approach considers a telephone call. For instance, a part of the data that are considered to be less sensitive, are collected by making a telephone conversation with managers, who are the main decision makers in the pig farm operating activities.

At the end, questionnaires that have insufficient information (or the response of the farmer is provided with insufficient information) are fulfilled by the data available on the internet. Usually, this kind of data are available on-line only for the biggest farms in the Republic of Macedonia. In respect to the new *Law on free access to public information* (Official Gazette, 13/2006) all information of public character should be available for those who are not going to abuse the data. Therefore, most of the farms that have their own web-page have already published their reports. Moreover, according to the *Law on Joint Stock Companies*, JSC are obliged to inform the public about their activities and a financial situation over the year (Official Gazette, 04/2002). The approach of public reporting allows information of the shareholders and those who are interested in the certain JSC.

3.2.2 Sampling approach

According to Casley and Kumar (1988) and Kinnear and Taylor (1987) in an empirical investigation a sample is used to collect certain amount of data instead of a whole. They explain that the limitation helps in saving money, time and data management to achieve acceptable results. Also, Eisenhardt (1989) and Robson (2002) stress that those external factors may limit the sources of information. In that case, they suggest the researcher to be provided by sample. Casley and Kumar (1988) and Kinnear and Taylor (1987) divided

[1] In the most cases, the decision maker or the farm manager is the owner of the farm.

sampling method in four steps: defining the population, sample frame, sample size and sample selection procedure. The first step is categorisation of the field of investigation. Then the classification goes more deeply due to the region, name and the area of production. Fateh Mohammad (2009) in her doctorial thesis starts the third sampling step with the question "How large the sample should be?" She explains that larger sample contributes for higher reliability, lower error and represents the measurement issues as a whole population. Moreover, Casley and Kumar (1988) and Kinnear and Taylor (1987) say that to have a good survey due to a population with unlimited measurement units the sample could have both, small and minimum standard error. There are also statistical methods to calculate sample size depending on the wanted reliability (Yamane, 1967). However, in this study we do not have the information needed for such a calculation.

Considering the above literature explanation, it is decided that the best way to collect data is to know the background of needed information. In respect to the study field of interest, data are collected from the primary producer of pigs in the Republic of Macedonia. It was considered that there are not many pig farms in the country, and the analysis should consist of data collected from a few big, medium and a few small pig farms which allow the analysis to be comparable and measurable between each other. Farms should have more than 10 sows for their production to be intended for the market. The aim of the thesis will be met if at least half of the total number of farms is included in the analysis. Selection of farms that would be subject of analysis depends on available contact information and the access to required data. Finally, the total number of farms depends on the farmers' positive response to give the requested information.

3.2.3 Preparing the questionnaire

To have a good overview of data collected and to avoid omission of certain information required, a questionnaire is prepared and used during interviewing farmers. The questionnaire is divided into four parts (see Appendix 1).

The first part includes general information regarding farm name, year of establishment, location, road accessibility and area of pig farm. Most of the questions in this part are descriptive and their influence on the efficiency would be analysed statistically. This part requests information for the second stage analysis of inputs which are previously described in the second chapter of the thesis.

The second part of the questionnaire is related to the second stage analysis of inputs described in the literature review part and it covers the decision maker characteristics. Hence, this part concerns the manager and the management activities provided on the farm. The questions are about the manager experience, the level of education and the involvement and interest in getting new information and innovations for manager capacity building. Their design allows managers to choose between several options already set, and some of the questions allow managers to answer with yes or no. Prepared questions like this prevent getting many different answers and make them easier for summering and analysing the data. Also, questions considering if the farm has accounting system and informative web page are included here as important management activities for efficient and sustainable farm.

The third part reviews the output produced in quantity and the profit reported by the farm at the end of the year. Because some farms have more than one output (for example pigs to 25kg, fattening pigs with around 100kg, sows and gilts) their total number in each farm is summarized as one output with one measurement unit, total kilograms of pork. Output characteristics and its measurement are explained in the second chapter.

The last part focuses on inputs that are included in production. These inputs are represented as traditional inputs in the analysis of the theory. Actually, they are variable inputs directly included in the production and their analysis is applicable to DEA model for estimating technical efficiency. They are classified in four sections: feed, labour, energy and other inputs.

1. Feed section includes all types of feed that are used for feeding pigs in different ages. Feed can be produced on the same farm or bought as concentrate. The questionnaire request data for total quantity of feed spent over an estimated year and a total price paid for feed for the same year.

2. Labour consists of family members or paid workers. The most important and measurable in this section is the cost of labour that farmers pay monthly for the whole year. Also, this part includes total working hours spent on the farm for the analysed period.

3. Energy section contains the cost and quantity of different types of energy mostly used for heating and lighting: electricity, oil, wood etc. Also, the cost and quantity of water consumption is included in this part.

4. The part of other inputs takes into consideration costs for veterinary and medicine, insemination doses and insemination, hygiene and disinfection costs, disposal of manure and ecology costs, costs for transport, insurance and other costs.

3.3 Processing collected data

Processing of the data is provided by four approaches. At the very beginning collected data are processed by using anonymity approach in order to protect pig producers. After that, collected data are simplified in order to develop a base of equal data for each farm and relevant information to be used for further analysis, then statistical analyses are used to help in explanation of the pig producers and their activities provided on the farm. The last approach use DEAP for measurement of the data in correlation to efficiency estimating. All these approaches are used as a basis for further analyses that are provided in the analysis part (Chapter 4 and 5) according to the theory and in a relation to the questionnaire.

3.3.1 Data protection through anonymity

In order to satisfy the research questions, stated within the aim in the introduction part of the thesis, one part of the research covers classification of pig farms in RM. The classification can help in providing the analysis separately for big, medium and small pig producers. The results come out with findings of one classification of pig farms according to the Official Gazette (53/2005) of RM, shown in the table below.

Table 5: Classification of farms for intensive pig production

	Number of places	
Farm category	Places for fattening pigs	Sows
Small	less than 100	less than 50
Medium	101 – 1999	51 – 749
Big	more than 2000	more than 750

Source: Official Gazette, 53/2005

As it is shown in the classification, farms included in the research are divided in three classes: big, medium and small farms according to the farm capacity to place a certain number of fattening pigs and sows. The classification is used in the anonymity approach. Latter of data request (shown in Appendix 2) ensure pig producers and the data obtained with protection from the external abuse by anonymity. Joveva (2011) in her thesis used the anonymity approach by adding the first letter of production capacity (S, M and L) to the analysed wineries. In example, S means small winery, M is medium and L is large winery. Also, to divide each winery within the group of small, medium and large producers, she used numbers (1, 2, 3,...) in the increasing order related to the capacity of production. In addition, winery S1 has less capacity of production instead of winery S2, while S3 has the biggest capacity considering these three wineries. This approach is found to be the most suitable for analysing pig farms by anonymity and hence is adapted to this study as well. Further analysis of pig farms included in the research and their capacities are provided in Chapter 4 and 5.

3.3.2 Simplifying approach

Simplification method is used in order to make an easier estimation of inputs and outputs relationship and to avoid errors while estimating the efficiency (Fateh Mohammad, 2009). The reason is that the data collected from farmers have different values, so to be estimated with DEA programme they must be reduced in the same measurement units.

Simplifying of the output is needed for making the data easier for processing. Especially, this approach is necessary in pig production sector, which represents a complex discipline that results with more than one output. Usually farmers produce fattening pigs with approximately 100kg live weight. The other products are: pigs from 25kg to 50kg, gilts ready for farrowing and sows that are not going to be farrowed anymore. If the analysis consists of some quantity of produced units, for example a total of units of sold fattening pigs or little pigs, depends on what type of production is the farm determined for. This case brings the researcher to have many categories of live weight. On the other hand, not all the farms use the same production categories. The output categories that are not going to be subject of analysis of the specific farm should be represented with measurement value 0. Hence, the process of estimating efficiency would be much difficult with a risk of appearing of some problems in respect to unrealistic data obtained during the analysis.

To simplify the estimation of all products in the farm, they are summarised in one unit that represents a single output. Kilograms are taken as measurement units. Hence, all output categories are elaborated in total kilograms per category and then, all categories produced in the same farm are summed up in one output measured in total kilograms of live weight.

Animal feed intended for pig production also consists of many different mixtures of feed. The mixtures are then sold to farms as a concentrated feed for different livestock categories. Even those farms that have their own production mix the ingredients to produce the same concentrates like the feed that is available on the market. To make the analysis of feed consumption with DEA all feed categories need to be aggregated in one category with a same measurement unit for each farm. Therefore, all categories are aggregated in a total quantity of feed used for production during the analysed period and kilograms are to be used as a measurement unit.

Labour in production is divided in two possible units, full-time and part-time workers. In the field of pig production particularly, some workers are full-time employed, but some of them work occasionally. The best indicator for labour measurement is the total hours spent by both full-time and part-time workers. Considering this, working hours spent by the full-time employed staff are easily to be calculated, but the problem appears because the farmers do not know the total hours paid for part-time workers and the total time spent on part-time working, as well (reference: interviews). Furthermore, there are additional workers on each farm considering the representatives from the family. Some of them are not employed, some of them are children, but they spend the whole day working on the farm. Hence, the labour in the study is aggregated in total number of employed and family members who have been involved in the farm activities during the considered period.

The other inputs involved in the production are veterinary costs, vaccinations of animals, insemination doses and insemination, hygiene and disinfection costs insurance, transport costs, disposal of manure and ecology costs. This part also includes *water, electricity and other types of energy* used for production for they are also considered costs. For DEA analysis, they are aggregated in total other cost involved in the production.

Some parts of the questionnaire need descriptive answers. For the analysis with DEA those answers have to be simplified and aggregated so that the analysed part represents one input. The input estimated with DEAP needs to be measurable and to have a value that would represent the level of efficiency.

3.3.3 Statistical approach

All data of farms available for analyses are entered into the database made in excel file, separately for each farm and in the same order as collected by the questionnaire. This approach is found to be an easier way for an overview and to allow different combinations and aggregations of the data due to managing data analysis.

All parts of the questionnaire are treated separately in the excel database. At the end, each part is aggregated according to the needs to give an average evaluation of the efficiency of farm operational activities. The aggregation is provided by the approach that DEAP request for the analysis. In respect to the programme, each part of the questionnaire is aggregated in one input measured by different units that are needed for estimating technical efficiency.

3.3.4 DEA programme approach

Data Envelopment Analysis model is applied in the study for measuring farm level efficiency of pig production. It consists of one output and three inputs. The aggregated output and inputs are applied for DEA analysis, previously simplified in the same measurement units. It is not important which measurement unit is taken in analysis as long as it gives relevant data for measuring production quantities (Coelli *et al*, 2005).

Therefore, the output in the study is taken to give a quantity produced in the period of analysis (total kg live weight). Some of the inputs consist of a number of units used in production, but some of them are measured in prices representing a value of costs used for production. For instance, feed input is measured in total kg spent during the analysed period, labour is measured in number of employed and family members that work on the farm and the other inputs are measured in total costs spent during the considered period. This kind of aggregated inputs may result in failure to make a difference between technical and allocative efficiency due to the fact that prices are subject of analysis of allocative efficiency (Thomas and Tauer, 1994). Even Farrell (1957) says that a firm while measuring its efficiency may affect price efficiency instead technical efficiency, which makes it quite difficult to distinguish between both efficiencies. However, the aggregation of inputs is used to reduce so many inputs of production and to make the data more available for further analysis.

The output and inputs aggregated like this, previously provided in database created in excel table, are placed in dta.txt file that DEAP use as a base for the analysis. The instructions for the analysis are provided in ins.txt file. The estimated values appear in the out.txt file from where the efficiency values are easy to be read. This activity is provided a few times considering the input and output oriented technically efficiency separately in the instructions.

For providing the analysis, researcher has adapted an analysis concept in order to describe the process by which technical efficiency is estimated with DEAP (see Figure 13).

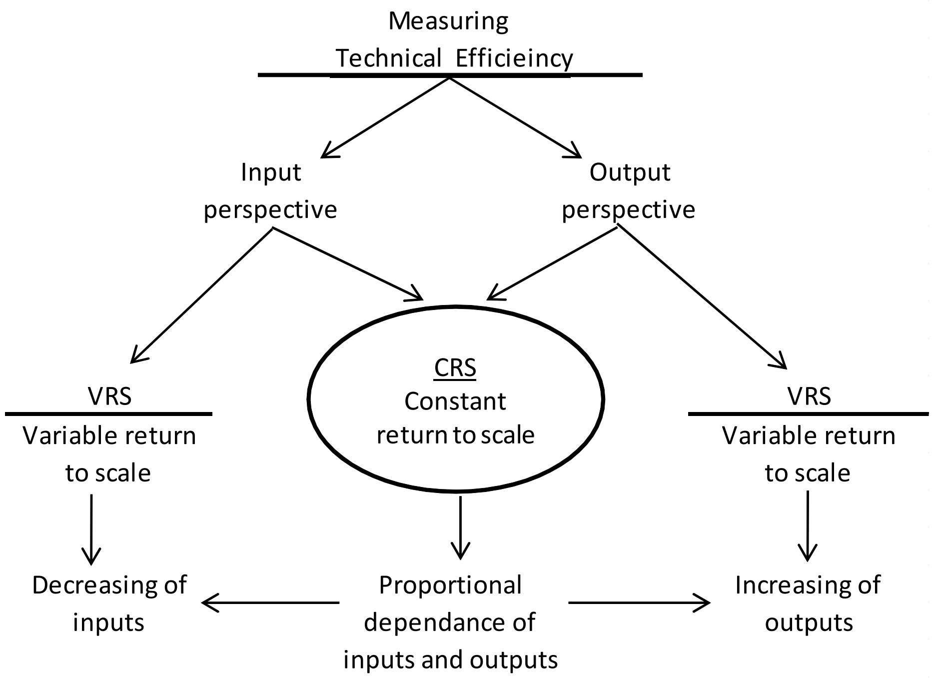

Figure 13: The concept of analysing technical efficiency
Source: Own version adopted for the theory

As it is shown in the figure above and related to the theory, technical efficiency of pig farms is analysed from both input and output perspective. Input perspective describes inputs relation to a certain quantity of output. Under the assumption that the output is going to have the same quantity as produced for the analysed period, input perspective finds the most favourable quantity of inputs for the farm to face the biggest level of efficiency. This perspective gives the level on which inputs utilization should decrease until farms produce the same level of output. On the contrary, output perspective describes the output relation to a certain level of inputs used in the production. This approach analyses for how much the output would increase without changing the level of utilised inputs.

The analysis includes both constant and variable efficiency scales under which farms operate. Hence, variable return to scale means that farms are operating under an imperfect environment where other issues depend on the production efficiency. On the other hand, constant return to scale means that farms are operating under perfect conditions and by increasing the level of inputs for one unit the output would increase for one unit as well. Moreover, constant return to scale has the same average efficiency[2] for both input and output perspectives, but input perspective analyses technical efficiency of inputs, while output perspective considers technical efficiency of outputs.

The empirical findings of collected data and their analysis are provided in the following two chapters.

[2] Considering a total average efficiency of all farms included in the analysis and the average efficiency separately for each farm.

4 Empirical findings

Chapter four of the study (Empirical findings) gives a brief analysis of interviews provided on farms and explains the data obtained by the questionnaire with an emphasis on farms characteristics and managerial activities. The empirical sectors are divided in the same order as the questionnaire is arranged:

- Farm characteristics
- Manager issues and
- Fixed and variable inputs.

Their explanation follows.

4.1 Interviews provided on farms

Interviews have been provided with the decision maker form each farm separately which has been found to be the most suitable approach to collect needed data. This is because the decision maker is the most involved in the activities provided on the farm and input-output relations.

It has been found that only the biggest farms that have more than 750 sows have highest specialization in the activities and labour units. Here, the interviews have been provided with the director of the farm[3] since he is the person who makes the decision making regarding the utilization of inputs. In the medium farms the owners are fully involved in farm activities and they are responsible for the decision making process. Specialization consists only of the owner and several employees that work on the farm. In most of the cases the owners live near the farms and involve their families in pig production activities. Therefore, interviews in this kind of farms have been conducted with the owner of the farm. The smallest farms in the country, with less than 50 sows, are owned by the decision making person as a private property[4], usually built in the same yard where the pig producer lives. Working activities on these farms are provided by family labour and part time workers involved only in the period when there is a need for extra work. Interviews in the smallest farms have been provided with the owners, as the only persons fully involved in the farm activities.

During the interviews, the researcher has faced different approaches by farmers to respond to the questionnaire. Mostly, all of the interviewed farmers have been willing to respond even though it takes around twenty minutes to fill in the questionnaire. Only one of the total numbers of contacted farms, unfortunately the biggest farm in Macedonia, has negatively responded to the questionnaire and a face to face interview could not be held. There have also been farmers with positive attitude for cooperation and available for suggestions. They represent 48% of total farmers interviewed for the study. For the interview, they explain the situation of Macedonian farmers today, in 2011 compared to 2010 and give important data

[3] In the biggest number of the interviewed farms, the director is not the owner of the farm, since they have more shareholders with different ownership status.

[4] As it is written in the introduction part of the study, all farms in the Republic of Macedonia are private properties even if the biggest farms were part of former agricultural cooperatives.

and useful coefficients for further estimating of the collected data. On the contrary, 24% of the interviewed farmers did not want to give fully information to the sensitive part of the questions regarding total revenues and costs of production.

4.2 Farm characteristics

To explain the characteristics of farms which are included in the analysis this part is divided in three sectors:

- The location and capacity of farms
- The year of establishment and farm status and
- The type of production within the farms.

4.2.1 Location and capacity of farms

The research includes 21 farms which comprise around 42% of the total pig farms in the Republic of Macedonia[5]. If the total number of pig farms is considered to be 35 (SSO, 2007), since it is official number of farms from 2007, then the research includes 60% of the total pig farms in the country. Figure 14 represented below, shows the number of farms included in the research according to the region in which they are located.

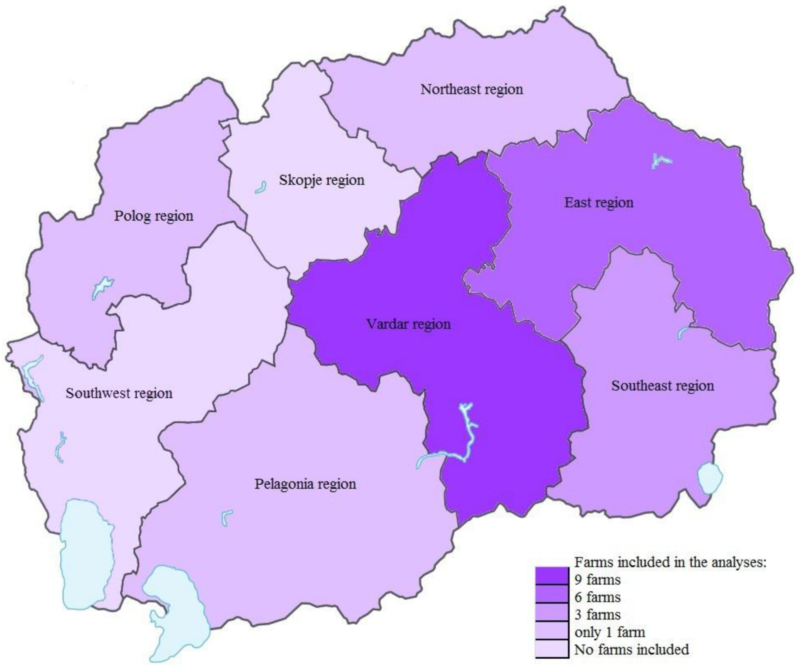

Figure 14: Regional location of pig farms included in the analysis
Source: own version of www, SSO, 10, 2011

The figure shows the regions according to which RM is divided in 8 areas. Hence, most of the farms are located in the east and southeast part of Macedonia, as well as in the Vardar region which covers the middle part of the country. Comparing these to the regions in Figure 14, the

[5] As a total number of pig farms in the country is considered to be 50 (pers. com., Saklev, 2011), since there is no public data for 2010.

Vardar region takes the first place according to the number of pig farms included in the analysis with 42.9%. The second place, in regards to farms' location belongs to the East region with 28.6% of the total number of farms included and on the third place is the southeast region with only 3 farms included in the analysis. On the other hand, the west and north part of the country are poor with pig farms. Northeast, Pelagonia and Polog region have only 1 farm included, while there is no data of farms taken for analysis of Skopje and the Southwest region. The findings confirm the literature in the introduction part of the study according to which the situation concerning pig production has the same distribution of farms in the country (see Figure 1). The regional location and more detail information about pig farms included in the analysis are shown in Table 6.

Table 6: Number of covered farms according to the region in RM

		Number of farms				
No.	Region	Per region	Big	Medium	Small	%
1	Vardar	9	2	6	1	42.9
2	East	6	3	2	1	28.6
3	Southeast	3	-	2	1	14.3
4	Northeast	1	-	1	-	4.8
5	Pelagonia	1	-	1	-	4.8
6	Polog	1	1	-	-	4.8
7	Southwest	-	-	-	-	-
8	Skopje	-	-	-	-	-
	Total	21	6	12	3	100

Source: Data collected from own survey

The research includes big, medium and small farms that would help for further analysis of the efficiency. Therefore, information and the data needed are collected for 6 big farms with 750 sows or more done according to the division of pig farms stated in the literature review part. They are located in the middle and the east part of Macedonia. The number of medium farms is 12 and they are spread over 5 regions while small farms are 3 and they are located in three regions.

Regional allocation of pig farms included in the research can be analysed from several aspects. For this, the following part concentrates on pig farms for each region respectively and their capacity projected at the time of the establishment of the farm compared to the capacity in the analysed period.

The Vardar region is found to have the biggest number of pig farms. In the analysis, the region consists of two big farms, six medium and one small farm. According to the table, the region includes the biggest, but in the same time the smallest farm in the analysis. The biggest farm has a production capacity of 1500 sows and yearly it produces more than 30000 fattening pigs. Its production covers most of the Macedonian market, and a part of the produced pigs are sold in the foreign market. Here, it is good to be known that only a few farms are selling their production in the foreign markets and according to this research their number is only two. The medium farms have around 100-200 sows and a production with 1000 – 4000 pigs per year. The smallest farm has only 10 sows.

Table 7: Pig farms and their capacity in the Vardar region

Vardar region						
	Projected capacity		Production capacity		%	
Farm code	Sows	Fattening pigs	Sows	Fattening pigs	Sows	Fattening pigs
B1	1,500	30,000	1,593	33,000	5.8	9.1
B3	900	18,000	680	14,125	-24.4	-21.5
M2	180	3,600	162	3,673	-10.0	2.0
M3	170	3,400	167	3,390	-1.8	-0.3
M4	150	3,000	120	2,000	-20.0	-3.0
M5	120	2,400	120	2,800	0.0	14.3
M7	90	1,800	54	1,000	-40.0	-44.4
M8	80	1,600	81	1,920	1.2	16.6
S3	10	200	10	200	0.0	0.0
Total per region	3,200	64,000	2,987	62,108	-6.7	-3.0

Source: Data collected from own survey

Taken into account that the thesis has considered at least 10 sows for the farms to be included in the analysis, there are no farms with smaller production. The reason is that farms with less than ten sows are not consistent and have no influence on the market and the environment. Comparison between projected and production capacity shows different values for each farm. Hence, five farms have reduced their production, two farms have increased the production percentage and two farms are producing at the same level as they have predicted. Taking into account all farms in the region, the production capacity shows reduction of sows for 6.7% and hence a reduction of fattening pigs for 3%.

Table 8: Pig farms and their capacity in the East region

East region						
	Projected capacity		Production capacity		%	
Farm code	Sows	Fattening pigs	Sows	Fattening pigs	Sows	Fattening pigs
B2	1,250	25,000	1,260	22,000	0.8	-12.0
B5	750	15,000	651	15,836	-13.2	5.3
B6	750	15,000	637	14,900	-15.1	-0.7
M10	70	1,400	65	1,450	-7.1	3.4
M12	60	1,100	58	600	-3.3	-45.5
S1	50	1,000	54	1,400	-7.4	28.6
Total per region	2,930	58,500	2,725	56,186	-7.0	-3.9

Source: Data collected from own survey

There are six farms in the East Region, three of them are big farms, two are medium and only one is a small farm. Two of the big farms are between big and small farms and considering the projected capacity they have 750 places for sows, which categorize them as big farms in the classification. Unfortunately, in 2010 they operated with lower capacity compared to the projected, but the production of fattening pigs has increased per sow in one farm which brings the reader to the idea that the farm, that is B5, has increased its production capacity. The increased capacity per sow is represented to the other farm categories as well. The small farm contacted from this region has a capacity between small and medium farm categories and taking into account the projected capacity the farm falls into the group of small farms in the country.

On the other hand, in 2010 the farm was producing more than it had been projected and considering the actual production capacity it should be considered as a medium farm. The East region also faces reduction of sows and pigs in individual farms and the total reduction of sows' takes7% while pigs' reduction is 3.9%.

Table 9: Pig farms and their capacity in the Southeast and the remaining regions

	Projected capacity		Production capacity		%	
Farm code	Sows	Fattening pigs	Sows	Fattening pigs	Sows	Fattening pigs
			Southeast region			
M9	80	1,600	30	605	-62.5	-62.2
M11	60	1,200	82	2,000	26.8	40.0
S2	50	1,000	50	1,000	0.0	0.0
Total per region	**190**	**3,800**	**162**	**3,605**	**-14.7**	**-5.1**
			Northeast region			
M6	100	2,000	100	1,300	0.0	-35.0
			Pelagonia region			
M1	430	7,000	416	6,790	-3.3	-3.0
			Polog region			
B4	750	15,000	882	18,000	15.0	16.7

Source: Data collected from own survey

The Southeast region is taken in the analysis with three farms, two medium and one small. The medium farms have projected capacity less than 100 sows and a production with around 1500 pigs for fattening. In regards to the capacity in 2010, the production considerably varies and differs from the projected values. Hence, farm M9 that is projected for 80 sows, in 2010 had a production capacity of only 30 sows. As a consequence, their quantity produced in 2010 is also lower than projected. At the same time, farm M11 has been projected as lower farm compared to M9, with projected capacity of 60 sows. Noteworthy is that the farm has increased its production and in 2010 produced with 82 sows, which has increased the produced quantity for 40%. Regarding the smallest farm production capacity it is interesting that the farm has been projected for 50 sows and has the same capacity in the analysed year, 2010. Concerning its capacity the farm is between small and medium farms and if it increases the production in the future it will be classified as medium farm. The Southeast region has 14.7% lower production in 2010 and 5.7% decrease in the number of fattening pigs produced the same year.

The remaining regions taken in the analysis, the Northeast, Pelagonia, and Polog are represented with one farm for pig production. Farms in two regions are considered as medium farms with a capacity between 100 – 500 sows and both farms have decreased their production in the analysed period. On the other side, the Polog is considered to be a region with one big farm whose projected capacity is of 750 sows. In 2010 farm B4 was working with a capacity of 882 pigs and increased its production of fattening pigs for 16.7% more than it was projected.

4.2.2 Farms establishment, legal status and land

Beside the categorisation of farms which is explained in the previous chapter, further analysis concerned farm M1 as a big farm. The reason is the history of establishment and the fact that the other farms with medium size established in the country are much smaller than M1. The details are explained below in this part.

Table 10: Year of establishment and legal status

Farm category	Year of establishment	Legal status			
		JSC	LLC	IAP	Other
B-farms and M1	1972 - 1979	4	2	-	1
M9	1983	-	-	-	1
M3, M4, M8, M10	1991-1999	-	3	1	-
M5, M6	2003	-	1	1	-
M2, M7, M11, M12	2007	-	4	-	-
S1	1991	-	1	-	-
S2	2005	-	1	-	-
S3	2008	-	-	1	-
Total		4	12	3	2

Source: Data collected from own survey

According to the data collected, there are three phases of establishment of pig farms in RM. The first phase starts in 1970s during the period when the country was a part of Yugoslavia. Second period is between 1990-2000 year and the last phase concerns the period after the 2000.

Findings show that all of the 7 big farms that are still working today have been established in the first phase period. They have managed to cross the period of privatisation, when most of them transformed their legal status from cooperatives in joint stock companies. More empirical findings emphasize a present situation of big farms which is briefly presented below:

- Farm B1 works as a part of a group of firms that cooperate between each other. And not only the farm but the partnership consists of a slaughterhouse and a feed production company. As a biggest farm in the country it supplies most of the Macedonian market with pig meat. The most interesting part is that this is the only farm in the country that uses renewable sources of energy in its production. Moreover, it has installed solar collectors, geothermal pump and biogas plant.

- Farms B2, B3, B5 and B6 are working together as daughter firms in one big family that consists of one mother and 10 daughter firms. These pig farms are primarily producing within the family while the remaining production is sold to external claimants. Also, farms are supplied with feed and use the services like veterinary and slaughterhouse from the other firms within the family.

- Farm B4 is still registered as a cooperative. Besides pig production it has production of grain and other cultures. A part of its own production is used for feeding pigs.

- Farm M1is part of an agricultural combine which is the largest food producer in the Republic of Macedonia. The farm is supplied with the remaining of feed produced within the combine. According to the classification of the production capacity the farm has lower capacity than 750 sows and therefore it is classified as medium farm. However, the farm takes the seventh place concerning pig farms capacity in the country and it stands out from the other medium farms with a surplus of around 300 sows.

The findings show that all medium farms have been established after 1990, except one farm which was established in 1983. They were all started as family business and most of them were not registered until 2005. After 2005, the biggest number of medium farms has been registered as Limited Liability Companies and the smaller number have been registered as individual agricultural producers. The oldest farm has been registered as Public Trade Company.

Concerning the smallest farms in the study, S1 was established in 1991 as a Limited Liability Company, S2 is also a Limited Liability Company established in 2005, and the farmer of S3 established in 2008 was registered as an individual agricultural producer.

Table 11: Land ownership and size

Farm category	Land ownership	Average size of land (m^2)	Average size of buildings (m^2)	Land/buildings proportion
Big farms	mostly - governmental	152,750	14,220	10.7
Medium farms	mostly - private	4,471	1,638	2.7
Small farms	private	833	567	1.5
Total		53,377	5,595	9.5

Source: Data collected from own survey

While the interview has been provided with big farms, owners explain that the land where the farm is established is still Governmental or its status has not been determined yet. Accordingly, farm respondent gave the following explanation:

> *"....it is still governmental property and the procedure of privatization is in process.... We have no payments for land until the problem for this issue is solved..."* (pers. com., Farm B5, 2011-07-15).

Moreover, the average size of the economic yard where big farms are located is around 10 times bigger than the size of farm buildings. Beside farm buildings and pig production, around 50% of the farms in this category have their own feed production. In some cases field crops are located nearly, in the same economic yard which is good for minimising transport costs for feed, but the other cases have located their crop production outside the farm property. The remaining 50% of the farms buy their feed from the organized network between them and cooperation partners.

As far as the medium farmers are concerned, most of them are owners of the land of production and they have no additional costs regarding the land. Their home is usually located in the same economic yard or near the farm. The proportion between land and farm objects is 2.7 and if there is an extra land left without buildings or other objects that the producer has, the land is used for crop production.

Small farms are owners of the land where the farms are located. The proportion between the economic yards is 1.5 times bigger than the size of farm buildings. Small farmers have their homes in the same yard where their farm is located. One of the interviewed farmers explains:

> *....I must live here in order to be 24 hours present on the farm.... Even sometimes at nights pigs need my help. I believe other persons cannot leave the responsibility to someone else to keep on the farm either...... If I have even one beg of feed less than it should be spent in the production, it would cost me too much. For those reasons I bring my whole family on the farm with me....* (pers. com., Farm S1, 2011-09-30).

4.2.3 Technology and type of production

According to the data collected, pig farms included in the analysis have different technology of production installed in their farms. According to Table 12, 6 farms are using new technology which was installed in farms after the year 2000. Most of the farms included in the analysis use old technology of production, and their number is 9 farms or 43% of the total number of farms. The research also finds out that there are farms that use a combined type of technology of production. Their number is also 6 and usually, these are the oldest established farms which are investing in new technologies in order to change the old one that was installed while building of farms.

Table 12: Installed technology of production in Macedonian pig farms

	Technology of production				
Type of technology	No. of farms	B-farms	M-farms	S-farms	%
Combination	6	4	2	-	28.6
New	6	1	5	-	28.6
Old	9	2	4	3	42.9
Total	21	7	11	3	100

Source: Data collected from own survey

In relation to the type of production, 71% of farms have their own boars that are used for natural insemination while only 4 farms are buying insemination material. Moreover, 9.5% of the farms use both natural insemination and bought insemination doses in order to reach bigger efficiency by applying different breeds in the production or to increase their performances. Statistical analysis of the type of production is shown in Table 13.

Table 13: Type of production of Macedonian pig farms

Type of production		
Type of farm	No. of farms	%
Breeding	15	71.4
Commercial	4	19.1
Both	2	9.5
Total	21	100

Source: Data collected from own survey

Concerning the types of breeds that are used in the production, only the biggest farms in the country have established control and future plans for qualitative reproduction. They produce their own reproductive material by selection of animals and choosing the best breed characteristics. In contrast, the insemination of sows in small and some medium farms in the country is provided by the veterinary stations. There are also many breeds used for production...

> *"Today, characteristics and types of breeds in the country are unknown because most of them are mixed with two or more breed types"* (pers. com., Vukovik, 2011).

The three main breeds, from which mixed breeds are made, were presented in the theoretical chapter.

4.3 Management issues

Management issues concern the manager and his activities that influence the farm efficiency. The questionnaire obtained several issues that are analysed by the following order:

- Education of manager, capacity building and experience
- Other activities that affect efficiency (internet and keeping of records).

4.3.1 Education, capacity building and experience

All interviews have been provided with the manager of each farm, who is actually the decision maker in the production activities. The findings show that the participation of women managers in pig production is only 14%. Of course, in family businesses both men and women work together, but most farms are managed by men. In addition, his or her performances and activities are very important for efficient working of the whole farm. To analyse the efficiency and the capacity building of the manager the research focuses on the level of manager's education, attendance of trainings and seminars, participation in different associations and the experience of working in pig production. Findings are explained below in this sector.

Findings of the level of managers' education are presented in Table 14. Hence, managers in all big farms and most of them working in medium farms have a university diploma obtained. Considering the total number of farms that are included in the analysis, nearly 66% of managers have finished university level, 4.7% have one level of education bigger than high school. Only 28.7% of the managers have finished high school, from whom 2 persons own small farms and 4 produce in pig farms with medium capacity.

Table 14: Level of manager education

Level of education	Manager education				
	Big farms	Medium farms	Small farms	Total farms	%
University	7	6	1	14	66.6
Extended high school	-	1	-	1	4.7
High school	-	4	2	6	28.7

Source: Data collected from own survey

Capacity building includes participation of the manager in various occasions, admission of suggestions and innovations and the experience from different perspective if the manager has worked in other pig farm. Those issues are yes/no questions and their findings are represented in Table 15.

Table 15: Capacity building activities of the manager

	Big farms		Medium farms		Small farms		Total farms		%	
	yes	no	yes	no	yes	no	yes	no	yes	no
Participation in trainings, seminars and conferences	7	-	10	1	3	-	20	1	95.2	4.8
Participation in agricultural association	2	5	5	6	2	1	9	12	42.8	57.2
Using advices	7	-	10	1	3	-	20	1	95.2	4.8
Previous employment in other pig farm	1	6	3	8	1	2	5	16	23.8	76.2

Source: Data collected from own survey

Respondents are divided in two groups, 95% who participate in conferences and trainings, if they are available usually in the country and nearly 5% do not attend such activities. Around 42% are participants in agricultural association and more than 12 managers are not interested in participation in any kind of associations. On the other hand, almost all managers, 95% use advices from the individual consultants and a lower number of respondents requests advice from other subcontractors. More than 23% of managers previously have been working in other farms, but now they have their own medium farm. Otherwise, 16 managers have their first experience in the same farm in which they are working today.

Table 16: Working experience of the manager

	Average	Median	Min	Max	St. Dev
			Working experience		
Big farms	28	33	2	36	11.79
Medium farms	15	15	2	37	10.25
Small farms	20	20	14	25	5.51
Total farms	20	20	2	37	11.69
			Age of the manager		
Big farms	55	60	34	62	9.84
Medium farms	46	47	30	59	7.37
Small farms	48	46	41	56	7.64
Total farms	49	49	30	62	8.98

Source: Data collected from own survey

Years of experience in working are explained as average, minimum, maximum and median values. From the findings represented below in Table 16, managers with the greatest experience in pig production are those from the big farms, but managers with only 2 years of experience (which are the minimum years of working) are also managers from big and medium farms. The biggest experience goes to the managers in medium farms. Total average experience of all managers is 20 years which is also the median between minimum years of experience (2 years) and maximum years of experience, which is 37 years.

Also, the table represents that the managers in big farms are the oldest which explains the longest period of years of working experience in pig farming. The youngest manager is 30 years old and works in a medium farm, while the oldest one is 62 years old and works in a big farm. Managers' average age in total is 49 years old.

4.3.2 Internet and keeping of records

The research comes out with other comparative issues that have an impact on the efficiency of working. Hence, this part analyses farms' appearance in the modern world that initiate using of internet, keeping of records or providing accounting evidence and reporting of farm activities that have happened within a year.

In regards to the fact that millions of people use the internet every day, providing a webpage can help in marketing of farms and making contacts with relevant firms in the native country and in the foreign countries, as well. The reason is to increase the demand which further on leads a more profitable production. The findings show that almost 1/3 of farms have webpage and almost 2/3 do not offer this activity. Also, the webpage is provided only by the biggest farms in the country while the medium and the small ones are not interested in affording this comfort. Figure 15-a gives a statistical overview of the number of farms with and without a webpage.

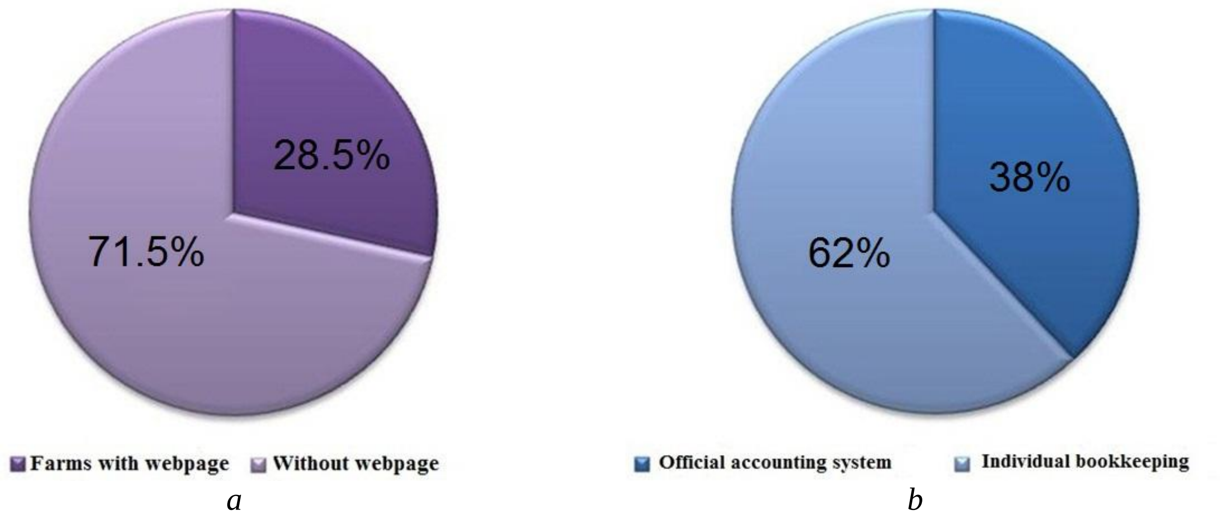

Figure 15: Availability of webpage (a) and accounting system (b)
Source: Data collected from own survey

Figure 15-b explains that in the Republic of Macedonia bookkeeping still depends on the willingness of farmers to have this activity. Only the biggest farms and some of the medium farms, which are 38% of the interviewed farmers, provide bookkeeping and accounting of total inputs and outputs that have been realized in the production. They have an accountancy body and their own accountant who is responsible for keeping of records and reporting of all incoming and outgoing activities on the farm. The remaining 62% of the medium and small farms do not have their accountant and farmers provide, enter, and keep records by themselves. These records include only the most important inputs and outputs of production and usually have incomplete information about the production activities.

Moreover, it is important to stress that only 8 farms, including both big and medium farms from the total number in the analysis, have their reports available on-line. Those are financial reports which consist of income statement, balance sheets or environmental reports. These kinds of reports are of public interest especially if the farm's legal status is Joint Stock Company.

The following chapter gives deeper analysis of the data collected through the interviews, related to the theory and literature provided in Chapter 2.

4.4 Inputs and output of production

The organization of inputs in the questionnaire is provided according to Table 17. Findings show that the division of inputs to fixed and variable is unable to follow in the further research while analysing the data, since farmers do not have or do not provide evidence for more fixed inputs. Hence, only the total number of pigs per category, labour unit and costs for labour were available for collecting.

Table 17: Fixed and variable inputs of pig farms in RM

Inputs of production in pig farms	
Fixed	Variable
Number of sows and boars	Feed quantities and cost
Labour costs for employees	Wages for hired labour
Building and equipment depreciation	Energy costs (electricity, wood, etc.)
Investment costs	Water costs
Insurance and taxes	Disposal of manures
Land rent	Veterinary and medicine
	Costs for insemination
	Transport costs
	Disinfection costs

Source: Data collected from own survey

Moreover, the depreciation of buildings and equipment is not provided by medium and small farmers. According to the findings, some buildings are more than 40 years old in all three categories of farms and their machinery and plants are more than 10 years. Few of the farmers (only in medium and big farms) invest in new technology of production, usually by changing the equipment in different objects or making renovation of farm buildings (see table 12). Despite medium and small farms, big farms estimate the depreciation of the equipment and provide insurance of the basic herd.

Variable inputs are considered the most important for analysing of the technical efficiency during the period of one year. In addition, the research includes total quantity of feed spent and total costs for feed for the analysed period. There are many different feed mixtures that are used for different categories of pigs. In addition, to avoid different values of feed that would be collected, the researcher has found that it is easier for farmers and for further research activities to collect only the summary of quantity and costs for feed used during the analysed period.

Another input included in estimating technical efficiency is labour, which is taken in number of employees and family members that work on the farm. Part-time workers are not included because medium and small farmers do not know a total number of part-time workers and their participation in providing farm activities.

The other variable inputs are considered in total costs of input for the analysed year. Researcher needs them in the same measurement unit in order to include those inputs in DEA for estimating technical efficiency of production. Since it is very hard to get those inputs in quantities it was easier to collect them as total costs of variable inputs. This approach includes: electricity, water, veterinary and medicine, insemination and insemination doses (for those farms which use artificial insemination), also costs for ecology and disposal of manure, transport costs and insurance (if it is provided as activity on the farm) and all other costs if happened during the analysed period.

Table 18: Net margin of pig production farms (n=21)

Item	Unit	Mean	Median	Min	Max	St.dev	CV
Sows	LU	204	65	5	837	255.3	1.3
Piglets	LU	102	53	1	527	134.2	1.3
Fattening pigs	LU	1,830	435	30	9,000	2,606.9	1.4
Total pigs	LU	2,136	540	46	10,277	2,978.7	1.4
Total output	MKD	59,232,899	14,760,000	1,200,000	270,000,000	81,222,482.0	1.4
Feed quantity	kg	2,395,063	600,000	58,000	10,000,000	3,120,970.7	1.3
Feed costs	MKD	33,095,113	8,500,000	661,200	138,803,840	42,971,013.8	1.3
Labour (workers)	No.	17	6	2	65	20.1	1.2
Labour costs	MKD	3,979,918	731,000	180,000	19,500,000	5,828,424.3	1.5
Margin 1	MKD	22,157,868	3,725,000	-889,667	140,500,000	36,419,832.2	1.6
Other costs	MKD	18,664,389	1,075,277	151,000	102,007,264	33,628,841.9	1.8
Total costs	MKD	55,739,420	9,397,620	1,052,200	253,631,104	80,398,926.0	1.4
Margin 2	MKD	3,493,479	1,602,380	-43,115,104	40,261,025	17,482,501.3	5.0

Source: Data collected from own survey

In Table 18 total pigs within the farms are presented in livestock units, separately measured for sows, piglets and fattening pigs. Converting from average number of pigs was done by using a coefficient for each category of livestock (www, EUROSTAT, 2011). The output is presented as revenue in Macedonian denar that farmers have received in 2010, and the input variables are represented with: total utilized feed measured in kilograms and costs spent for feed; number of persons involved in production (which consist of family labour and total employees) and labour costs spent for the year. Margin 1 is estimated by dividing total revenues with costs for feed and labour. The idea is to present the influence of feed and labour (variable costs) on total revenue received by the farm. The other costs are taken in Macedonian denar and they include both variable and fixed other costs, if they happen in the current year. Hence, net margin of the production is estimated by dividing total revenue and total costs.

Analysis of data separately for each farm can be very confusing process. Therefore, all requested data have been summed and then analysed by using the main values. This approach is found to be suitable for analysing general tendencies of pig production in the country. In relation to this, the main value is used to find the average data of pig farm inputs and output, while median represent the middle value of the analysed data. Minimum values are taken from farms with lower units of analysis and in contrast to this, maximum values are taken from farms which have maximum units value. Standard deviation compares the data between each farm and estimates a variation of those data. Coefficient of variation is used for measuring a variation between data of different farms, similar to standard deviation, but it does not concern the measurement unit to be included and by this it is more appropriate in the agricultural production. It is measured as ratio between standard deviation and average value of inputs and outputs. At the end, the estimates show that some farms are in loss, but the others have really high profit.

5 Analysis of findings

To fulfil the aim of the study, chapter 5 provides deeper analysis of findings from data collected. Moreover, the analysis should give an explanation of the research questions provided together with the aim. Also, according to the theory explained in Chapter 2, the analysis concentrates on issues that influence the efficiency of production and hence input-output relationship. It is divided in two sections:

Section one emphasises the traditional inputs and outputs which are used directly in the production process. Here, the relationship between inputs and outputs is estimated with DEAP, programme related with DEA models for estimating efficiency. Its background is explained in Chapter 2 and the activities provided within DEAP are shown in Chapter 3. This section is provided in relation to the research questions because the model of estimating technical efficiency with DEA gives an answer to those questions. According to DEA estimates, this section is divided into the following parts:

- Technical efficiency of Macedonian pig farms
- Technical efficiency from input perspective
- Technical efficiency from output perspective
- Technical efficiency analysed between big, medium and small pig farms.

Section two concentrates on the second stage variables that additionally influence the production efficiency. They are more descriptive and are not analysed with DEAP, but their overview can contribute to create an overall picture of factors influencing the efficiency of pig farms in the country.

5.1 First stage analysis

In relation to the above stated, technical efficiency is analysed from input and output perspectives and under constant and variable return to scale.

5.1.1 Technical efficiency of sample farms

The results show technical efficiency of 21 pig farms in the Republic of Macedonia which was considered as 42% (60%) of the total number of pug farms in the country and was elaborated in the empirical findings chapter. Summary of results is represented in Table 19.

According to the table, only 24% of the analysed farms operate on an optimal scale which means that they are fully efficient and have an efficiency score equal to 1. Farms that have an optimal scale of production face the same technical efficiency (which is equal to 1) in both CRS and VRS. Unfortunately, 75% of farms face technical inefficiency under CRS and they operate under an inefficient scale. Here, all big farms (without one which is fully efficient) or 28.5% from the total number of considered farms face decreasing return to scale which means that if inputs increase by one unit, the output increases for less than one unit (Calanopoulos *et al*, 2006). The remaining 47.5% (medium and small farms) have increasing return to scale which means that if inputs increase by one unit, the output increases by more than one unit. Scale inefficiency differs with 0.023 from both input and output perspectives.

Table 19: Summary of technical efficiency results

EFFICIENCY SUMMARY							
	Input oriented			Output oriented			
Firm	CRS TE	VRS TE	SE	CRS TE	VRS TE	SE	Description
B1	0.897	1.000	0.897	0.897	1.000	0.897	DRS
B2	0.850	0.942	0.902	0.850	0.943	0.901	DRS
B3	0.620	0.784	0.790	0.620	0.802	0.773	DRS
B4	0.814	0.936	0.870	0.814	0.939	0.867	DRS
B5	0.683	0.864	0.791	0.683	0.873	0.783	DRS
B6	1.000	1.000	1.000	1.000	1.000	1.000	-
B7	0.524	0.598	0.876	0.524	0.683	0.767	DRS
M1	1.000	1.000	1.000	1.000	1.000	1.000	-
M2	1.000	1.000	1.000	1.000	1.000	1.000	-
M3	0.927	0.928	0.999	0.927	0.928	0.999	IRS
M4	0.760	0.809	0.940	0.760	0.776	0.981	IRS
M5	1.000	1.000	1.000	1.000	1.000	1.000	-
M6	0.372	1.000	0.372	0.372	1.000	0.372	IRS
M7	0.660	0.681	0.969	0.660	0.665	0.992	IRS
M8	0.948	1.000	0.948	0.948	1.000	0.948	IRS
M9	0.870	0.882	0.986	0.870	0.877	0.993	IRS
M10	0.420	0.539	0.780	0.420	0.434	0.969	IRS
M11	0.583	1.000	0.583	0.583	1.000	0.583	IRS
S1	1.000	1.000	1.000	1.000	1.000	1.000	-
S2	0.371	1.000	0.371	0.371	0.500	0.742	IRS
S3	0.626	1.000	0.626	0.626	1.000	0.626	IRS
Mean	0.758	0.903	0.843	0.758	0.877	0.866	
Median	0.814	1.000	0.902	0.814	0.943	0.948	
Min	0.371	0.539	0.371	0.371	0.434	0.372	
Max	1.000	1.000	1.000	1.000	1.000	1.000	
St. Dev	0.218	0.143	0.198	0.218	0.173	0.172	

Source: DEA results of data collected from own survey

Another important issue related to the theory is that CRS has the same values for input and output perspectives. In regards to CRS, farms have an average efficiency score of 0.758 which means that farms could reduce their inputs by 24.2% and still produce the same quantity of output if they have the same efficiency as the best. The minimum efficiency score is 0.371 and the farm that is in the middle according to the efficiency face 81.4% technical efficiency.

Seen from another point of view, results obtained by VRS are different for input and output orientation, but this scale is more optimal for analysing considerable variation performances that are usual in agricultural production and accordingly in pig production as well. VRS and SE have different values of technical efficiency seen from input and output perspective. Farms that are operating on VRS face inefficiency of 9.7% in regards to the input perspective, while they have output technical inefficiency of 12.3%. Minimum technical efficiency under variable return to scale from input perspective is almost 54% efficient while the middle value has full technical efficiency. In output orientation the situation is different and the medium value is 94% efficient, with minimal efficiency 0.434 and variance of 0.173.

Scale inefficiency is estimated by the ratio of TE in CRS and TE in VRS (Coelli, 1996). Hence, the operating scale is efficient 84.3% in inputs analysis and 2.3% less efficient from output perspective.

Comparing CRS and VRS efficiency, both variable returns to scale are less inefficient than the constant return to scale is. The difference between input and output VRS is 2.6% bigger efficiency for farms analysed under input oriented perspective. Also, maximum efficiency in both constant and variable return to scale is 1 which indicates that there is a fully efficient farm in each scale. Of course, compared to the literature written in the second chapter, 1 is the maximum value that a technical efficiency score can obtain in relation to DEA estimates.

On the other hand, VRS input and output perspectives are around 12% more efficient than farms that operate under CRS. Moreover, CRS TE is 14.5% lower than the efficiency of VRS from input perspective and 11.9% lower than VRS from output perspective. Contrary to VRS, scale efficiency is bigger from output analyses instead of inputs SE.

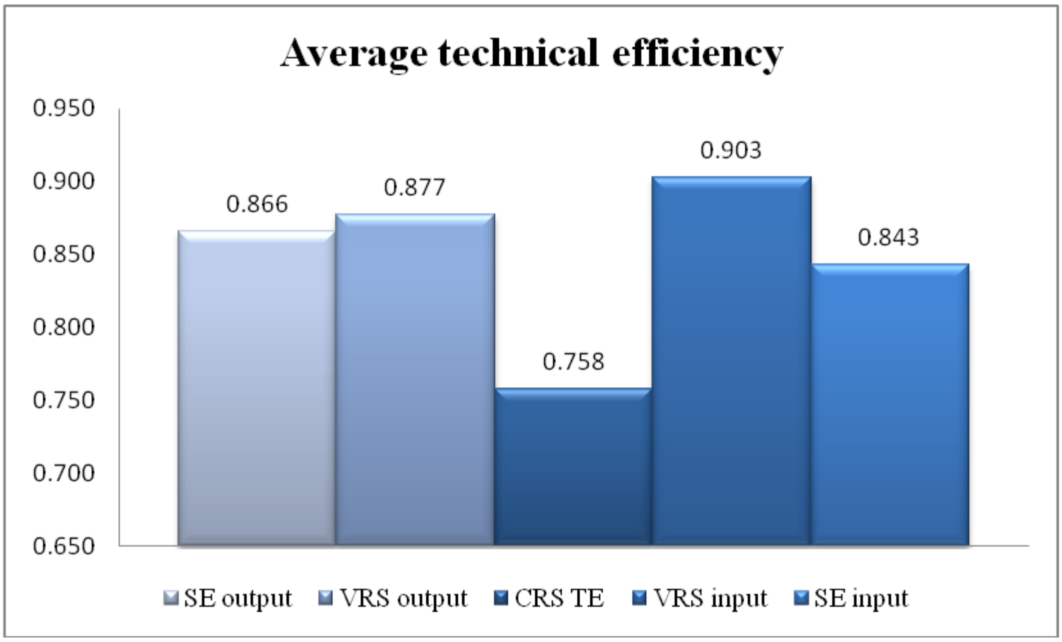

Figure 16: Average results of technical efficiency
Source: DEA results of data collected from own survey

Figure 16 visually represents findings from an average technical efficiency for both input and output orientation. Hence, CRS provides lowest technical efficiency which is also confirmed in the theoretical chapter where CRS is always lower than the other efficiency scales. This leads to the fact that the least efficient are farms analysed under CRS. More on this theoretical perspective is shown in Figure 17 that represents all analysed farms according to the level of their technical efficiency.

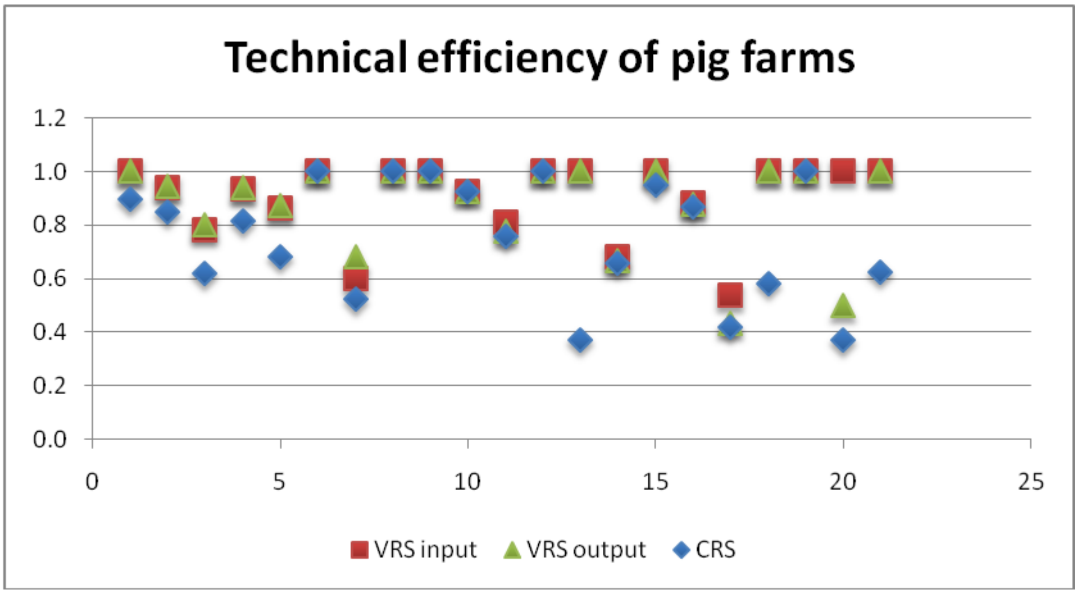

Figure 17: Technical efficiency separately for each farm
Source: DEA results of data collected from own survey

In order to know what the level of technical efficiency of each farm is separately, the figure shows that most farms have almost the same level of efficiency scores under VRS from both input and output perspectives, but different score under CRS. Also, more farms under VRS from input perspective are fully efficient and their number is 11, while 10 farms under VRS from output perspective and only 5 farms under CRS have an efficiency score equal to 1. Fully efficient farms have the same score for all three scales and their location is on the production frontier line which is equal to 1. According to the figure, farms analysed from constant return to scale have lower efficiency than the level of efficiency that they would have in variable return to scale. This is confirmed with figure 16 and 17, and with literature as well (www, DEA home page, 2011), where efficiency score of farms under CRS is presented below the efficiency score under farms on VRS and under frontier. In addition, the most inefficient farms operate under CRS conditions.

The efficiency depends on the availability of inputs and outputs in production and management activities provided by the decision maker. For that reason they are analysed separately in the following parts.

5.1.2 Technical efficiency from input perspective

Input perspective analyses the utilisation of inputs in the production under the assumption that the output quantity is not going to be changed. Here, the efficiency analysis are concentrated in utilization of feed, labour and other costs, since they are the most important for pig production. For better analysis, each input has been considered separately and the technical efficiency is analysed for both constant and variable return to scale.

An average efficiency score under VRS input perspective is 0.903 (see figure 16). This means that the average farm in the analysis should decrease the level of utilized inputs for 9.7% in order to be fully efficient, while farms operating under CRS should decrease the level of utilised inputs for 24.2%. According to the figure, farms operating under VRS have the biggest efficiency score, which is further confirmed in the literature stated in Chapter 2 (www, DEA home page, 2011), that VRS model always increases the efficiency of farms.

Technical efficiency of feed utilisation

Figure 18 represents the efficiency of utilised feed input in kg. Hence, blue and red columns together represents the quantity of feed that farms have used in the production during the analysed year and only red lines show for how much farms need to minimise the utilization of feed in order to increase the efficiency score. Farms that have only blue lines have efficiency score 1 and they have the best utilization of feed in the sample.

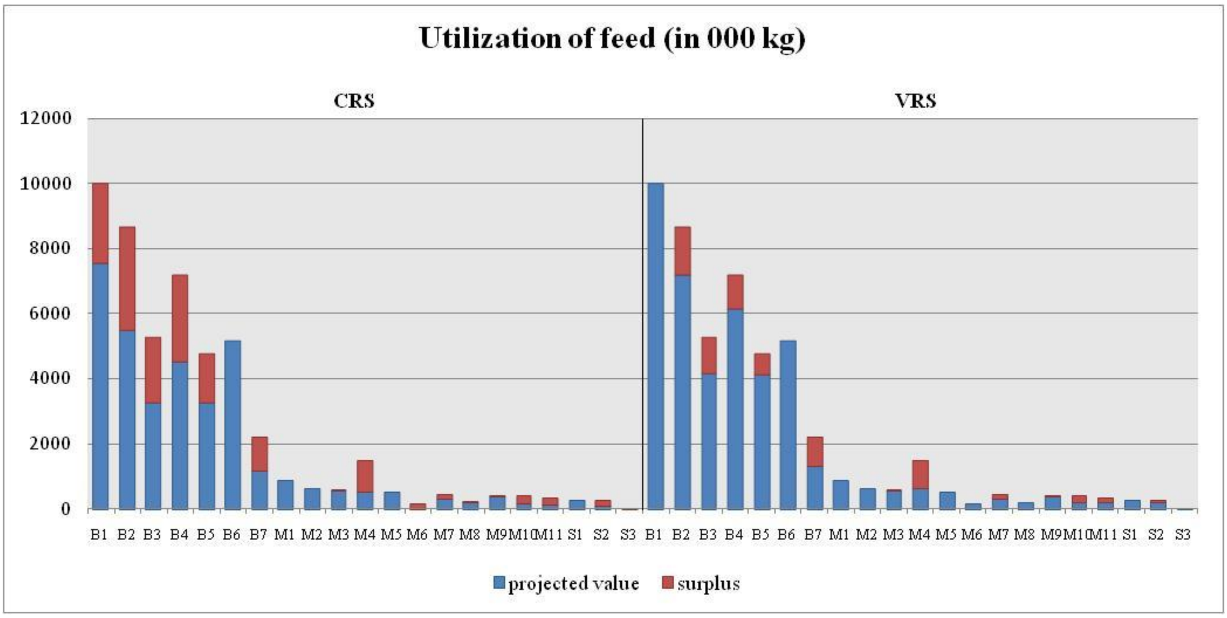

Figure 18: Efficiency score of utilized feed under CRS and VRS
Source: DEA results of data collected from own survey

The figure can be seen from two aspects, one according to constant return to scale, and the other according to the variable return to scale. As stated in the literature (www, DEA home page, 2011), the analysis from CRS aspect shows lower efficiency value than the analysis of VRS. Accordingly, when CRS is concerned, most of the farms need to minimise more quantity of feed, around 1/3 feed, in order to be efficient, while there are only four farms that face fully technical efficiency (B6, M1, M2 and S1).

On the other hand, since VRS assumption increases the efficiency of farms (which is confirmed by the blue columns) smaller quantity of feed, about 15%, should be reduced. There are eight farms that face full technical efficiency under VRS and they are: B1, B6, M1, M2, M5, M6, M8, and S1.

Table 20 elaborates the utilization of feed input in regards to technical efficiency estimated with DEA model. Here, the average quantity of feed utilized and the minimum and maximum utilization by farms is given in kilograms. Also, the table gives a projected value that should be used in production and the surplus that according to DEA should be reduced from the current production for the farms to face technical efficiency. A surplus and projected quantities are also given in kg in order to be comparable with the utilized quantity of feed.

The table gives explanation of both overall technical efficiency (technical efficiency under constant return to scale) and pure technical efficiency (technical efficiency under variable return to scale) estimated from input perspective with DEA.

Table 20: Feed utilization from input oriented DEA

Feed input	Unit	Mean	Median	Min	Max	St. Dev
			Overall technical efficiency (TE_{CRS})			
Utilised quantity	kg	2,395,063	600,000	58,000	10,000,000	3,120,971
Surplus	kg	707,055	159,113	0	3,168,273	1,029,198
Projected quantity	kg	1,688,008	547,500	36,297	7,561,883	2,244,117
Decrease	%	29.40	34.00	64.73	0.00	23.82
			Pure technical efficiency (TE_{VRS})			
Utilised quantity	kg	2,392,779	561,037	58,000	10,000,000	3,121,684
Surplus	kg	318,205	51,718	0	1,483,054	476,688
Projected quantity	kg	2,074,575	556,708	58,000	10,000,000	2,872,505
Decrease	%	15.33	11.75	57.24	0.00	17.86

Source: DEA results of data collected from own survey

Table 21 shows the consumption of feed in kg for 1kg live weight growth. Hence, the average use of feed is 4kg per 1kg growth. This is also confirmed by the literature where the feed consumption in the Republic of Macedonia is estimated to be 4kg of feed for 1kg live weight growth of pigs (Gjosevski et al, 2007). Compared to the other studies, an average feed consumption is 3.4-3.6 per day for pigs with 100kg weight (www, The Pig Site, 2011; Lauwers *et al*, n.d.). One study explains that pigs consume feed in quantity approximately 4% of their body weight per day (www, The Pig Site, 2011). On the other hand, Lammers *et al* (2007) estimate pig consumption of feed in Niche and find out that the average consumption of feed is around 3kg for 1kg live weight growth.

Table 21: Feed consumption per kg live weight production

	Feed consumption per kg live weight production					
	Unit	Mean	Median	Min	Max	St. Dev
Feed	kg	2,395,063	600,000	58,000	10,000,000	3,120,971
Pigs for sale	no.	6,705	1,640	144	30,000	9,035
Average weight	kg	92	100	25	100	22
Pigs x average weight	no.	620,163	164,000	14,400	3,000,000	856,433
Feed consumption	kg	4	4	3	6	1

Source: Findings of data collected from own survey

Technical efficiency of labour utilization

The utilization of labour in the production is measured by total number of workers involved in the production activities and this activity involves both family members and hired workers. The efficiency score estimated with DEA explains by how much the number of workers should be reduced so farms to increase their efficiency level. Measuring the efficiency of labour utilization is provided with the same approach used for feed measurements. Hence, the efficiency is analysed from CRS and VRS aspect (see Figure 19).

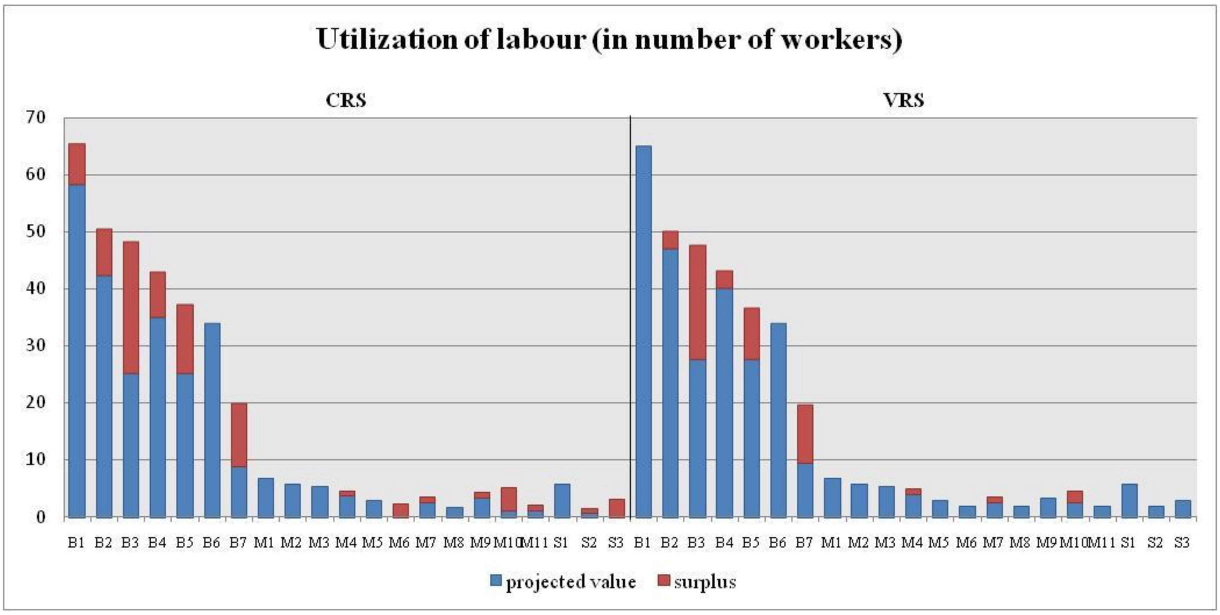

Figure 19: Efficiency score of labour utilization under CRS and VRS
Source: DEA results of data collected from own survey

According to the figure, the efficiency score of farms that are not fully efficient vary from farm to farm. The biggest number of workers should be reduced in B3 while the only efficient big farm is B6, which can be easily noticed from the figure. Medium farms M1, M2, M3, M5 and M8 have the favourable number of workers in both CRS and VRS aspects, with more efficient farms under variable return to scale (M6, M9, and M11).

Furthermore, only S1 face fully technical efficiency under CRS, but under VRS, all small farms are fully efficient and this indicates that they are efficient in this respect.

Table 22: Labour utilization from input oriented DEA

Labour input	Unit	Mean	Median	Min	Max	St. Dev
			Overall technical efficiency (TE_{CRS})			
Utilised quantity	no. of workers	17	6	2	65	20
Surplus	no. of workers	4	1	0	23	6
Projected quantity	no. of workers	13	6	0	58	17
Decrease	%	28.89	18.60	90.67	0.00	28.81
			Pure technical efficiency (TE_{VRS})			
Utilised quantity	no. of workers	17	6	2	65	20
Surplus	no. of workers	2	0	0	20	5
Projected quantity	no. of workers	14	6	2	65	18
Decrease	%	11.78	0.00	51.51	0.00	17.23

Source: DEA results of data collected from own survey

Similarly to feed analysis, Table 22 explains the utilization of labour input in the production. Hence, there are already utilized workers that should be reduced for an efficient production. A surplus shows the number of workers that are over used and the projected quantity gives the number of workers that is an optimal quantity for an efficient production. The decrease value is actually a percentage of labour input that should be reduced if farms are to face technical efficiency.

Technical efficiency of other inputs utilization

Figure 20 represents findings of other inputs and their efficient utilisation in farms' production. The data of all other inputs relevant for pig farms have been collected as costs and then summarised in total costs of production.

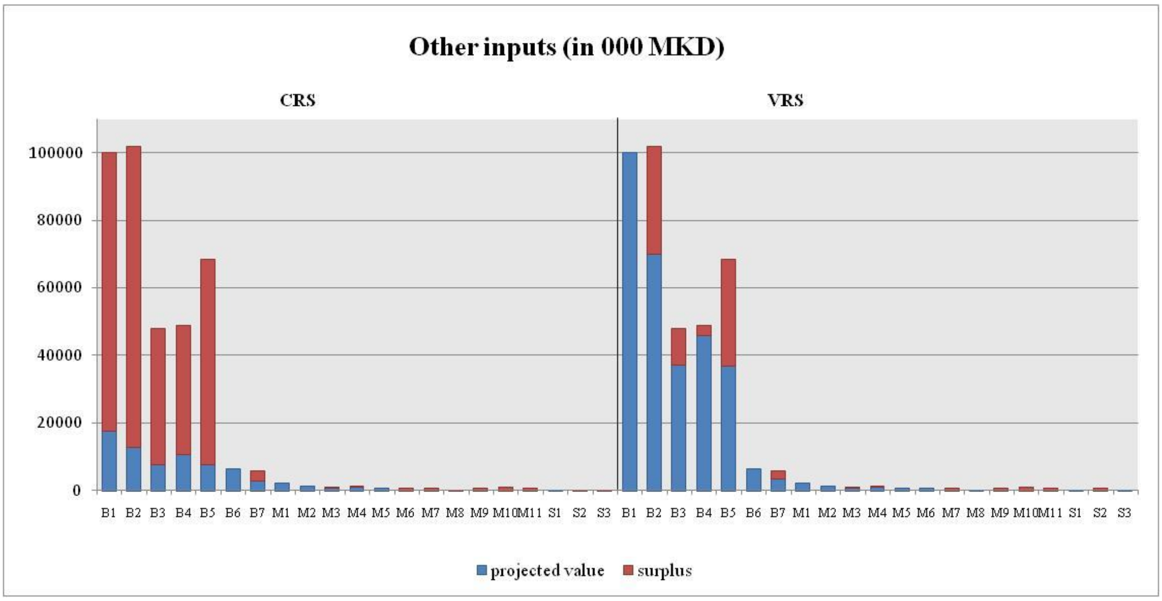

Figure 20: Efficiency score of other costs under CRS and VRS
Source: DEA results of data collected from own survey

The results show that the difference between big farms from one side and medium and small farms from another side is much bigger than it is the case with feed and labour efficiency measurements. Here, big farms have really high costs[6], while small and medium farms have minimum utilisation of this input which depend on farms activities and involvement of different inputs in their production.

As far as big farms efficiency goes, there is also a big difference between CRS and VRS assumptions. CRS request big reduction of costs, around 4/5 of costs should be reduced so that farms can have efficient utilisation of this input. Only B6 is fully efficient in both constant and variable scales. In VRS, pig farms are more efficient than in CRS and only B2 and B4 need to decrease 1/3 of costs to be efficient with this input. The fact that farm B1 faces high inefficiency score under CRS, but in VRS it is fully efficient seems very interesting, and leads to the conclusion that its production varies from other issues related to the environment of production, and not only the input-output perspective.

The utilization of other inputs in all farms taken in the analysis is shown in Table 23. The table is divided on overall and pure technical efficiency from input perspective. It represents the utilization of inputs in MK denars, the surplus of utilization and the requested quantity for technical efficiency. Accordingly, the percentage of decreasing explains that 41% of other inputs should be reduced if farms are analysed under CRS or the reduction of 17.5% should be made under VRS for the farms to face full technical efficiency of other inputs.

[6] Costs for feed and labour are not included here.

Table 23: Other inputs utilization from input oriented DEA

Other inputs	Unit	Mean	Median	Min	Max	St. Dev
			Overall technical efficiency (TE_{CRS})			
Utilised quantity	MKD	18,664,389	1,075,277	151,000	102,007,264	33,628,842
Surplus	MKD	15,092,272	277,428	0	89,081,678	28,941,295
Projected quantity	MKD	3,572,116	849,528	85,194	17,748,750	5,037,537
Decrease	%	41.20	43.58	88.76	0.00	34.98
			Pure technical efficiency (TE_{VRS})			
Utilised quantity	MKD	18,664,389	1,075,277	151,000	102,007,264	33,628,842
Surplus	MKD	3,891,227	71,655	0	32,064,684	9,557,753
Projected quantity	MKD	14,773,161	900,272	151,000	100,238,975	27,645,715
Decrease	%	17.59	7.22	62.12	0.00	20.81

Source: DEA results of data collected from own survey

At the end of inputs analysis, figures and tables give a global perception of the utilised inputs on farms that alert that there is a big difference between big and small farms in the country, which depends on farms' size and their capacity. In context, big farms have big utilization of inputs, and small farms do not utilise big quantities of inputs. Moreover, findings give an answer of the question: *Why do big farms have much more other costs than small and medium farms?* The answer is that the costs of big farms include costs for investments which happen in the analysed period, depreciation of fixed inputs and other administrative costs of production. Farms were not willing to give those data separately for investments, depreciation and variable other inputs, hence, in the analysis they are included all together as other costs (represented in Figure 20). Here, only farms B1, B2, B3, B4, B5 and B6 invest in new technology of production and provide a depreciation for all fixed inputs (basic herd, buildings and equipment), while farm B7 has only depreciation for the analysed period. On the other hand, most of the small and medium farms do not have these kinds of costs since they do not provide big investments for production and they do not pay for some of the activities that bigger farms need to pay for, for example water costs and costs for land rent, administration, accounting staff, etc. Here, it is good to be mentioned that big farms operate like formal companies with established working time, norms, administration activities, specialization and specification of working positions, while small and medium farms operate more like a family business with one to two persons hired for help. Also, all obligations in small and medium farms are owner's responsibility, so there are no additional costs of production paid for administration activities or work specialisation. There are 6 medium farms (M3, M4, M5, M6, M7 and M8) that have new technology of production, established after 2000, but they produce in very old buildings, which are already depreciated. Other medium farms do not provide investments and their fixed inputs are already depreciated. Concerning small farms, they do not have investments for the analysed period and their fixed inputs are already depreciated.

5.1.3 Technical efficiency from output perspective

Output of pig production is summarised as total pigs live weight in kg. With this approach there is only one output to be analysed which is easier to follow and also reduces the risk of appearance of irregularities in the calculations. Moreover, the output efficiency is estimated with DEA from CRS and VRS assumptions.

Table 24: Output technical efficiency from output oriented DEA

Output	Unit	Mean	Median	Min	Max	St. Dev
			Overall technical efficiency (TE_{CRS})			
Observed output	kg	620,163	164,000	14,400	3,000,000	856,433
Increased output for TE	kg	159,222	42,857	0	799,137	235,028
Projected output at full TE	kg	779,385	176,941	23,010	3,342,857	1,023,702
Output increasing	%	24.16	18.60	0.00	62.88	21.80
			Pure technical efficiency (TE_{VRS})			
Observed output	kg	620,163	164,000	14,400	3,000,000	856,433
Increased output for TE	kg	58,498	12,797	0	322,304	89,492
Projected output at full TE	kg	678,661	176,797	14,400	3,000,000	891,366
Output increasing	%	12.29	5.72	0.00	56.62	17.30

Source: DEA results of data collected from own survey

Table 24 elaborates output quantities in kg according to the value received by DEA estimates. Moreover, the table is analysed from the average output quantities obtained by the production, as well as, minimum, middle and maximum value of the output. Accordingly, under CRS the output should increase for 24% without increasing of utilised inputs in the production. In the pure technical efficiency or variable return to scale, the output should increase for 12.29% in order farms to face full technical efficiency from output perspective, while the inputs utilization is not going to change their quantities.

Concerning all farms included in the analysis, Figure 21 shows the output production from a constant and from a variable return to scale. Both perspectives represent the output obtained by the production and the need for increasing the output in order farms to be fully efficient if the output perspective is concerned.

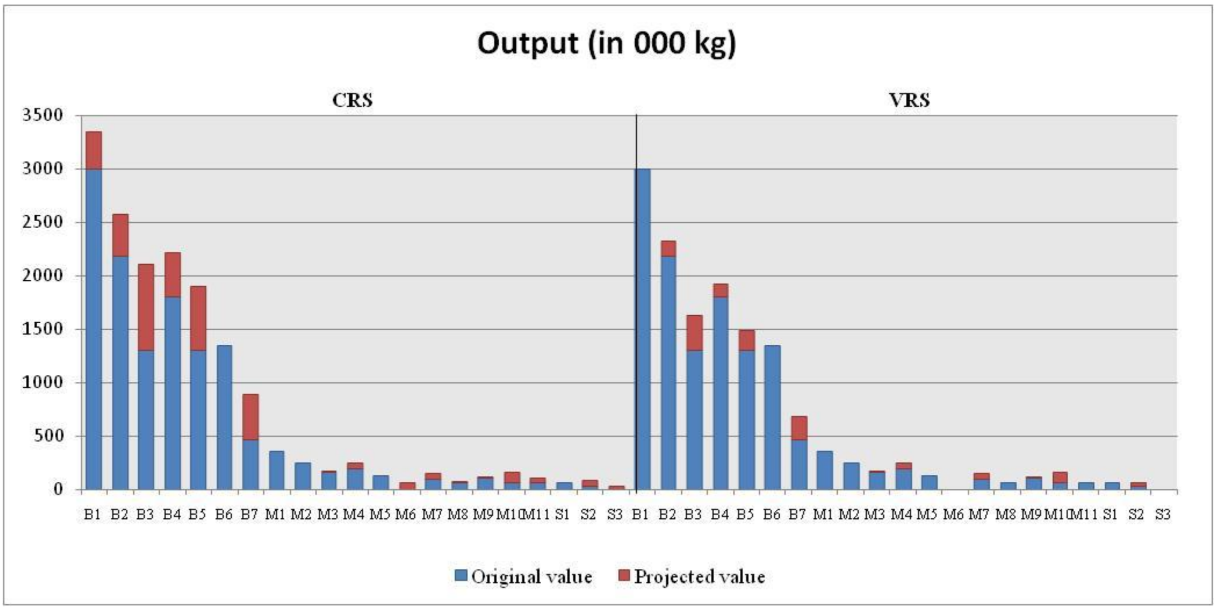

Figure 21: Efficiency score of output under CRS and VRS
Source: DEA results of data collected from own survey

According to Figure 21, there are only 5 farms that are fully efficient in CRS analysis, but when VRS are concerned the number of fully efficient farms is double. As we have already considered farms B6, M1, M2, M5 and S1 are fully efficient and they produce on the optimal scale (which means that they face efficiency equal to one in both CRS and VRS). Other farms do not produce on an optimal scale and their efficiency varies in different scales. Blue columns in the figure represent the quantity of output produced in 2010. Red columns are the estimated values by which farms should increase the output quantity in order to be fully efficient. There is a difference in the quantity of output by each farm separately, but the lower efficiency is estimated in CRS, while the same farms in VRS are more efficient and should increase the small quantity of output than in CRS. An average consumption is that output should increase by 24.2% in CRS and 12.3% in VRS, while Scale efficiency is 86.6%.

5.1.4 Technical efficiency analysed between big, medium and small pig farms

Technical efficiency analysis can be divided according to the farms' capacities. In relation to this study the efficiency is analysed separately for big, medium and small farms that are included in the analysis.

The results show that big and medium farms are with similar technical efficiency scores. Hence, big farms have technical efficiency of 77% under CRS, while medium farms are more efficient than big farms with 0.006% considering CRS perspective.

According to the variable return to scale, average technical efficiency is quite the same for both big and medium farms with around 88% from input and from output perspective. These results elaborate a scale efficiency which is also around 87% concerning input orientation, but the difference in comparison between big and medium farms is in the output orientation. Here, big farms in inputs analysis have scale efficiency 85% and medium farms are operating on inefficient scale of 10.6%.

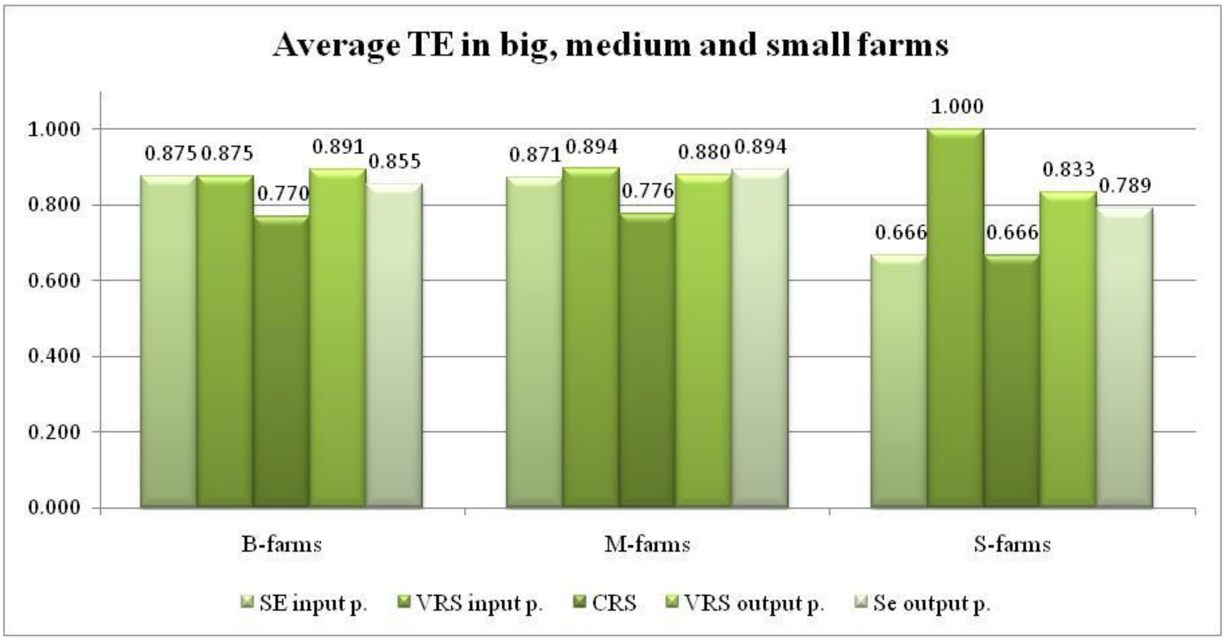

Figure 22: Average technical efficiency of big, medium and small farms
Source: DEA results of data collected from own survey

On the other hand, small farms face big variations in their technical efficiency. While operating on CRS they face technical inefficiency of 66%, but the output perspective under VRS is similar to the efficiency of big and medium farms, with 83%. The most interesting part is that small farms face full efficiency under VRS input perspective, which leads to the scale efficiency of 66% or the same efficiency as under CRS. The average efficiency of big, medium and small farms is shown in Figure 22.

Table 25: DEA efficiency scores considering big, medium and small farms

	Mean	Median	Min	Max	St. Dev	CV	Share of efficiency score of 1 (%)
			CRS (input and output perspectives)				
B - farms	0.77	0.81	0.52	1.00	0.17	0.22	14.28
M - farms	0.78	0.87	0.37	1.00	0.24	0.30	27.27
S - farms	0.67	0.63	0.37	1.00	0.32	0.48	33.33
			VRS (input perspective)				
B - farms	0.87	0.94	0.60	1.00	0.14	0.16	28.57
M - farms	0.89	1.00	0.54	1.00	0.16	0.18	54.54
S - farms	1.00	1.00	1.00	1.00	0.00	0.00	100.00
			VRS (output perspective)				
B - farms	0.89	0.94	0.68	1.00	0.12	0.13	28.57
M - farms	0.88	1.00	0.43	1.00	0.19	0.21	54.54
S - farms	0.83	1.00	0.50	1.00	0.29	0.35	66.66

Source: DEA results of data collected from own survey

Furthermore, more detailed explanation of the efficiency of big, medium and small farms is shown in Table 25. Accordingly, the table is divided into three parts: input and output perspective under constant return to scale, variable return to scale from input perspective and variable return to scale from output perspective.

The table shows an average efficiency score for big, medium and small farms separately. Also, it includes median and minimal efficiency score. Maximum efficiency scores are equal to one which indicates that in all farm categories (big, medium and small) there are fully technical efficient farms in all scales of analysis. Then, standard deviation explains the variation between technical efficiency scores of all farms included in the analysis and the ratio between standard deviation and average scores or coefficient of variation allows cooperation of technical efficiency scores without depending on the unit of measurement. At the end of the table, percentages of participation of fully efficient farms in the analysed series of data are given.

Figure 23 explains the utilization of inputs and production of output by different farm categories and in constant return to scale. Hence, all farms should increase the output, big farms for 23%, medium farms for 22.3% and small farms 33.4%. Accordingly, medium farms are the most efficient from output perspective since they have lower values for increasing.

The input figures are down-turned because farms need to reduce that amount of inputs. In addition, big farms have the biggest utilization of other costs and they need to decrease the utilization of other costs for 67.5% in order to be efficient. Medium farms have some middle value of around 25% that should be reduced for all inputs. In relation, small farms are most inefficient in labour unit which they need to decrease for more than 50%.

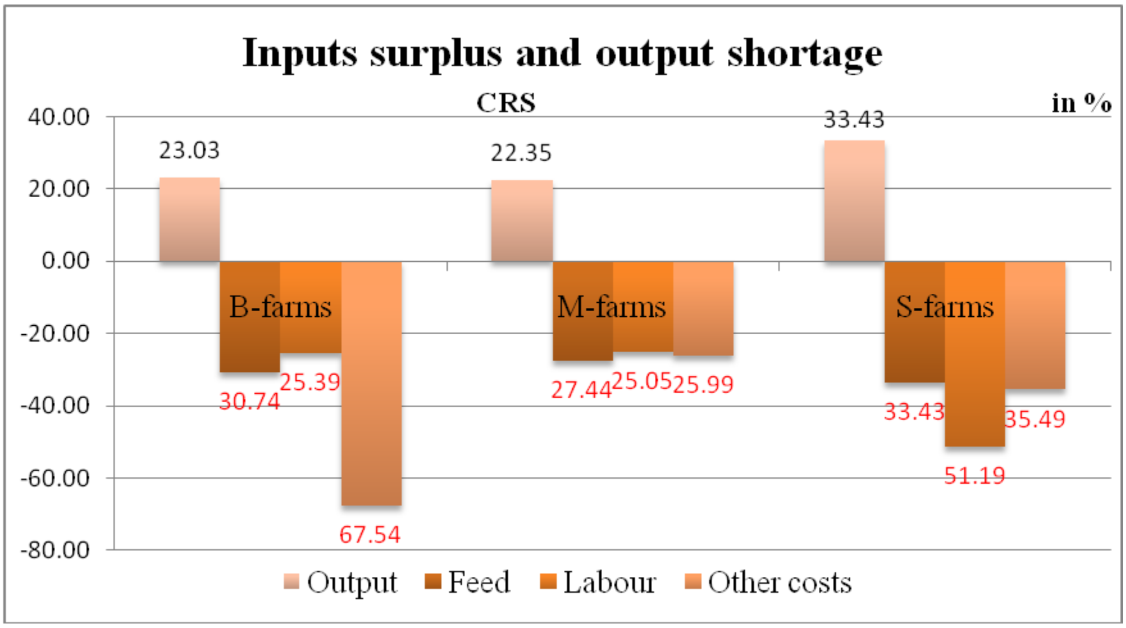

Figure 23: Inputs surplus and output shortage under CRS
Source: DEA results of data collected from own survey

Under the variable return to scale farms have different values than in CRS. The results are shown in Figure 24. Here, the most efficient farms according to the output need to increase are big farms, because they should increase their output for only 10.8%, and the last efficient are small farms with more than 16%.

On the other hand, inputs should be decreased differently for each farm category. Concerning inputs, small farms are the most efficient since around 7% of the inputs should be reduced and the labour input is fully efficient, which is quite opposite from CRS.

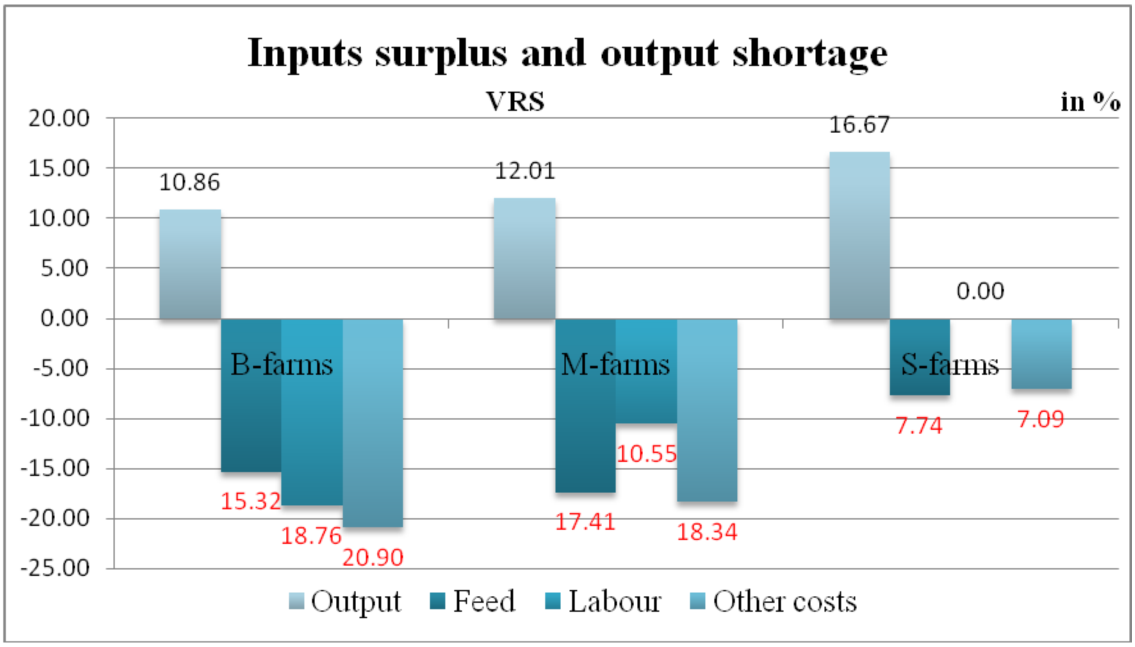

Figure 24: Inputs surplus and output shortage under VRS
Source: DEA results of data collected from own survey

Big farms should decrease the utilization of other costs which is the same compared to the CRS analysis, but their efficiency score is much bigger than it was the case in CRS perspective. Also, medium farms have more than 10% inefficiency in labour input, more than 17% in feed input and 18.3% in other costs.

5.2 Second stage analysis

Second stage variables, in relation to the literature explained in Chapter 2, are divided in two parts: environmental factors and decision maker characteristics.

5.2.1 Environmental factors

The environmental issues that influence the technical efficiency are analysed one by one in the following part.

Location of farm

Findings show that the average distance concerning pig farms location is 1.7km to the closest market or big city. A maximum distance of big and medium farms is 3km, while the minimum distance is a half kilometre to the big market. Compared to the literature reviewed, the most efficient approach according to the distance between closest market and farm location is 1km (Galev and Lazarov, 1968; Bamiro, 2008).

Medium and small farms have big variations according to their destinations. In addition, farms are located or too close to the living places or so far away. The closest destination is 0.5km which may lead to additional problems with the population in that region. The largest distance has small farms, located 2.5km away and the farthest from big market is located S1 which has 6.5km long destination. The location of farms and the distance to the closest market are shown in Table 26.

Table 26: Location and size of big, medium and small farms

	Unit	Mean	Min	Max	St. Dev
			Big farms		
Distance to the closest market or big city	km	1.44	1.00	3.00	0.73
Accessibility to farm	rating	5.00	5.00	5.00	0.00
Land/buildings proportion	ratio	11.89	3.65	42.76	13.73
			Medium farms		
Distance to the closest market or big city	km	1.65	0.50	3.00	1.15
Accessibility to farm	rating	3.55	2.00	5.00	1.04
Land/buildings proportion	ratio	3.06	1.25	5.00	1.20
			Small farms		
Distance to the closest market or big city	km	2.50	0.50	6.50	3.46
Accessibility to farm	rating	3.67	3.00	5.00	1.15
Land/buildings proportion	ratio	2.26	1.10	4.00	1.54

Source: Analysis according to the empirical findings

Seen thus, all big farms and some medium farms have the most efficient destination (around 1km) to the populated places where the big markets are located.

In relation to the literature, it is important where farms sell their products. In chapter 1, it is stated that all farms produce only for the domestic market. However, the findings show that there are beginnings of selling the products in the foreign countries. This trend appears only in two big farms (B1 and B6). All other farms sell on the domestic market usually to slaughterhouses.

Road accessibility

The road accessibility is also important for analysis of efficiency since the long and uncomfortable road increases the cost of transport and causes difficulties during the exchange of inputs and outputs. This issue has been confirmed by Galev and Lazarov (1968) who analyse the benefits of farm location.

In order to be estimated, the road accessibility rates from 1 (if the road is difficult to access) to 5 (if there is an excellent road which leads to the farm). With that approach the analysis shows that big farms in the country have an excellent road and together with the optimal distance they should have the best efficiency concerning transportation costs. Medium and small farms have less efficient transport and not so good road to the farm even if in all farm categories there are farms with an excellent road.

Proportion between land and buildings

According to the proportion between land and buildings, big farms land is from 3.6 to 42.7 times bigger than the size of farm buildings with an average of more than 11 times bigger land. Otherwise, medium and small farms have the biggest proportion of 5 and 4 times, respectively. The minimum proportion of land and building in medium and small farms is around 1. If it is considered that bigger land availability allows production of bigger quantities of feed and also increasing of farms if there is a need for such activity, then big farms have more options to increase the production efficiency. On the other hand, medium and small producers usually live in the same yard where the farm is located, which emphasises the fact that they have very little land available for feed production or they are completely dependent on purchased feed. Availability of land is concern of other studies, for example: Larsen, n.d.; Ortner *et al*, n.d.; Ramilan *et al*, 2009; Rios and Shively, 2005; Bamiro, 2008).

Legal status of the farm

Considering the legal status represented in Table 11 in the empirical findings, Chapter 4, only big farms are Joint stock companies with more than one shareholder. The other farms, some of the biggest farms, also medium and small farms, are Limited liability companies or the farmer is registered as Individual agricultural producer. In both categories the responsibility depends on the only one person who in most cases is the owner of the farm. These two divisions have a positive and a negative side, considering farm efficiency. The decisions in the first form, JSC, are adopted by a common agreement and exchange of opinions between all shareholders which leads to the efficient decision making process. Otherwise, there is a prolongation in the process for those decisions that should be made quickly, because the decision making board should have a meeting in order to find out the best decision.

On the other hand, farms that are registered as LLC and IAP have easier decision making process and the decisions can be made quickly. However, decisions which are made without any consultations may be wrong or not enough efficient. In this way the whole responsibility falls to one person.

Influence of different types of production technology on the efficiency

According to the literature reviewed in Chapter 2 the production technology has a big influence on the technical efficiency of production (Campos Labbe, 2003; www, Compassion in world farming, 2011). Hence, Table 27 has been made in order to analyse the utilisation of different types of technology and their influence on some issues that are closely related to the efficiency of farms. Considered issues are: the quantity of utilised feed per one kg live weight, percentage of mortality and an average number of piglets per sow (their influence is also analysed and confirmed by www, Compassion in world farming, 2011 and Todorovski, 1969; Lauwers *et al*, n.d.).

Furthermore, some of the analysed farms use new technology of production or have a combination of new and old technology and they constantly invest and renovate their buildings. Accordingly, those farms that improve their technology and buildings have decreased the quantity of utilised feed for increasing of one kilogramme live weight on pigs. With decreasing the level of utilised feed as an input of production, farms increase their technical efficiency as well.

On the other hand, there are farms that have only old technology and do not make investments in renovation. Comparing given technologies, we come to the conclusion that farms which use old type of technology spend one kg more feed for satisfying the pigs' needs.

If the mortality of piglets is considered, the findings show similar values as in the feed utilisation. Hence, those farms that use new technology in production have the lowest mortality rate with an average of 3.4%. The average mortality in farms with combined technology 5.7%, while in farms with old technology mortality rate is bigger for 1.1%.

Table 27: Relationship between production technology, utilised feed and mortality

	Unit	Mean	Min	Max	St.dev
			Combination		
Feed/live weight	kg	3.87	3.33	4.67	0.45
Mortality	%	5.70	1.20	15.00	5.28
Pigs/sow	no.	13.50	9.00	15.00	2.35
			New		
Feed/live weight	kg	4.66	2.52	7.89	2.21
Mortality	%	3.40	1.20	8.00	2.67
Pigs/sow	no.	12.50	8.00	18.00	3.73
			Old		
Feed/live weight	kg	5.14	3.64	9.39	1.79
Mortality	%	6.89	1.00	13.00	4.51
Pigs/sow	no.	10.67	9.00	12.00	1.12

Source: Analysis according to the empirical findings

The mortality percentages also confirm the fact that new technology of production increases the efficiency of farm production. A farmer has discussed the relationship between the technology and mortality:

> *"Ever since I changed the technology of production and bought a new system, piglets mortality has decreased... and now the mortality in my farm is 1.2%"* (pers. com., Farm M2, 2011-09-25).

Moreover, farms with new technology influence the percentage of piglets born per sow, because it increases the welfare and living conditions on the farms and reduce the appearance of disease and pure animal health. Another farmer says:

> *"...of course that changing of the technology would influence the elimination of diseases and would increase animal welfare as well...Since I am a vet, I admit that for more efficient production there is a need of using new technology and renovation of the existing buildings....On the other hand, I have not changed them from some other reason....the farm is not in my ownership and because of that I do not want to make an investment..."* (pers. com., Farm M10, 2011-07-07).

Indeed, farms with new technology have 12 piglets per sow per one farrowing; farms with combined technology have 1 piglet per farrowing more, and farms with old technology have 10 piglets per sow in one farrowing.

The number of pigs born depends on the breed of pig, as well. In addition, big farms have their own insemination process and make different mixtures of semen by themselves. By making different combinations they can increase pigs' performances for more efficient production.

Differently, smaller farms usually buy the semen or use a natural insemination by their own boars. With this, producers do not increase pigs' performances or this activity is on the low level so to have big influence on the efficiency.

5.2.2 Decision maker and capacity building factors

Managers' behaviour and their decisions influence the efficiency of production and the technical efficiency by providing decisions on the farm, considering input-output relationship. Compared to the literature provided in Chapter 2, managers' characteristics are very important for efficient production due to increasing of the efficiency by education and capacity building of the manager (Kilpatrick *et al*, 1999).

It has been previously confirmed that by changing the technology of production managers influence the production efficiency. In order to see the connection between managers' education and capacity building, and providing a new technology of production, the analysis is established according to the findings in Chapter 4 and the results are represented in Table 28.

Table 28: Relationship between production technology and manager capacity building

		Number of farms		
		Combination	***New***	***Old***
Education level	university	**5**	**5**	**4**
	high school	1	1	**4**
	extended high school			**1**
Participation in trainings, seminars and conferences	often	**4**	2	2
	rarely	2	**4**	**6**
	not participate			**1**
Participation in agricultural associations	participate	3	2	4
	not participate	3	4	5
Information for innovations	more than one source	**4**	**5**	**7**
	only one source of information	2	1	2
Bringing decisions	analysis	2	1	2
	intuition	0	1	2
	both	**4**	**4**	**5**

Source: Analysis according to the empirical findings

According to the analyses, more than a half of the managers have higher education which represents a certain level of human potential in pig production in the country. Most of the managers who have obtained university degree are changing the technology of production with a new one, which depends on the available funds that they have to spend on this issue, but also on their knowledge related to the benefits of production that would be realised by investing in new production technologies. In regards to this, around 1/3 are already producing using new technology.

The relationship between the technology and managers' education was also confirmed with the other issues about manager capacity building. Thus, half of the managers who are positive in utilization of new technology often participate in different trainings, seminars and conferences. These kinds of trainings are usually available in the native country, but sometimes there is an opportunity for some of the managers to participate in a seminar or conference which is organised in some foreign countries in Europe.

Moreover, most of the managers, who are not interested in changing the technology, do not show any interests for participation in trainings, conferences or seminars. Some of them used to participate in such activities in the past. Beside this, there are managers that seldom participate in trainings, but use new production technologies.

The findings show that there does not seem to be any correlation between the types of technology of production, hence the education of farmers, and participation in an agricultural association. Consequently, most of farmers included in the analysis do not participate in any association and are not interested in participation. Their opinion is that participation in such associations does not provide any benefits to them and they have no need to participate in it.

On the other hand, there are farmers that participate in agricultural associations and think that the participation is very helpful in their work, by increasing their education and exchange of information. Most of them have established new contacts within the association and learn about new technologies and innovations from different experiences. Their recommendation is that the meetings within the association should be held more often where the farmers should contribute more in solving different problems regarding the production.

It has been found out that the sources of information do not influence the technology of production. Accordingly, most of the producers are providing information from different sources and a very small number of managers use only one source of information. Indeed, most of the managers use professional literature for learning new issues related to pig production especially if they face some problem within the production. Some of the managers usually get information by communicating with other farmers, or reading newspapers, internet articles or they hear about some innovation from other media.

Also, the way of making decisions does not influence the utilisation of different kinds of technology. Hence, most of the managers use analysis and estimates, but also their intuition and experience before making a decision for new activities. However, the number of managers who use analysis and estimate the benefits of new technologies is bigger, and the number of managers who use only intuition and experience in order to begin with something new in the production is lower.

On the basis of the above stated 95% of the managers use advices in the production. The advices are usually provided by private consultants or by the firms the managers cooperate with. The utilization of advices does not show influence on the production technology and for that reason it is not included in the table.

However, the efficiency increases if the manager has higher level of education followed by a high level of experience. In this study, those managers who have higher education and many years of experience have opened a web page of the farm and provide official accounting system. On the contrary, those managers who have secondary education and less experience do not have an internet page and their accounting system consists of book keeping evidence of inputs and outputs in the production that managers provide by themselves. Compared to the empirical findings, in Chapter 4, it has been found out that the first type of managers in regards to the experience, internet, and accounting evidence work in big farms, while the other managers are owners of the medium and small farms in the country.

There are other studies that analyse managerial characteristics in terms of education, age of managers and years of experience (in example: Ortner *et al*, n.d.; Larsen, n.d.). They all agree that the education level is very important for sustainable production and efficiency increasing. More about the managerial skills is shown in Appendix 3. Findings are analysed due to the importance of factors that influence management activities.

6 Discussion

This chapter provides a discussion on the analysis and empirical findings in order to give deeper explanation of the research and estimated technical efficiency on the sample farms. The chapter is divided into three parts: the survey activities, first stage analysis and second stage analysis.

6.1 The survey

In this thesis, an analysis of technical efficiency of pig farms in the Republic of Macedonia has been prepared using Data Envelopment Analysis (DEA) method for the very first time. The analysis concentrates on inputs and outputs of production. In order to make the analysis, the survey has included 21 pig farms spread in many regions in the country. To meet the purpose of the thesis, the research focuses on few pig farm categories referred to as big, medium and small farms. They have been categorised according to a division given in the method chapter (Chapter 3).

Moreover, the research consists of interviewing the decision makers (managers) of farms, in relation to the previously prepared questionnaire which contains all of the necessary questions to provide the necessary answers. Gender issue has not been addressed because most of the managers in pig production are males and there are only 3 female managers of the sample farms. The reason for the low level of participation of women in pig production remains in the unfavourable educational structure and the traditional background of the rural population in the country. Even though women are well educated there is a long term tradition according to which the father leaves all his land and business to his son, but not to his daughter. Thus, only men are registered as managers and owners subsequently, even if there are benefits for rural women managers that exist in the country. For instance, the subsidies that agricultural producers can request and receive from Payment Agency are higher for women managers.

During the preparation for the survey, the researcher faced the problem of finding a data base of pig producers in the country. Therefore, it was necessary to contact local governments and governmental institutions in order to ask for contacts. They have a few years old data base with no categorisation of farms which increases the need of research, i.e. to investigate which farms are still operating and what is their capacity for the analysed period. Compared to the other countries in the world, there are established and official data base that could be used for research purposes (Larsen, n.d.; Brock *et al*, n.d.; Silva *et al*, n.d.; Tzouvelekas *et al*, 2001; Johansson and Ohlmer, 2007; Lauwers *et al*, n.d.; Larue and Latruffe, 2009; Bojnec and Ferto, 2011; Karagiannis and Sarris, 2002; Bielik and Hupkova, 2011).

On the other hand, the researcher found difficulties in collecting the appropriate data needed for providing the analysis, while measurements and theoretical approach of technical efficiency were found to be much easier activity for preparing the thesis. Accordingly, most of the farmers have feared to give the requested data or have given incomplete data. Their explanation for this has been that the questions touch very sensitive issues. The letter signed and certified by the Faculty of Agricultural Sciences and Food (see Appendix 2), which guarantees safety of the data and their utilization only for science purposes has been the extenuating circumstance.

Another challenge has been the data obtained to have the same measurement units. In order to be used in the programme as such, the researcher needs to make the data equivalent to each other. The problem appears because most of the farmers do not know all of the costs and utilised quantities or they know the quantities but in different units and values depending on the way of utilization, particularly for collecting the values for other inputs (except feed and labour). The findings show that farmers know only the costs for other inputs made within one year, but not the quantities, for example electricity, water, manures etc.

Otherwise, all of the farmers know the quantities and cost of feed in total amount and separately in different sorts of feed. Noteworthy, not all farmers have their own production or they do not prepare mixtures by themselves, but some farmers use purchased feed which has various prices for different categories of pigs. Also, farmers have certain information about the salary of employees, which is not the case with part-time workers.

6.2 First stage analysis – application of DEA

After the data have been collected and calculated in the same measurable units, they have been included in the programme for estimating technical efficiency. The programme gives the results from several aspects in respect to DEA: constant and variable return to scale both divided on input and output perspectives. All aspects have been separately analysed in the Analysis of findings chapter (Chapter 5).

There are three inputs analysed separately: feed, labour and all other inputs of the production, since it has been defined that three inputs are an optimal number for analysing technical efficiency. Compared to the other studies in the world and in the neighbouring countries as well, those are the most frequent inputs used for analysing technical efficiency in livestock production (in example: Sharma *et al*, 1996; Galanopoulos *et al*, 2006; Cesaro *et al*, 2009).

There are mixtures of feed used for different categories of livestock. Their composition depends on pigs' age and the purpose for their production. All feed mixtures consist of different ingredients and they all have different prices. Thus, feed for the little piglets is most expensive, around 30MKD/kg (pers. com., Farm S1, 2011-09-30), while the other feed costs are around 18MKD/kg[7]. On the other hand, a lot of pig producers have their own feed production in terms of the most important feed components that are included in all feed mixtures, like: corn, barley, soybeans and other ingredients (pers. com., Farm S1, 2011-09-30). In those cases, farmers buy only the necessary part of feed mixtures that consist of minerals and vitamins which are used usually for piglets.

As far as labour is concerned as an input included in the analysis, there are three categories of workers appropriate for pig production: employees, hired workers and family members. Accordingly, the survey has found out that there is no evidence of the total hours spent for working on the farm by different categories of labour. Especially, family members are full time involved in farm activities, but the evidence does not provide their labour utilisation. Full commitment to the production is one reason why the pig producers together with the whole family live near the farms. Additional workers are hired only when there is a need for such

[7] An average cost that all farmers confirm in their estimates, if they do not have detail accountancy evidence.

activity. Farmers do not provide evidence of their involvement hours because their time is not fixed and the days of working depend on the need and obligations. One farmer explains:

> *...We do not provide evidence of the number of part time workers. Usually there are 2 or 3 additional persons included during a year....... I do not know how many days or working hours they spend on the farm, because that depends on the need* (pers. com., Farm S1, 2011-09-30).

On the other hand, it is much easier to measure the involvement of labour per hours spent on the production activities in big farms. They have hierarchy and classification of labour obligations with a certain time that should be spent on farm activities. Also, those farms do not include unpaid family labour.

The electricity is important especially for little piglets where special heaters and lights are installed that heat the object sometimes for 24 hours. All farms use the electricity as a primary source of energy, as the electricity is not only the easiest way but also, it is still cheap in Macedonia where the electricity price is around 2.5 MKD/KW or 0.04 EUR/KW (www, EVN Macedonia, 2011) compared to the other European countries where the electricity price is around 15MKD/KW which is equal to 0.25 EUR/KW (www, Europe's energy portal, 2011). Instead of the electricity, few farms use wood for heating the farm objects (M2, M6, M8, M9, M10 and S3) and B7, M1, M6, M7 use the other kind of heating energy like oil etc. Noteworthy, only the biggest pig farm in the Republic of Macedonia (farm B1) uses renewable sources of energy. Indeed, it has installed solar energy for heating the objects on the farm in winter and geothermal heat pump which is one of the largest in the Balkans. It uses the pump for heating in winter and cooling in summer period. Sometimes it is not enough to use only the renewable energy, usually in cold winters, so the electricity is used as additional energy for heating. Furthermore, most of the farms do not have costs for water and the need of water is satisfied by using technical water taken from wells which are installed on the farms.

According to the veterinary and medicine, some farms have veterinary costs, but those farmers who have a veterinary diploma provide veterinary activities by themselves (S1, M11, and M8). There is a comment of one farmer about the utilization of veterinary and medicine:

> *"...if I employed a vet to do all veterinary activities it would cost me a lot...the good thing is that I am a vet and I have a licence by which I am allowed to do veterinary activities by myself. On the other hand, medicines are necessary in pig production... even if pigs are healthy, it is important to protect them from big diseases, so to buy vaccines for all pigs that are on the farm..."* (pers. com., Farm M11, 2011-07-07).

Big farms have their own vet that has evidence for the health of all the pigs on the farm (B1, B2, B3, B4, B5, and B6). Usually, those farms have their own repro centre for artificial insemination by which they get maximal production of best genetic livestock characteristics. The other smaller farms provide insemination activities by buying already purchased semen or by natural insemination by using boars.

In regards to the disposal of manure and ecology costs, some farms do not have costs for this activity yet, since they use the manure on their own agricultural fields as a natural fertilizer and the liquid manures are thrown outside the farm through a several kilometres long channel. The other farms collect the manures until they are disposed outside the farm. Some farmers dispose of the manure on their own and throw it on the crop fields, which means the only costs they have are the transportation costs.

Obviously, transportation costs are necessary for all farmers. The transport is important to get the pigs to the nearest slaughterhouse or to the market. Also, transport is used for buying feed, medicine and other necessary issues. Those farmers, who do not have a proper accounting system, provide evidence of transport costs by estimating with 60 MKD for each transported pig (pers. com., Farm M11, 2011-07-07).

Moreover, it must be mentioned that the other inputs are differently considered in small, medium and big farms. Data collected of those inputs depend on how farmers provide the evidence, and some farms include both variable and fixed costs in the costs for other inputs, and consider them as total costs for other inputs. Also, one farmer explained:

> *"...I cannot tell you how much profit we have...the reason is that we made few investments during the year....it is about buildings renovation and also we bought some new technology for the farm...and the costs for the investment are included in the total sum of costs that I've already given to you.....since they are for the farm needs I do not provide separate calculations..."* (pers. com., Farm M4, 2011-09-27).

This happens because some sample farms do not use accounting and book-keeping evidence. Therefore, a lot of their additional costs of production (like depreciation of objects and machinery) have not been taken into account. Some farmers, usually on medium and small farms, provide evidence of the main costs of production only (feed, electricity and salaries). The other farmers, who apply accounting, prepare it under the historical cost convention. It is very important here to notice that some of the medium and small farms do not have many additional inputs that increase the costs of production a lot since they do not make such big investments. The investments are usually taken by big farms and some medium farms who start to use a new technology or to change a part of technologies depending on funds availability.

However, 90% of sample farms work in very old buildings and machinery. Those fixed inputs have been installed while the farms were built and never changed. The amortization time has already finished. Most of the farmers have never invested in new buildings and equipment and they have inherited the old ones from their parents. For that reason the capital part has not been included in the analysis of technical efficiency. On the other hand, big farms have big costs because of the investments in new technology, but later in the future they would have more profitable production. For example, "*if farms invested in new buildings with better isolation, they would reduce electricity costs for heating"* (pers. com., Farm M10, 2011-07-07).

Also, the research includes only one year (2010) in order to analyse technical efficiency provided in pig production for that period. However, better approach is to include at least three years while analysing technical efficiency because the additional inputs used in the production would result with effectiveness after several years. As mentioned above, those are fixed investments which represent only additional costs while analysing the period of one year.

In relation to inputs and outputs, the efficient production depends not only on their quantities used in the production, but also on their prices. This is the subject of analysis of allocative efficiency which can also be analysed with DEA. Technical and allocative efficiency used together give a value of total efficiency of production. Measurements of total efficiency would help farmers to decide about different activities in production and by knowing the prices represented in allocative efficiency farmers would find out the profitability of their production. In the medium and small farms there is a constant variation in their revenues and costs. Its working depends on the external factors, first of all from the market prices of feed. Feed plays the most important role in fattening pig production. For instance, the research finds out that 2010 has been a profitable production year, but the situation in 2011 has changed. In 2010 the feed was 50% cheaper than it is in 2011. However, 2011 is not finished yet, consequently 2010 has been taken into account for the analysis.

> "*In 2011 almost all farms work with loss...consequently, there is a trend of decreasing the number of pigs especially if the small farms are concerned...all farmers that have around 50 sows, now produce with around 30"* (pers. com., Farm S1, 2011-09-30).

Noteworthy, not only the price of feed has changed and the costs for feed have increased for 50%, but the price of pigs in live weight remained the same.

> *"Inputs in pig production are too expensive...even I have 10 sows and a part of feed is home production, I do not find it as profitable a business, so I am going to sell all the pigs that I have and the next year I will try cattle breeding, it seems more profitable..."* (pers. com., Farm S3, 2011-08-29).

Besides considering different inputs and outputs, another challenge was to define how technical efficiency of farms would be analysed in order to be understandable and transparent after having gone through so many aspects and divisions. The most appropriate aspect in analysing technical efficiency is by variable return to scale since there are a lot of external variables that have a significant influence on technical efficiency. However, it has been concluded that it is good to make a comparison among all efficiency aspects and to find out if the analysis would confirm the theory of the model. The results explain that constant return to scale has always low efficiency values compared to the variable return to scale which proves that there are many other issues that influence the efficiency of production, not only the inputs-outputs relationship.

The findings show various efficiency scores, average values of technical efficiency from all aspects and technical efficiency scores of each farm respectively. Also, inputs and outputs quantities and the quantities that should be reduced or increased respectively have been given. The results show that there are fully technically efficient farms in the country and they should not change the utilization of inputs and output obtained. Otherwise, their efficiency score would change as well. The other farms which are not fully technically efficient could increase their efficiency by changing the management practices in respect to the inputs and outputs of production. Indeed, inputs should be minimised for a certain efficiency level and output production should be increased until farms maximise technical efficiency without increasing the quantity of utilised inputs.

Technical efficiency depends on the number of farms included in the analysis and under the assumption that all farms in the country are working under the same conditions the representative farms give a relative technical efficiency of all pig farms in the country (Coelli *et al*, 2005). Technical efficiency scores have been analysed from input and output perspective. In that respect, Macedonian pig farms have technical efficiency score from input perspective 0,758 and 0,903 for CRS and VRS respectively, with the scale efficiency of 0,843. From the output perspective TE is 0,758 and 0,877 for CRS and VRS respectively, with scale efficiency 0,866.

Compared to the other countries, Hungarian pig farms have lower technical efficiency, which has been estimated under CRS is 0,423-0,553 when the output contains of different categories of pigs and 0,546-0,568 when quantities of nitrogen produced are included in the output (Latruffe *et al*, 2010).

Technical efficiency is also estimated for Hawaiian pig farms from both input and output perspectives (Sharma *et al*, 1996). From input perspective technical efficiency scores are 0,635 and 0,748 for CRS and VRS respectively. From output perspective TE is 0,644 for CRS and 0,726 for VRS. They have scale efficiency of 0,842 from input perspective and 0,895 from output perspective (Sharma *et al*, 1996).

Furthermore, Lansink and Reinhard (2004) estimated technical efficiency of pig farms in Netherland. They analysed CRS, VRS and SE from input perspective. Hence, technical efficiency of Netherlands pig farms under CRS is 0,89, VRS score is 0,90 and SE is 0,98.

Larue and Latruffe (2009) estimated technical efficiency from output perspective of French pig farms. The distinct TE according to the farm type and their scores are 0,82-0,89 under CRS, 0,84-0,92 under VRS and SE 0,97-0,98.

Technical efficiency is also estimated for the Balkan countries. Here, Bojnec and Ferto (2011) have estimated technical efficiency of Slovenian agricultural farms. They have included pig and poultry farms in the analysis and found out that technical efficiency of 26 pigs and poultry farms is 0,822 by applying stochastic efficiency analysis method. Also, analysis of the neighbouring countries shows that technical efficiency of pig farms in Greece from input perspective is quite similar to technical efficiency in Macedonian pig farms. In Greece, CRS TE is 0,782 and VRS TE is 0,828, with SE of 0,947 (Galanopoulos *et al*, 2006).

According to the comparison made between the findings in this study and studies from the foreign countries shown above, CRS has always lower efficiency scores than VRS. Also, technical efficiency in both CRS and VRS show similar results to results in other studies as well.

6.3 Second stage analysis

Efficiency of production does not depend only on the inputs-outputs relationship which farmers use in the production, but also on the governmental policy and market prices. Since prices have been discussed previously in the first stage analysis, this part focuses more on the governmental policy and other environmental and management variables.

Second stage analysis includes environmental variables and personal characteristics of managers that influence the decision making activities. The manager can influence some variables, but there are some factors that cannot be changed. For instance: the external environment is not under the control of the farmer. Here, most important external variables in pig production have been considered, such as: governmental regulations and location of farm. On the other hand, operational activities explain the situation on the market over which decision makers have a certain level of control and the internal environment in the farm that is under the influence of the decision maker performances.

Governmental regulations have not been collected as data since farmers do not provide evidence of this issue and therefore have not been included in the analysis of empirical findings. However, pig production is supported by laws and farmers are obliged to implement them in the production activities. Consequently, there are few issues that have to be discussed.

The first one is animal welfare which is still a challenge to be implemented on a high level in the country. In addition, most farmers have been producing in very old buildings and with old technology which does not allow so good accommodation of animals in respect to dry and clean living places. Nowadays, farmers are investing in new technology but this issue depends on the availability of funds for investment.

The second one is the organic production of meat. Today, many people wonder should they buy healthy products like natural pork produced without chemicals utilization in pigs. Also, a lot of foreign, but also neighbouring countries have already established organic pig farms. One of them is Greece that has been producing organic pork since 2002 (Papatsiros, 2011). In the Republic of Macedonia there are no organic pig farms and it is not even imaginable for them to be established since pig production takes a lot of medicine, vaccines and hygiene products that are not allowed in the organic production. One possible solution that would help in reduction of all those veterinary and hygiene products is modernisation of living places and new technology that would decrease the risk of appearance of diseases.

Another thing is the ecology laws. The ecology does not allow old production types since pig production is known as one of the biggest pollutants of the environment. According to the laws established in the country, which are in relation to the European standards, pig producers have to change the production in a way of modernization of buildings and technologies. Here, it is important to stress that pig producers are obliged to have a permit for Integrated Pollution Prevention Control (IPPC) obtained, based on already prepared elaborates for environmental impact assessment (pers. com., Petrovska, 2011-10-20). In addition, they must elaborate how much and what kind of medicine and hygiene products they spend in the production. Also, the disposal of manures is a concern of the ecology laws. Here, farmers must find a way how to handle this issue.

Regarding this, the ecology activities are still costly in Macedonia, since farmers are not introduced to their benefits, like making compost or biogas from manures and dead animals. According to the findings, some farmers know about the ecological benefits, but have no finances to invest and there are other farmers that do not believe that it would be profitable for a few years after the investment. Compared to the other countries in Europe, manures are considered as output and farmers have benefits from their utilization as heating energy. There is only one farm in the country that has tried to do something concerning this issue, B1 which has installed biogas plant that is used for producing biogas from manures. All other farms have only costs for disposal of manures.

Governmental regulations are established, but penalty provisions are not applied in the country yet and therefore the producers sometimes undertake the activities on their own. Otherwise, the ecology is still a big challenge in Macedonia and makes additional costs to farmers. Compared to the other more developed countries, the ecology allows better production of healthier animals and costs reduction by using renewable energy sources.

Environmental regulations are highly correlated with the location. It has already been stated that the optimal location of farm should be 1 km away from big cities. If the farm is located in a populated environment there is a possibility of a problem emerging in regards to the disposal of manures and pollution of waters and air. Hence, farms may need to dispose the manures in distant places which would result in increased transport costs.

The location is something that cannot be changed in regards to the already established farms. On the other hand, before building of the farm it is good to analyse the location regarding the nearness of big cities, slaughterhouses and consumers. Findings explain that regional allocation of farms in Macedonia depends on a number of reasons. Firstly, small number of farms, usually with small and medium capacity, in the west part of the country may depend on the population who lives there and their religion and tradition in consuming pig products. Also, as it has been elaborated in the theory, pig farms should be located near cereal fields due to the big consumption of feed within the sector (Galev and Lazarov, 1968). This is confirmed with farm B7, established in the biggest cereals production region, Pelagonia, by the largest feed producer in the country. Besides, in the west part B4 is also established, in the Polog region, but concerning the fact that it is very close to the capital city, Skopje, the farm has suitable opportunities since it is very near to the biggest market in the country.

Slaughterhouses have a significant and positive impact on the technical efficiency. Thus, it is very important where the farms are going to sell their products. All big farms in the country have their own slaughterhouses, or they cooperate with them within one big company. On the other hand, small and medium farms face difficulties in selling their products with profitable prices especially if the costs for other inputs, like feed, are very high. Indeed, it is important for the farms to be located near the slaughterhouses in order to reduce additional transportation costs.

The year of establishment represents the experience of farms over the year. The important and interesting thing is that the establishment explains not only the history of the farm but the history of the whole country as well. There is a close relationship to the year of establishment and the farm capacity. Indeed, big farms from the sample are the oldest ones established in the country, even before the transition period. The capacity and the production that they provide explain their sustainability over the years. Moreover, medium and small farms are not so old, and those which have been more efficient in the production succeed to enter in the market, to expand the business and to start to think about the activities that would initiate their sustainability. However, there are some farms on which activities are influenced by a lot of other external variables, they survive from year to year and in most cases they have some additional business activities.

The findings show that there is an influence between the technology used and technical efficiency of production. In that respect, the old technology requests more labour in cleaning and disinfection activities, as well as in feeding, heating and other management activities that need to be provided on each farm. Otherwise, new technologies are more automatic which reduce the need of labour utilisation. Accordingly, innovations in production activities and utilization of modern technologies in production lead towards technical efficiency. Therefore, some farms are starting to change the technology and they find out that a new breeding technology provides welfare, reduce the mortality and quantities of medicine and chemicals use which leads to reduced production costs (pers. com., Farm M11, 2011-07-07).

For market oriented pig production, the education of farmers is very important. In the respect of efficiency, the education plays a significant role in improvement of a personal behaviour, labour quality and professional performance of working tasks. Farmers should know the biology of pigs and their needs. Especially, the education is important for farmers to know how to handle biological challenges that are present in a natural production like the pig production is. Also, the communication with other farms and associations helps to learn about the innovations and how the farmer can reach them.

7 Conclusion

This study has examined technical efficiency of pig farms in the Republic of Macedonia and the need for improving their performances and sustainability of the sector based on different types of technical efficiency. Estimated efficiency should give an answer of the following five questions:

- Are the operating activities in the average Macedonian pig farms efficient?
- What is the efficiency from the input perspective?
- What is the efficiency from the output perspective?
- Are bigger pig farms more efficient than smaller farms?
- What other factors influence the efficiency?

The efficiency of operating activities in Macedonian pig farms depend on many issues considering inputs and outputs of production. How the production would become more efficient is a question for providing the analysis, but certainly farms are producing with a specific level of efficiency and have a potential for increasing technical efficiency by different combinations of inputs and outputs.

The method applied in the study is very detailed and gives an efficiency score of every input utilised in the production. In this way farmers could have evidence of their overall and pure technical efficiency.

Technical efficiency of Macedonian pig farms

The research allows determination of the best farms from those included in the sample under the assumption that the other farms in the country have similar technical efficiency scores. However, the best efficient farms can also improve their efficiency if they are compared to the other, more efficient farms (from the country or foreign countries) because the results show the most efficient farms from the best of the sample.

The study shows that technical efficiency of pig production is variable in regards to different aspects of analysis, but never less that 75%, obtained from the aspect of a constant return to scale. According to the variable return to scale, farms have higher technical efficiency, which has also been confirmed by the theory, and has different values for input and output perspectives of analyses. Also, there are farms that operate on the production frontier and face full technical efficiency from both constant and variable return to scale.

This paper confirms that variable return to scale is more suitable for analysing technical efficiency of pig production, since there are many other influencing factors that can change the efficiency scores.

Technical efficiency from input perspective

Input perspective is more suitable for analysing technical efficiency of agricultural production since the farmer cannot influence the output mix to any extent in the real world. Hence, in variable return to scale, an average technical efficiency from input perspective is 87.7%. Except fully efficient farms, the results show that the remaining farms should reach technical efficiency by reduction of inputs in different quantities.

As far as feed is concerned as the most important input in pig production, it should be said that its utilization should be reduced by around 15% for those farms that have pure technical efficiency (TE_{VRS}) and 30% for those farms that face overall technical inefficiency (TE_{CRS}).

The utilization of labour has been considered by the number of workers included in the production. The reduction of labour input should be around 12% for those farms that have pure technical efficiency (TE_{VRS}) and around 30% for those farms that produce with overall technical inefficiency (TE_{CRS}).

However, the biggest reduction of inputs should be made in the total amount of other inputs. Here, the biggest farms included in the sample have the biggest utilization of other inputs which depends on the investments in the production. Therefore, they need to reduce almost 18% of other inputs if the variable return to scale is considered and 41% if a constant return to scale is analysed.

Technical efficiency from output perspective

Considering the output perspective, farmers have no big influence on the output due to the nature of agricultural production. The findings show that in order to face full technical efficiency farmers who produce inefficiently have to increase the output quantities. Indeed, farms analysed by constant return to scale should increase 24% of the output quantities and farms under the variable return to scale should increase their production by 12%.

Technical efficiency of big, medium and small farms

The study has examined the efficiency level by individual farms and how they use inputs and outputs of production. In this respect, the study has provided analysis of technical efficiency for big, medium and small farms respectively. The results show that all farms have similar efficiency that varies between 70-90% in all aspects of analysis. Only small farm have different efficiency in constant and variable return to scale. They are the least efficient (67%) considering constant return to scale and fully efficient in variable return to scale. This leads to the fact that technical efficiency of small farms depends on various external factors that cannot be managed by farmers, especially not in the short term. Hence, inefficient farms can become more efficient by increasing the output or by reducing the overall utilization of inputs. More reasonable is to increase the production by using the existing resources more efficiently.

At the end, it has been discussed how pig farms should increase technical efficiency and their performances. It has been concluded that specific activities can influence the increase of the level of efficiency due to the close relation between inputs and outputs. For instance, considering input utilization farms should reduce their quantities and should use all inputs that they obtain in the production, while considering the production, farms should increase the output and its quality in order to obtain bigger profit.

Technical efficiency from the perspective of other influencing factors

There are a few things to be made in order to increase technical efficiency from the second stage analysis aspect. One possibility is to invest in energy efficient buildings and new technology that would contribute for quality breeding of pigs and animals welfare. This approach would reduce feed utilization, heating energy costs and mortality of piglets. Also, utilization of quality feed and more fertility breeds would improve animal health, meat quality and output performances. Waste management has also become very important for sustainability of the environment and pig production sector, and for upholding social responsibility of pig producers. Hence, the other possibility is to use renewable energy sources, and to invest in technology for utilisation of the organic waste and its conversion in energy or gas which would be used as input.

Farmers should invest in their knowledge and ensuring sustainability of farmers' associations because they increase communication between farmers, exchange of information and farmers opinion for utilization of innovations, management and technological practices. Hence, they should use the benefits from the Government and private organisations which organise workshops and trainings for capacity building of the producers.

Second stage variables are useful for political analysis and policy makers' decisions hence they give a clear picture of what influences the efficiency of production and what should be changed in order farms to face efficient production. But not only the environmental and socio-economic variables, other variables for example inputs included in the production, represent the quality of production activities and management process provided on the farm. Moreover, the Government should organise educational workshops in order to increase the knowledge and to have more efficient domestic production. In that way the Government would inform farmers about the innovation and trends that appear in the domestic and foreign markets. Indeed farmers would save money and time to organise educative activities by themselves.

In addition, in order for the production to be profitable for those farmers who provide good management practices on their farms, the production costs should be minimised at the optimal level. Also, Governmental regulations should contribute for healthy and quality production and for that reason more controls should be applied, but in the same time, opportunities for farmers as to how to handle those regulations should be provided as well. This way, the policy makers would contribute for sustainable pig production.

In general, the purpose of every manager is to maximise the profitability of the business. In this respect, the relationship between technical efficiency and profitability needs additional research, because of the many factors that influence the production, not only the inputs-outputs relationship. Therefore, it is important that the situation of the country is to be known as to where farms are producing, the market where the products are sold, cooperates and the competition. Otherwise, pig production is a profitable sector but it is highly limited with high costs of production. The most expensive input is feed, which is the most important input as well. Indeed, farmers should use cost reduction strategy and because they cannot influence feed price, the best thing is to analyse the possibility for lower consumption of feed without reducing pigs' weight and quality.

Limitations of the study and method

The study includes a certain number of farms in the analysis which do not allow globalization of finding for estimating the efficiency of pig farms in the whole country. The results explain technical efficiency of sample farms, under the assumption that the other farms in the country are faced with the similar production conditions and have the same technical efficiency.

The method applied does not recommend utilization of zero values due to the appearance of measurement errors that could cause problems for analysing the data. This challenge has been solved by making aggregation of inputs and outputs used in the analysis by summing the same measurement units in one input or one output.

According to the research, if the study consists of few observations with many outputs the estimates would result with bigger efficiency scores, while using a lot of samples may decrease the efficiency score. However, there are studies that use even 10 samples in measuring technical efficiency, so a population of 21 has been considered as an acceptable value considering the high data collecting costs. Otherwise, the sample should include at least three inputs in the analysis to avoid any problems, which has also been observed in this study.

While estimating technical efficiency, inputs and outputs are limited in the utilization quantities in order to face production efficiency, but the reduction of one input would not cause efficiency if the other inputs were used inefficiently. Thus, one farm would produce on the frontier only if it increased the efficiency of all inputs and outputs.

Moreover, the study does not include prices of inputs and output and as a result does not analyse the productivity of farms. Even if productivity is much interesting for farmers, it is a subject of analysis of allocative efficiency.

DEA takes into account only measurable inputs and outputs of production. But the production depends on other issues as well. In that respect, second stage variables have not been estimated by DEA, even if they have a certain influence on the production efficiency. Measurements of second stage variables should be provided by another programme in order to be compared with the first stage analysis.

Further research

Efficiency of a farm is a broad area, affected by many aspects and each of them can be considered separately with a more detailed analysis in the field. In relation to this, the study allows further research in measuring efficiency from many characteristics that would give different results and pictures of farm activities in the country.

One possibility is to measure the efficiency by including all pig farms in the country. Also, efficiency of pig farms can be compared to the efficiency of pig farms in the neighbouring and other foreign countries. The other possibility is to have a longer period of time, for example three years period gives relevant analysis and information of the efficiency.

Otherwise, the efficiency should be analysed with some other programme that would complement with DEA in those parts that DEA does not include in the analysis. Hence, the technical efficiency can be estimated by including other programs to measure the efficiency of environmental variables and decision maker factors and together with DEA to find the results of the whole technical efficiency of farms.

The other research may focus on the efficient utilization of inputs considering their prices, which is the field of analysis of allocative efficiency. Here, farmers would be able to choose an optimal level of inputs and outputs in order to undertake activities for cost minimisation and profit maximisation, because it seems more interesting for farmers to find out how much they should reduce of their costs in order to have profitable production. The constraint here is the willingness of farmers to give the real prices of inputs and outputs and detailed evidence of production for the research purposes.

Finally, a further research may focus on the other fields of agriculture, not only the pig production sector and to compare this sector results with the efficiency of other farms.

Concluding remarks

It is the first study in analysing pig production technical efficiency in the Republic of Macedonia and general application of DEA method. Therefore, it is an advantage to make a research in the new area of one country, but on the other hand, it has been difficult to collect data needed for the research purposes.

The method applied in the study allows analysing the best farms from a population and comparison of their technical efficiency with the other farms included in the analysis. Also, the analysis has been provided on a sample of different categories of farms which allow information of technical efficiency respectively by big, medium and small farms in the sample.

The analysis methods are provided under the assumption that not all farms are producing under the same conditions. They provide different research for each farm considering that they are working under an imperfect environment.

A good thing is that DEA allows different measurement units to be included in the analysis. As nonparametric method it does not need the same values for analysing technical efficiency. Also, technical efficiency is analysed only by applying the quantities of inputs and outputs, while the prices are not considered here. Also, the method does not provide a standard error that depends on the number of farms included in the analysis.

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Personal messages

Vukovik, Vlado
Professor, Faculty of agriculture and food, Skopje
Personal meeting, 2011-06-27

Eftim Saklev
President, Association of farmers, Skopje
Personal meeting, 2011-07-15

Svetlana Petrovska
Manager, CeProSARD, Skopje
Personal meeting, 2011-10-20

Farm B5,
Interview, 2011-07-15

Farm M2,
Interview, 2011-09-25

Farm M4,
Interview, 2011-09-27

Farm M10,
Interview, 2011-07-07

Farm M11,
Interview, 2011-07-07

Farm S1,
Interview, 2011-09-30

Farm S3,
Interview, 2011-08-29

Appendixes

Appendix 1: Questionnaire used for data collecting

Questionnaire for pig farms input-output activities

Data collection for year 2010

Basic questions for the farm

1 Name of the farm ______________________ Year of establishing: [ ]
2 Address and location: ______________________
3 Legal form: a. Individual agricultural producer b. LLC c. Other: __________
4 Distance to closest town/big market [ ] km, to place: __________
5 Road infrastructure and accessibility: __________
6 Total area of the farm with the commercial yard (ha)? [ ] Objects area? [ ]
7 Land ownership? Annual costs for renting the land
a. Private b. Under concession c. Rental [ ]

Questions for the farm manager

8 Is the manager an owner of the farm? a. Yes b. No
9 Year of birth of the manager: [ ] year
10 Education of the manager? a. Faculty b. Upper c. High school d. Primary school
11 Participation in the trainings, seminars and conferences? a. Yes b. No
If it is yes: a. In the country b. In the foreign countries
a. Often (Few times per year) b. Rarely (Ones per year) c. Not in the last 3 years
12 Participation in a producers cooperation? a. Yes b. No
13 Additional information for production (innovation)?
a. Communication with other farmers b. Newspapers, media, internet c. Professional literature
14 Usually, how do you make decisions for the farm?
a. Experience and intuition b. Analysis and estimation c. Both
15 Do you use suggestions? a. Yes b. No
If it is yes:
a. From private consultants b. From the firms that you collaborate with c. Both
16 Previous employment in another pig farm? a. Yes b. No
17 How long do you work in this field? [ ] years

Questions about the output and realized revenues

18

Output	Weight (kg)	Quantity sold	Price per 1kg MKD	Domestic/foreign market	Total revenues for 2010 in MKD
				D / F	
				D / F	
				D / F	

19 Output used for own needs:

Output	Weight (kg)	Total quantity of output used for own needs for 2010

Questions for inputs used in production

20 Does the farm have a web page? a. Yes b. No

21 Does the farm provide bookiping? a. Yes b. No

22 Technology of breeding? a. New (after 2000) b. Old (before 2000) c. Combination

23 Farm type: a. Breeding b. Production c. Both

24 Projected capacity of the farm (annual number of pigs and fattening pigs per sow) ______

25 The current capacity of the farm (for 2010) ______

26

Number of pigs	for 2010	Average value per head	Mortality (%)
Piglets up to 8kg			
Piglets from 8 to 25kg			
Fattening pigs (25-110kg)			
Gilts			
Sows			
Male pigs			

Questions for costs of production (for 2010)

Feed

27

Type	Bought/Own product	Quantity	Price MKD
	B / O		
	B / O		
	B / O		

Labour

28

Workers	Number of workers for 2010 year (1 worker/8h working time)	Monthly engage (per worker)	Total costs for salary MKD
Family members			
Total paid workers			

Energy

29 Does the farm use: a. Cooling b. Heating c. Ventilation

30 Does the farm use renewable sources of energy?

a. Yes, and those are: ______

b. No Interest for implementation: a. Yes b. No

31

Utilized energy on the farm for 2010			
Type	**KW/h**	**Price MKD**	**Total utilization in MKD**
Electricity			
Wood			
Oil for household			
Other			

32

Water	Quantity	Price MKD	Total used in MKD
Plumbing water			
Technical water			

Other costs

33

Other costs	Total costs in MKD
Costs for veterinary and medicine	
Insemination doses and insemination	
Hygiene and disinfection costs	
Disposal of manures and ecology costs	
Transport costs	
Insurance costs	
Other costs	

Appendix 2: Letter of data collection

РЕПУБЛИКА МАКЕДОНИЈА
УНИВЕРЗИТЕТ Св. КИРИЛ И МЕТОДИЈ - СКОПЈЕ
ФАКУЛТЕТ ЗА ЗЕМЈОДЕЛСКИ НАУКИ И ХРАНА

REPUBLIC OF MACEDONIA
UNIVERSITY St's CYRIL AND METHODIUS - SKOPJE
FACULTY OF AGRICULTURAL SCIENCES AND FOOD

До

____

____

Предмет: Барање за доставување на податоци

Почитувани,

Ве известуваме дека дипл.зем.инж. Марина Петровска е во тек на изработка на својата магистерска теза под наслов **“Ефикасност на производство на свињарски фарми во Република Македонија” – по пристап на програмот *Data Envelopment Analysis*,** пријавена на Факултетот за земјоделски науки и храна во Скопје, Македонија и Универзитет за земјоделство во Упсала, Шведска.

За остварување на целите на тезата и анализа на работењето на свињарските фарми во Република Македонија потребни се податоци за влезните инпути на производство и излезните производи на секоја свињарска фарма поединечно за 2010 година.

Во таа насока, Ве замолуваме да ѝ излезете во пресрет на нашата колешка и да ѝ овозможите достап до соодветните податоци. **Податоците ќе бидат обработени анонимно и ќе се користат исклучиво за истражувачки цели.**

Со почит,

Декан,

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Appendix 3: Managerial skills and activities

Descriptive characteristics of managers						
Farm code	Education and ability	Participation on seminars, trainings and conferences	Making decisions	Advices and consultations	Participation in agricultural associations	Additional information for news and innovations
B1	higher education, ability to identify new market opportunities	occasionally, usually in the foreign countries	by using analysis and estimation	working with private consultants	no active participation	use professional literature
B2	higher education, managerial skills	sometimes if they are organised in the country	use both, analysis and intuition	working with private consultants and cooperation partners	no need to participate, there are more decision makers	communication with other farmers, professional literature
B3	higher education, managerial skills	occasionally, only in the country	use both, analysis and intuition	working with private consultants and cooperation partners	no need to participate, there are more decision makers	communication with other farmers, professional literature
B4	big experience and managerial skills	if there is an opportunity in the native and foreign countries	use both, analysis and intuition	working with private consultants	no need to participate, the farm is working as cooperative	communication and consultation, mediums and professional literature
B5	higher education, managerial skills, professional experience	occasionally, only in the country	by using analysis and estimation	working with private consultants and cooperation partners	no need to participate, there are more decision makers	communication with other farmers, professional literature
B6	higher education, managerial skills, big experience	occasionally, only in the country	use both, analysis and intuition	working with private consultants and cooperation partners	no need to participate, there are more decision makers	communication and consultation with other farmers and neighbours
B7	no experience in the field, but has good managerial skills	occasionally, only in the country	by using analysis and estimation	working with private consultants	no active participation	communication and consultation with other farmers and neighbours

M1	education in the field of agriculture	often when they are organised in the country	by using analysis and estimation	working with private consultants	not believe that participation would help in better farming	use professional literature
M2	professional knowledge, managerial skills	in the native and foreign countries	experience and intuition	private consultations and cooperation with other firms	no, the participation is not important	communication and consultation, mediums and professional literature
M3	higher education of agricultural sciences	yes, usually in the country	use both, analysis and intuition	working with private consultants	yes, in one association	communication and consultation, mediums and professional literature
M4	education in the field of agriculture	rarely, if there are in the country	use both, analysis and intuition	working with private consultants	yes, in one association	communication and consultation, mediums and professional literature
M5	education in the field of agriculture	rarely, if there are in the country	use both, analysis and intuition	private consultations and cooperation with other firms	yes, in one association	communication and consultation, mediums and professional literature
M6	big experience from many farms, managerial skills	yes, usually in the country	use both, analysis and intuition	working with private consultants	do not find this activity useful	by using mediums and professional literature
M7	professional veterinary	sometimes in the country but mostly in the foreign countries	use both, analysis and intuition	private consultations and cooperation with other firms	does not show interest for participation	communication and consultation, mediums and professional literature
M8	knowledge in the field of agriculture	in the past, usually in the country	use both, analysis and intuition	do not believe in other persons	yes, but have more activities in the past	communication with other farmers, professional literature
M9	education of agriculture, managerial skills	of course, in the native and foreign countries, sometimes initiated and organiser	use both, analysis and intuition	consultation with suppliers	the manager of one association	communication and consultation, mediums and professional literature

M10	higher education and veterinary studies	yes, usually in the country and in the field of veterinary	use both, analysis and intuition	private consultations and cooperation with other firms	have no time for participation	communication with other farmers, professional literature
M11	in the field of agriculture	do not believe that that would bring any benefits	experience and intuition	private consultations and cooperation with other firms	no and do not want to	communication and consultation with other farmers and neighbours
S1	professional veterinary	I used to go, in the country	by using analysis and estimation	working with private consultants	used to participate when the association exist	by communication and consultation, mediums and professional literature
S2	education in the field	sometimes, in the country	experience and intuition	private consultations and cooperation with other firms	yes, in one association	by communication and consultation, mediums and professional literature
S3	knowledge on various areas of agriculture	sometimes, in the country	experience and intuition	consultation with suppliers	used to participate in the past	communication with other farmers, professional literature

Source: Analysis according to the empirical findings

Appendix 4: Results from input oriented CRS perspective

Results from DEAP Version 2.1

Input orientated DEA
Scale assumption: CRS
Slacks calculated using multi-stage method

EFFICIENCY SUMMARY:

firm	te
1	0.897
2	0.850
3	0.620
4	0.814
5	0.683
6	1.000
7	0.524
8	1.000
9	1.000
10	0.927
11	0.760
12	1.000
13	0.372
14	0.660
15	0.948
16	0.870
17	0.420
18	0.583
19	1.000
20	0.371
21	0.626
mean	**0.758**

FIRM BY FIRM RESULTS:

Results for firm: 1
Technical efficiency = 0.897
PROJECTION SUMMARY:

variable		original value	radial movement	slack movement	projected value
output	1	3000000.000	0.000	0.000	3000000.000
input	1	10000000.000	-1025641.026	-1412475.641	7561883.333
input	2	65.000	-6.667	0.000	58.333
input	3	100238975.000	-10280920.513	-72209304.487	17748750.000

LISTING OF PEERS:

peer	lambda weight
8	8.333

Results for firm: 2
Technical efficiency = 0.850
PROJECTION SUMMARY:

variable		original value	radial movement	slack movement	projected value
output	1	2184760.000	0.000	0.000	2184760.000
input	1	8675240.000	-1304505.478	-1863767.778	5506966.744
input	2	50.000	-7.519	0.000	42.481
input	3	102007264.000	-15338945.629	-73742732.021	12925586.350

LISTING OF PEERS:

peer	lambda weight
8	6.069

Results for firm: 3
Technical efficiency = 0.620
PROJECTION SUMMARY:

variable		original value	radial movement	slack movement	projected value
output	1	1302883.000	0.000	0.000	1302883.000
input	1	5298410.000	-2014326.919	0.000	3284083.081
input	2	48.000	-18.248	-4.418	25.334
input	3	47925062.000	-18219945.697	-21996934.754	7708181.549

LISTING OF PEERS:

peer	lambda weight
8	3.619

Results for firm: 4
Technical efficiency = 0.814
PROJECTION SUMMARY:

```
  variable           original         radial          slack     projected
                        value       movement       movement         value
 output     1     1800000.000          0.000          0.000   1800000.000
 input      1     7200000.000   -1339534.884   -1323335.116   4537130.000
 input      2          43.000         -8.000          0.000        35.000
 input      3    49058994.000   -9127254.698  -29282489.302  10649250.000
 LISTING OF PEERS:
  peer   lambda weight
    8      5.000
Results for firm:     5
Technical efficiency = 0.683
 PROJECTION SUMMARY:
  variable           original         radial          slack     projected
                        value       movement       movement         value
 output     1     1300185.000          0.000          0.000   1300185.000
 input      1     4798200.000   -1519683.959      -1233.614   3277282.427
 input      2          37.000        -11.719          0.000        25.281
 input      3    68453485.000  -21680560.018  -39080705.476   7692219.506
 LISTING OF PEERS:
  peer   lambda weight
    8      3.612
Results for firm:     6
Technical efficiency = 1.000
 PROJECTION SUMMARY:
  variable           original         radial          slack     projected
                        value       movement       movement         value
 output     1     1348613.000          0.000          0.000   1348613.000
 input      1     5195400.000          0.000          0.000   5195400.000
 input      2          34.000          0.000          0.000        34.000
 input      3     6628940.000          0.000          0.000   6628940.000
 LISTING OF PEERS:
  peer   lambda weight
    6      1.000
Results for firm:     7
Technical efficiency = 0.524
 PROJECTION SUMMARY:
  variable           original         radial          slack     projected
                        value       movement       movement         value
 output     1      463771.000          0.000          0.000    463771.000
 input      1     2230474.000   -1061479.935          0.000   1168994.065
 input      2          20.000         -9.518         -1.464         9.018
 input      3     5736908.000   -2730187.723    -262935.099   2743785.179
 LISTING OF PEERS:
  peer   lambda weight
    8      1.288
Results for firm:     8
Technical efficiency = 1.000
 PROJECTION SUMMARY:
  variable           original         radial          slack     projected
                        value       movement       movement         value
 output     1      360000.000          0.000          0.000    360000.000
 input      1      907426.000          0.000          0.000    907426.000
 input      2           7.000          0.000          0.000         7.000
 input      3     2129850.000          0.000          0.000   2129850.000
 LISTING OF PEERS:
  peer   lambda weight
    8      1.000
Results for firm:     9
Technical efficiency = 1.000
 PROJECTION SUMMARY:
  variable           original         radial          slack     projected
                        value       movement       movement         value
 output     1      250000.000          0.000          0.000    250000.000
 input      1      650000.000          0.000          0.000    650000.000
 input      2           6.000          0.000          0.000         6.000
 input      3     1423656.000          0.000          0.000   1423656.000
 LISTING OF PEERS:
  peer   lambda weight
    9      1.000
Results for firm:    10
Technical efficiency = 0.927
 PROJECTION SUMMARY:
  variable           original         radial          slack     projected
                        value       movement       movement         value
 output     1      164000.000          0.000          0.000    164000.000
 input      1      600000.000     -43880.911          0.000    556119.089
```

```
 input      2           6.000        -0.439         0.000         5.561
 input      3      916560.000    -67032.479         0.000    849527.521
 LISTING OF PEERS:
  peer   lambda weight
    6      0.051
   19      0.352
    9      0.287
```

Results for firm: 11

```
Technical efficiency = 0.760
 PROJECTION SUMMARY:
  variable           original        radial         slack     projected
                        value      movement      movement         value
 output     1      190000.000         0.000         0.000    190000.000
 input      1     1500000.000   -359350.595   -611586.597    529062.809
 input      2           5.000        -1.198         0.000         3.802
 input      3     1432080.000   -343079.200         0.000   1089000.800
 LISTING OF PEERS:
  peer   lambda weight
   12      0.228
    8      0.445
```

Results for firm: 12

```
Technical efficiency = 1.000
 PROJECTION SUMMARY:
  variable           original        radial         slack     projected
                        value      movement      movement         value
 output     1      130000.000         0.000         0.000    130000.000
 input      1      547500.000         0.000         0.000    547500.000
 input      2           3.000         0.000         0.000         3.000
 input      3      615300.000         0.000         0.000    615300.000
 LISTING OF PEERS:
  peer   lambda weight
   12      1.000
```

Results for firm: 13

```
Technical efficiency = 0.372
 PROJECTION SUMMARY:
  variable           original        radial         slack     projected
                        value      movement      movement         value
 output     1       23640.000         0.000         0.000     23640.000
 input      1      160000.000   -100412.359         0.000     59587.641
 input      2           2.000        -1.255        -0.285         0.460
 input      3      900272.000   -564990.222   -195421.628    139860.150
 LISTING OF PEERS:
  peer   lambda weight
    8      0.066
```

Results for firm: 14

```
Technical efficiency = 0.660
 PROJECTION SUMMARY:
  variable           original        radial         slack     projected
                        value      movement      movement         value
 output     1      100000.000         0.000         0.000    100000.000
 input      1      468000.000   -159113.156         0.000    308886.844
 input      2           4.000        -1.360         0.000         2.640
 input      3      816000.000   -277428.067         0.000    538571.933
 LISTING OF PEERS:
  peer   lambda weight
    6      0.026
   19      0.045
    9      0.250
```

Results for firm: 15

```
Technical efficiency = 0.948
 PROJECTION SUMMARY:
  variable           original        radial         slack     projected
                        value      movement      movement         value
 output     1       60000.000         0.000         0.000     60000.000
 input      1      220000.000    -11514.278         0.000    208485.722
 input      2           2.000        -0.105         0.000         1.895
 input      3      325040.000    -17011.823         0.000    308028.177
 LISTING OF PEERS:
  peer   lambda weight
   19      0.095
    6      0.024
    9      0.085
```

Results for firm: 16

```
Technical efficiency = 0.870
 PROJECTION SUMMARY:
  variable           original        radial         slack     projected
```

variable		original value	radial movement	slack movement	projected value
output	1	105440.000	0.000	0.000	105440.000
input	1	440000.000	-57005.554	0.000	382994.446
input	2	4.000	-0.518	0.000	3.482
input	3	609620.000	-78981.194	0.000	530638.806

LISTING OF PEERS:

peer	lambda weight
19	0.198
6	0.050
9	0.100

Results for firm: 17

Technical efficiency = 0.420

PROJECTION SUMMARY:

variable		original value	radial movement	slack movement	projected value
output	1	68430.000	0.000	0.000	68430.000
input	1	410326.000	-237839.441	0.000	172486.559
input	2	5.000	-2.898	-0.771	1.331
input	3	1075277.000	-623268.525	-47159.488	404848.987

LISTING OF PEERS:

peer	lambda weight
8	0.190

Results for firm: 18

Technical efficiency = 0.583

PROJECTION SUMMARY:

variable		original value	radial movement	slack movement	projected value
output	1	60000.000	0.000	0.000	60000.000
input	1	350877.000	-146198.750	-53440.583	151237.667
input	2	2.000	-0.833	0.000	1.167
input	3	800000.000	-333333.333	-111691.667	354975.000

LISTING OF PEERS:

peer	lambda weight
8	0.167

Results for firm: 19

Technical efficiency = 1.000

PROJECTION SUMMARY:

variable		original value	radial movement	slack movement	projected value
output	1	67300.000	0.000	0.000	67300.000
input	1	300000.000	0.000	0.000	300000.000
input	2	6.000	0.000	0.000	6.000
input	3	295000.000	0.000	0.000	295000.000

LISTING OF PEERS:

peer	lambda weight
19	1.000

Results for firm: 20

Technical efficiency = 0.371

PROJECTION SUMMARY:

variable		original value	radial movement	slack movement	projected value
output	1	30000.000	0.000	0.000	30000.000
input	1	286480.000	-180126.489	0.000	106353.511
input	2	2.000	-1.258	0.000	0.742
input	3	412881.000	-259602.083	0.000	153278.917

LISTING OF PEERS:

peer	lambda weight
6	0.015
9	0.032
12	0.015

Results for firm: 21

Technical efficiency = 0.626

PROJECTION SUMMARY:

variable		original value	radial movement	slack movement	projected value
output	1	14400.000	0.000	0.000	14400.000
input	1	58000.000	-21702.960	0.000	36297.040
input	2	3.000	-1.123	-1.597	0.280
input	3	151000.000	-56502.534	-9303.466	85194.000

LISTING OF PEERS:

peer	lambda weight
8	0.040

Appendix 5: Results from input oriented VRS perspective

```
Results from DEAP Version 2.1

Input orientated DEA
Scale assumption: VRS
Slacks calculated using multi-stage method

EFFICIENCY SUMMARY:
  firm  crste  vrste  scale
    1  0.897  1.000  0.897 drs
    2  0.850  0.942  0.902 drs
    3  0.620  0.784  0.790 drs
    4  0.814  0.936  0.870 drs
    5  0.683  0.864  0.791 drs
    6  1.000  1.000  1.000  -
    7  0.524  0.598  0.876 drs
    8  1.000  1.000  1.000  -
    9  1.000  1.000  1.000  -
   10  0.927  0.928  0.999 irs
   11  0.760  0.809  0.940 irs
   12  1.000  1.000  1.000  -
   13  0.372  1.000  0.372 irs
   14  0.660  0.681  0.969 irs
   15  0.948  1.000  0.948 irs
   16  0.870  0.882  0.986 irs
   17  0.420  0.539  0.780 irs
   18  0.583  1.000  0.583 irs
   19  1.000  1.000  1.000  -
   20  0.371  1.000  0.371 irs
   21  0.626  1.000  0.626 irs
 mean  0.758  0.903  0.843

FIRM BY FIRM RESULTS:
Results for firm:     1
Technical efficiency = 1.000
Scale efficiency     = 0.897  (drs)
 PROJECTION SUMMARY:
  variable           original        radial         slack     projected
                        value      movement      movement         value
 output     1     3000000.000         0.000         0.000   3000000.000
 input      1    10000000.000         0.000         0.000  10000000.000
 input      2          65.000         0.000         0.000        65.000
 input      3   100238975.000         0.000         0.000 100238975.000
 LISTING OF PEERS:
  peer   lambda weight
    1      1.000
Results for firm:     2
Technical efficiency = 0.942
Scale efficiency     = 0.902  (drs)
 PROJECTION SUMMARY:
  variable           original        radial         slack     projected
                        value      movement      movement         value
 output     1     2184760.000         0.000         0.000   2184760.000
 input      1     8675240.000   -504998.865   -978055.540   7192185.596
 input      2          50.000        -2.911         0.000        47.089
 input      3   102007264.000  -5937997.394 -26126686.706  69942579.900
 LISTING OF PEERS:
  peer   lambda weight
    1      0.691
    8      0.309
Results for firm:     3
Technical efficiency = 0.784
Scale efficiency     = 0.790  (drs)
 PROJECTION SUMMARY:
  variable           original        radial         slack     projected
                        value      movement      movement         value
 output     1     1302883.000         0.000         0.000   1302883.000
 input      1     5298410.000  -1143547.087         0.000   4154862.913
 input      2          48.000       -10.360        -9.925        27.715
 input      3    47925062.000 -10343587.045   -411690.823  37169784.132
 LISTING OF PEERS:
  peer   lambda weight
    8      0.643
```

1 0.357

Results for firm: 4

Technical efficiency = 0.936
Scale efficiency = 0.870 (drs)

PROJECTION SUMMARY:

variable		original value	radial movement	slack movement	projected value
output	1	1800000.000	0.000	0.000	1800000.000
input	1	7200000.000	-463463.220	-602676.161	6133860.619
input	2	43.000	-2.768	0.000	40.232
input	3	49058994.000	-3157922.127	0.000	45901071.873

LISTING OF PEERS:

peer	lambda weight
8	0.266
1	0.432
6	0.302

Results for firm: 5

Technical efficiency = 0.864
Scale efficiency = 0.791 (drs)

PROJECTION SUMMARY:

variable		original value	radial movement	slack movement	projected value
output	1	1300185.000	0.000	0.000	1300185.000
input	1	4798200.000	-652629.422	0.000	4145570.578
input	2	37.000	-5.033	-4.312	27.656
input	3	68453485.000	-9310732.846	-22073232.575	37069519.579

LISTING OF PEERS:

peer	lambda weight
8	0.644
1	0.356

Results for firm: 6

Technical efficiency = 1.000
Scale efficiency = 1.000 (crs)

PROJECTION SUMMARY:

variable		original value	radial movement	slack movement	projected value
output	1	1348613.000	0.000	0.000	1348613.000
input	1	5195400.000	0.000	0.000	5195400.000
input	2	34.000	0.000	0.000	34.000
input	3	6628940.000	0.000	0.000	6628940.000

LISTING OF PEERS:

peer	lambda weight
6	1.000

Results for firm: 7

Technical efficiency = 0.598
Scale efficiency = 0.876 (drs)

PROJECTION SUMMARY:

variable		original value	radial movement	slack movement	projected value
output	1	463771.000	0.000	0.000	463771.000
input	1	2230474.000	-895715.168	0.000	1334758.832
input	2	20.000	-8.032	-2.270	9.698
input	3	5736908.000	-2303831.166	0.000	3433076.834

LISTING OF PEERS:

peer	lambda weight
6	0.079
1	0.010
8	0.911

Results for firm: 8

Technical efficiency = 1.000
Scale efficiency = 1.000 (crs)

PROJECTION SUMMARY:

variable		original value	radial movement	slack movement	projected value
output	1	360000.000	0.000	0.000	360000.000
input	1	907426.000	0.000	0.000	907426.000
input	2	7.000	0.000	0.000	7.000
input	3	2129850.000	0.000	0.000	2129850.000

LISTING OF PEERS:

peer	lambda weight
8	1.000

Results for firm: 9

Technical efficiency = 1.000
Scale efficiency = 1.000 (crs)

PROJECTION SUMMARY:

variable	original	radial	slack	projected

```
                       value      movement      movement         value
 output     1      250000.000         0.000         0.000    250000.000
 input      1      650000.000         0.000         0.000    650000.000
 input      2           6.000         0.000         0.000         6.000
 input      3     1423656.000         0.000         0.000   1423656.000
 LISTING OF PEERS:
  peer   lambda weight
    9      1.000
```

Results for firm: 10

```
Technical efficiency = 0.928
Scale efficiency     = 0.999  (irs)
 PROJECTION SUMMARY:
  variable           original        radial         slack     projected
                        value      movement      movement         value
 output     1      164000.000         0.000         0.000    164000.000
 input      1      600000.000    -43291.544         0.000    556708.456
 input      2           6.000        -0.433         0.000         5.567
 input      3      916560.000    -66132.163         0.000    850427.837
 LISTING OF PEERS:
  peer   lambda weight
    9      0.330
    6      0.015
   19      0.374
   12      0.281
```

Results for firm: 11

```
Technical efficiency = 0.809
Scale efficiency     = 0.940  (irs)
 PROJECTION SUMMARY:
  variable           original        radial         slack     projected
                        value      movement      movement         value
 output     1      190000.000         0.000         0.000    190000.000
 input      1     1500000.000   -286956.522   -571649.739    641393.739
 input      2           5.000        -0.957         0.000         4.043
 input      3     1432080.000   -273963.130   -147716.870   1010400.000
 LISTING OF PEERS:
  peer   lambda weight
    8      0.261
   12      0.739
```

Results for firm: 12

```
Technical efficiency = 1.000
Scale efficiency     = 1.000  (crs)
 PROJECTION SUMMARY:
  variable           original        radial         slack     projected
                        value      movement      movement         value
 output     1      130000.000         0.000         0.000    130000.000
 input      1      547500.000         0.000         0.000    547500.000
 input      2           3.000         0.000         0.000         3.000
 input      3      615300.000         0.000         0.000    615300.000
 LISTING OF PEERS:
  peer   lambda weight
   12      1.000
```

Results for firm: 13

```
Technical efficiency = 1.000
Scale efficiency     = 0.372  (irs)
 PROJECTION SUMMARY:
  variable           original        radial         slack     projected
                        value      movement      movement         value
 output     1       23640.000         0.000         0.000     23640.000
 input      1      160000.000         0.000         0.000    160000.000
 input      2           2.000         0.000         0.000         2.000
 input      3      900272.000         0.000         0.000    900272.000
 LISTING OF PEERS:
  peer   lambda weight
   13      1.000
```

Results for firm: 14

```
Technical efficiency = 0.681
Scale efficiency     = 0.969  (irs)
 PROJECTION SUMMARY:
  variable           original        radial         slack     projected
                        value      movement      movement         value
 output     1      100000.000         0.000         0.000    100000.000
 input      1      468000.000   -149070.969         0.000    318929.031
 input      2           4.000        -1.274         0.000         2.726
 input      3      816000.000   -259918.613         0.000    556081.387
 LISTING OF PEERS:
  peer   lambda weight
```

12	0.046
9	0.080
8	0.072
15	0.802

Results for firm: 15

Technical efficiency = 1.000

Scale efficiency = 0.948 (irs)

PROJECTION SUMMARY:

variable		original value	radial movement	slack movement	projected value
output	1	60000.000	0.000	0.000	60000.000
input	1	220000.000	0.000	0.000	220000.000
input	2	2.000	0.000	0.000	2.000
input	3	325040.000	0.000	0.000	325040.000

LISTING OF PEERS:

peer	lambda weight
15	1.000

Results for firm: 16

Technical efficiency = 0.882

Scale efficiency = 0.986 (irs)

PROJECTION SUMMARY:

variable		original value	radial movement	slack movement	projected value
output	1	105440.000	0.000	0.000	105440.000
input	1	440000.000	-51717.945	0.000	388282.055
input	2	4.000	-0.470	0.000	3.530
input	3	609620.000	-71655.213	0.000	537964.787

LISTING OF PEERS:

peer	lambda weight
12	0.316
19	0.188
9	0.115
15	0.380

Results for firm: 17

Technical efficiency = 0.539

Scale efficiency = 0.780 (irs)

PROJECTION SUMMARY:

variable		original value	radial movement	slack movement	projected value
output	1	68430.000	0.000	0.000	68430.000
input	1	410326.000	-189137.652	0.000	221188.348
input	2	5.000	-2.305	0.000	2.695
input	3	1075277.000	-495643.385	-172265.337	407368.278

LISTING OF PEERS:

peer	lambda weight
15	0.609
8	0.076
21	0.315

Results for firm: 18

Technical efficiency = 1.000

Scale efficiency = 0.583 (irs)

PROJECTION SUMMARY:

variable		original value	radial movement	slack movement	projected value
output	1	60000.000	0.000	0.000	60000.000
input	1	350877.000	0.000	-130877.000	220000.000
input	2	2.000	0.000	0.000	2.000
input	3	800000.000	0.000	-474960.000	325040.000

LISTING OF PEERS:

peer	lambda weight
15	1.000

Results for firm: 19

Technical efficiency = 1.000

Scale efficiency = 1.000 (crs)

PROJECTION SUMMARY:

variable		original value	radial movement	slack movement	projected value
output	1	67300.000	0.000	0.000	67300.000
input	1	300000.000	0.000	0.000	300000.000
input	2	6.000	0.000	0.000	6.000
input	3	295000.000	0.000	0.000	295000.000

LISTING OF PEERS:

peer	lambda weight
19	1.000

Results for firm: 20

Technical efficiency = 1.000

```
Scale efficiency     = 0.371  (irs)
 PROJECTION SUMMARY:
  variable           original        radial         slack     projected
                        value      movement      movement         value
 output     1       30000.000         0.000     30000.000     60000.000
 input      1      286480.000         0.000    -66480.000    220000.000
 input      2           2.000         0.000         0.000         2.000
 input      3      412881.000         0.000    -87841.000    325040.000
 LISTING OF PEERS:
  peer   lambda weight
   15      1.000
```
Results for firm: 21
```
Technical efficiency = 1.000
Scale efficiency     = 0.626  (irs)
 PROJECTION SUMMARY:
  variable           original        radial         slack     projected
                        value      movement      movement         value
 output     1       14400.000         0.000         0.000     14400.000
 input      1       58000.000         0.000         0.000     58000.000
 input      2           3.000         0.000         0.000         3.000
 input      3      151000.000         0.000         0.000    151000.000
 LISTING OF PEERS:
  peer   lambda weight
   21      1.000
```

Appendix 5: Results from output oriented CRS perspective

```
Results from DEAP Version 2.1

Output orientated DEA
Scale assumption: CRS
Slacks calculated using multi-stage method

EFFICIENCY SUMMARY:
  firm     te
    1  0.897
    2  0.850
    3  0.620
    4  0.814
    5  0.683
    6  1.000
    7  0.524
    8  1.000
    9  1.000
   10  0.927
   11  0.760
   12  1.000
   13  0.372
   14  0.660
   15  0.948
   16  0.870
   17  0.420
   18  0.583
   19  1.000
   20  0.371
   21  0.626
 mean  0.758

FIRM BY FIRM RESULTS:
Results for firm:     1
Technical efficiency = 0.897
 PROJECTION SUMMARY:
  variable           original        radial         slack     projected
                        value      movement      movement         value
 output     1     3000000.000    342857.143         0.000   3342857.143
 input      1    10000000.000         0.000  -1573901.429   8426098.571
 input      2          65.000         0.000         0.000        65.000
 input      3   100238975.000         0.000 -80461796.429  19777178.571
 LISTING OF PEERS:
  peer   lambda weight
    8      9.286
Results for firm:     2
Technical efficiency = 0.850
 PROJECTION SUMMARY:
  variable           original        radial         slack     projected
                        value      movement      movement         value
 output     1     2184760.000    386668.571         0.000   2571428.571
 input      1     8675240.000         0.000  -2193625.714   6481614.286
 input      2          50.000         0.000         0.000        50.000
 input      3   102007264.000         0.000 -86794049.714  15213214.286
 LISTING OF PEERS:
  peer   lambda weight
    8      7.143
Results for firm:     3
Technical efficiency = 0.620
 PROJECTION SUMMARY:
  variable           original        radial         slack     projected
                        value      movement      movement         value
 output     1     1302883.000    799136.999         0.000   2102019.999
 input      1     5298410.000         0.000         0.000   5298410.000
 input      2          48.000         0.000        -7.127        40.873
 input      3    47925062.000         0.000 -35488986.178  12436075.822
 LISTING OF PEERS:
  peer   lambda weight
    8      5.839
Results for firm:     4
Technical efficiency = 0.814
 PROJECTION SUMMARY:
  variable           original        radial         slack     projected
```

variable		original value	radial movement	slack movement	projected value
output	1	1800000.000	411428.571	0.000	2211428.571
input	1	7200000.000	0.000	-1625811.714	5574188.286
input	2	43.000	0.000	0.000	43.000
input	3	49058994.000	0.000	-35975629.714	13083364.286

LISTING OF PEERS:

peer	lambda weight
8	6.143

Results for firm: 5

Technical efficiency = 0.683

PROJECTION SUMMARY:

variable		original value	radial movement	slack movement	projected value
output	1	1300185.000	602672.143	0.000	1902857.143
input	1	4798200.000	0.000	-1805.429	4796394.571
input	2	37.000	0.000	0.000	37.000
input	3	68453485.000	0.000	-57195706.429	11257778.571

LISTING OF PEERS:

peer	lambda weight
8	5.286

Results for firm: 6

Technical efficiency = 1.000

PROJECTION SUMMARY:

variable		original value	radial movement	slack movement	projected value
output	1	1348613.000	0.000	0.000	1348613.000
input	1	5195400.000	0.000	0.000	5195400.000
input	2	34.000	0.000	0.000	34.000
input	3	6628940.000	0.000	0.000	6628940.000

LISTING OF PEERS:

peer	lambda weight
6	1.000

Results for firm: 7

Technical efficiency = 0.524

PROJECTION SUMMARY:

variable		original value	radial movement	slack movement	projected value
output	1	463771.000	421117.288	0.000	884888.288
input	1	2230474.000	0.000	0.000	2230474.000
input	2	20.000	0.000	-2.794	17.206
input	3	5736908.000	0.000	-501687.664	5235220.336

LISTING OF PEERS:

peer	lambda weight
8	2.458

Results for firm: 8

Technical efficiency = 1.000

PROJECTION SUMMARY:

variable		original value	radial movement	slack movement	projected value
output	1	360000.000	0.000	0.000	360000.000
input	1	907426.000	0.000	0.000	907426.000
input	2	7.000	0.000	0.000	7.000
input	3	2129850.000	0.000	0.000	2129850.000

LISTING OF PEERS:

peer	lambda weight
8	1.000

Results for firm: 9

Technical efficiency = 1.000

PROJECTION SUMMARY:

variable		original value	radial movement	slack movement	projected value
output	1	250000.000	0.000	0.000	250000.000
input	1	650000.000	0.000	0.000	650000.000
input	2	6.000	0.000	0.000	6.000
input	3	1423656.000	0.000	0.000	1423656.000

LISTING OF PEERS:

peer	lambda weight
9	1.000

Results for firm: 10

Technical efficiency = 0.927

PROJECTION SUMMARY:

variable		original value	radial movement	slack movement	projected value
output	1	164000.000	12940.519	0.000	176940.519
input	1	600000.000	0.000	0.000	600000.000
input	2	6.000	0.000	0.000	6.000

```
 input      3      916560.000         0.000         0.000    916560.000
 LISTING OF PEERS:
  peer   lambda weight
   19      0.379
    6      0.055
    9      0.310
Results for firm:    11
Technical efficiency = 0.760
 PROJECTION SUMMARY:
  variable            original        radial         slack     projected
                         value      movement      movement         value
 output     1      190000.000     59857.668         0.000    249857.668
 input      1     1500000.000         0.000   -804261.056    695738.944
 input      2           5.000         0.000         0.000         5.000
 input      3     1432080.000         0.000         0.000   1432080.000
 LISTING OF PEERS:
  peer   lambda weight
   12      0.300
    8      0.586
Results for firm:    12
Technical efficiency = 1.000
 PROJECTION SUMMARY:
  variable            original        radial         slack     projected
                         value      movement      movement         value
 output     1      130000.000         0.000         0.000    130000.000
 input      1      547500.000         0.000         0.000    547500.000
 input      2           3.000         0.000         0.000         3.000
 input      3      615300.000         0.000         0.000    615300.000
 LISTING OF PEERS:
  peer   lambda weight
   12      1.000
Results for firm:    13
Technical efficiency = 0.372
 PROJECTION SUMMARY:
  variable            original        radial         slack     projected
                         value      movement      movement         value
 output     1       23640.000     39836.250         0.000     63476.250
 input      1      160000.000         0.000         0.000    160000.000
 input      2           2.000         0.000        -0.766         1.234
 input      3      900272.000         0.000   -524730.634    375541.366
 LISTING OF PEERS:
  peer   lambda weight
    8      0.176
Results for firm:    14
Technical efficiency = 0.660
 PROJECTION SUMMARY:
  variable            original        radial         slack     projected
                         value      movement      movement         value
 output     1      100000.000     51511.795         0.000    151511.795
 input      1      468000.000         0.000         0.000    468000.000
 input      2           4.000         0.000         0.000         4.000
 input      3      816000.000         0.000         0.000    816000.000
 LISTING OF PEERS:
  peer   lambda weight
   19      0.069
    6      0.039
    9      0.378
 Results for firm:    15
Technical efficiency = 0.948
 PROJECTION SUMMARY:
  variable            original        radial         slack     projected
                         value      movement      movement         value
 output     1       60000.000      3313.688         0.000     63313.688
 input      1      220000.000         0.000         0.000    220000.000
 input      2           2.000         0.000         0.000         2.000
 input      3      325040.000         0.000         0.000    325040.000
 LISTING OF PEERS:
  peer   lambda weight
    6      0.025
   19      0.100
    9      0.089
Results for firm:    16
Technical efficiency = 0.870
 PROJECTION SUMMARY:
  variable            original        radial         slack     projected
                         value      movement      movement         value
```

output	1	105440.000	15693.871	0.000	121133.871
input	1	440000.000	0.000	0.000	440000.000
input	2	4.000	0.000	0.000	4.000
input	3	609620.000	0.000	0.000	609620.000

LISTING OF PEERS:

peer	lambda weight
6	0.057
19	0.228
9	0.115

Results for firm: 17

Technical efficiency = 0.420

PROJECTION SUMMARY:

variable		original value	radial movement	slack movement	projected value
output	1	68430.000	94357.225	0.000	162787.225
input	1	410326.000	0.000	0.000	410326.000
input	2	5.000	0.000	-1.835	3.165
input	3	1075277.000	0.000	-112187.083	963089.917

LISTING OF PEERS:

peer	lambda weight
8	0.452

Results for firm: 18

Technical efficiency = 0.583

PROJECTION SUMMARY:

variable		original value	radial movement	slack movement	projected value
output	1	60000.000	42857.143	0.000	102857.143
input	1	350877.000	0.000	-91612.429	259264.571
input	2	2.000	0.000	0.000	2.000
input	3	800000.000	0.000	-191471.429	608528.571

LISTING OF PEERS:

peer	lambda weight
8	0.286

Results for firm: 19

Technical efficiency = 1.000

PROJECTION SUMMARY:

variable		original value	radial movement	slack movement	projected value
output	1	67300.000	0.000	0.000	67300.000
input	1	300000.000	0.000	0.000	300000.000
input	2	6.000	0.000	0.000	6.000
input	3	295000.000	0.000	0.000	295000.000

LISTING OF PEERS:

peer	lambda weight
19	1.000

Results for firm: 20

Technical efficiency = 0.371

PROJECTION SUMMARY:

variable		original value	radial movement	slack movement	projected value
output	1	30000.000	50809.744	0.000	80809.744
input	1	286480.000	0.000	0.000	286480.000
input	2	2.000	0.000	0.000	2.000
input	3	412881.000	0.000	0.000	412881.000

LISTING OF PEERS:

peer	lambda weight
6	0.040
9	0.085
12	0.041

Results for firm: 21

Technical efficiency = 0.626

PROJECTION SUMMARY:

variable		original value	radial movement	slack movement	projected value
output	1	14400.000	8610.141	0.000	23010.141
input	1	58000.000	0.000	0.000	58000.000
input	2	3.000	0.000	-2.553	0.447
input	3	151000.000	0.000	-14866.255	136133.745

LISTING OF PEERS:

peer	lambda weight
8	0.064

Appendix 6: Results from output oriented VRS perspective

Results from DEAP Version 2.1

Output orientated DEA
Scale assumption: VRS
Slacks calculated using multi-stage method

EFFICIENCY SUMMARY:

firm	crste	vrste	scale	
1	0.897	1.000	0.897	drs
2	0.850	0.943	0.901	drs
3	0.620	0.802	0.773	drs
4	0.814	0.939	0.867	drs
5	0.683	0.873	0.783	drs
6	1.000	1.000	1.000	-
7	0.524	0.683	0.767	drs
8	1.000	1.000	1.000	-
9	1.000	1.000	1.000	-
10	0.927	0.928	0.999	irs
11	0.760	0.776	0.981	irs
12	1.000	1.000	1.000	-
13	0.372	1.000	0.372	irs
14	0.660	0.665	0.992	irs
15	0.948	1.000	0.948	irs
16	0.870	0.877	0.993	irs
17	0.420	0.434	0.969	irs
18	0.583	1.000	0.583	irs
19	1.000	1.000	1.000	-
20	0.371	0.500	0.742	irs
21	0.626	1.000	0.626	irs
mean	**0.758**	**0.877**	**0.866**	

FIRM BY FIRM RESULTS:

Results for firm: 1

Technical efficiency = 1.000
Scale efficiency = 0.897 (drs)

PROJECTION SUMMARY:

variable		original value	radial movement	slack movement	projected value
output	1	3000000.000	0.000	0.000	3000000.000
input	1	10000000.000	0.000	0.000	10000000.000
input	2	65.000	0.000	0.000	65.000
input	3	100238975.000	0.000	0.000	100238975.000

LISTING OF PEERS:

peer	lambda weight
1	1.000

Results for firm: 2

Technical efficiency = 0.943
Scale efficiency = 0.901 (drs)

PROJECTION SUMMARY:

variable		original value	radial movement	slack movement	projected value
output	1	2184760.000	132481.379	0.000	2317241.379
input	1	8675240.000	0.000	-1026767.759	7648472.241
input	2	50.000	0.000	0.000	50.000
input	3	102007264.000	0.000	-27141338.569	74865925.431

LISTING OF PEERS:

peer	lambda weight
1	0.741
8	0.259

Results for firm: 3

Technical efficiency = 0.802
Scale efficiency = 0.773 (drs)

PROJECTION SUMMARY:

variable		original value	radial movement	slack movement	projected value
output	1	1302883.000	322304.472	0.000	1625187.472
input	1	5298410.000	0.000	0.000	5298410.000
input	2	48.000	0.000	-13.004	34.996
input	3	47925062.000	0.000	0.000	47925062.000

LISTING OF PEERS:

peer	lambda weight
6	0.038

```
    1      0.465
    8      0.497
Results for firm:     4
Technical efficiency = 0.939
Scale efficiency     = 0.867  (drs)
 PROJECTION SUMMARY:
  variable           original        radial         slack     projected
                        value      movement      movement         value
 output     1     1800000.000    117090.214         0.000   1917090.214
 input      1     7200000.000         0.000   -630174.720   6569825.280
 input      2          43.000         0.000         0.000        43.000
 input      3    49058994.000         0.000         0.000  49058994.000
 LISTING OF PEERS:
  peer   lambda weight
    8      0.198
    1      0.463
    6      0.339
Results for firm:     5
Technical efficiency = 0.873
Scale efficiency     = 0.783  (drs)
 PROJECTION SUMMARY:
  variable           original        radial         slack     projected
                        value      movement      movement         value
 output     1     1300185.000    189488.881         0.000   1489673.881
 input      1     4798200.000         0.000         0.000   4798200.000
 input      2          37.000         0.000        -5.181        31.819
 input      3    68453485.000         0.000 -24342075.904  44111409.096
 LISTING OF PEERS:
  peer   lambda weight
    1      0.428
    8      0.572
Results for firm:     6
Technical efficiency = 1.000
Scale efficiency     = 1.000  (crs)
 PROJECTION SUMMARY:
  variable           original        radial         slack     projected
                        value      movement      movement         value
 output     1     1348613.000         0.000         0.000   1348613.000
 input      1     5195400.000         0.000         0.000   5195400.000
 input      2          34.000         0.000         0.000        34.000
 input      3     6628940.000         0.000         0.000   6628940.000
 LISTING OF PEERS:
  peer   lambda weight
    6      1.000
Results for firm:     7
Technical efficiency = 0.683
Scale efficiency     = 0.767  (drs)
 PROJECTION SUMMARY:
  variable           original        radial         slack     projected
                        value      movement      movement         value
 output     1      463771.000    214884.189         0.000    678655.189
 input      1     2230474.000         0.000         0.000   2230474.000
 input      2          20.000         0.000        -4.650        15.350
 input      3     5736908.000         0.000         0.000   5736908.000
 LISTING OF PEERS:
  peer   lambda weight
    6      0.255
    1      0.025
    8      0.720
Results for firm:     8
Technical efficiency = 1.000
Scale efficiency     = 1.000  (crs)
 PROJECTION SUMMARY:
  variable           original        radial         slack     projected
                        value      movement      movement         value
 output     1      360000.000         0.000         0.000    360000.000
 input      1      907426.000         0.000         0.000    907426.000
 input      2           7.000         0.000         0.000         7.000
 input      3     2129850.000         0.000         0.000   2129850.000
 LISTING OF PEERS:
  peer   lambda weight
    8      1.000
Results for firm:     9
Technical efficiency = 1.000
Scale efficiency     = 1.000  (crs)
 PROJECTION SUMMARY:
```

```
  variable           original        radial         slack     projected
                        value      movement      movement         value
 output     1      250000.000         0.000         0.000    250000.000
 input      1      650000.000         0.000         0.000    650000.000
 input      2           6.000         0.000         0.000         6.000
 input      3     1423656.000         0.000         0.000   1423656.000
 LISTING OF PEERS:
  peer   lambda weight
    9      1.000
```
Results for firm: 10

```
Technical efficiency = 0.928
Scale efficiency     = 0.999  (irs)
 PROJECTION SUMMARY:
  variable           original        radial         slack     projected
                        value      movement      movement         value
 output     1      164000.000     12796.893         0.000    176796.893
 input      1      600000.000         0.000         0.000    600000.000
 input      2           6.000         0.000         0.000         6.000
 input      3      916560.000         0.000         0.000    916560.000
 LISTING OF PEERS:
  peer   lambda weight
    9      0.345
    6      0.025
   19      0.398
   12      0.232
```
Results for firm: 11

```
Technical efficiency = 0.776
Scale efficiency     = 0.981  (irs)
 PROJECTION SUMMARY:
  variable           original        radial         slack     projected
                        value      movement      movement         value
 output     1      190000.000     55000.000         0.000    245000.000
 input      1     1500000.000         0.000   -772537.000    727463.000
 input      2           5.000         0.000         0.000         5.000
 input      3     1432080.000         0.000    -59505.000   1372575.000
 LISTING OF PEERS:
  peer   lambda weight
    8      0.500
   12      0.500
```
Results for firm: 12

```
Technical efficiency = 1.000
Scale efficiency     = 1.000  (crs)
 PROJECTION SUMMARY:
  variable           original        radial         slack     projected
                        value      movement      movement         value
 output     1      130000.000         0.000         0.000    130000.000
 input      1      547500.000         0.000         0.000    547500.000
 input      2           3.000         0.000         0.000         3.000
 input      3      615300.000         0.000         0.000    615300.000
 LISTING OF PEERS:
  peer   lambda weight
   12      1.000
```
Results for firm: 13

```
Technical efficiency = 1.000
Scale efficiency     = 0.372  (irs)
 PROJECTION SUMMARY:
  variable           original        radial         slack     projected
                        value      movement      movement         value
 output     1       23640.000         0.000         0.000     23640.000
 input      1      160000.000         0.000         0.000    160000.000
 input      2           2.000         0.000         0.000         2.000
 input      3      900272.000         0.000         0.000    900272.000
 LISTING OF PEERS:
  peer   lambda weight
   13      1.000
```
Results for firm: 14

```
Technical efficiency = 0.665
Scale efficiency     = 0.992  (irs)
 PROJECTION SUMMARY:
  variable           original        radial         slack     projected
                        value      movement      movement         value
 output     1      100000.000     50298.132         0.000    150298.132
 input      1      468000.000         0.000         0.000    468000.000
 input      2           4.000         0.000         0.000         4.000
 input      3      816000.000         0.000         0.000    816000.000
 LISTING OF PEERS:
```

```
  peer   lambda weight
    9      0.386
   12      0.237
   19      0.055
   15      0.322
```
Results for firm: 15
```
Technical efficiency = 1.000
Scale efficiency     = 0.948  (irs)
 PROJECTION SUMMARY:
  variable           original       radial         slack     projected
                        value     movement      movement         value
 output     1       60000.000        0.000         0.000     60000.000
 input      1      220000.000        0.000         0.000    220000.000
 input      2           2.000        0.000         0.000         2.000
 input      3      325040.000        0.000         0.000    325040.000
 LISTING OF PEERS:
  peer   lambda weight
   15      1.000
```
Results for firm: 16
```
Technical efficiency = 0.877
Scale efficiency     = 0.993  (irs)
 PROJECTION SUMMARY:
  variable           original       radial         slack     projected
                        value     movement      movement         value
 output     1      105440.000    14792.460         0.000    120232.460
 input      1      440000.000        0.000         0.000    440000.000
 input      2           4.000        0.000         0.000         4.000
 input      3      609620.000        0.000         0.000    609620.000
 LISTING OF PEERS:
  peer   lambda weight
   12      0.405
   19      0.240
    9      0.159
   15      0.196
```
Results for firm: 17
```
Technical efficiency = 0.434
Scale efficiency     = 0.969  (irs)
 PROJECTION SUMMARY:
  variable           original       radial         slack     projected
                        value     movement      movement         value
 output     1       68430.000    89318.409         0.000    157748.409
 input      1      410326.000        0.000         0.000    410326.000
 input      2           5.000        0.000        -0.341         4.659
 input      3     1075277.000        0.000   -103487.072    971789.928
 LISTING OF PEERS:
  peer   lambda weight
    8      0.415
   21      0.585
```
Results for firm: 18
```
Technical efficiency = 1.000
Scale efficiency     = 0.583  (irs)
 PROJECTION SUMMARY:
  variable           original       radial         slack     projected
                        value     movement      movement         value
 output     1       60000.000        0.000         0.000     60000.000
 input      1      350877.000        0.000   -130877.000    220000.000
 input      2           2.000        0.000         0.000         2.000
 input      3      800000.000        0.000   -474960.000    325040.000
 LISTING OF PEERS:
  peer   lambda weight
   15      1.000
```
Results for firm: 19
```
Technical efficiency = 1.000
Scale efficiency     = 1.000  (crs)
 PROJECTION SUMMARY:
  variable           original       radial         slack     projected
                        value     movement      movement         value
 output     1       67300.000        0.000         0.000     67300.000
 input      1      300000.000        0.000         0.000    300000.000
 input      2           6.000        0.000         0.000         6.000
 input      3      295000.000        0.000         0.000    295000.000
 LISTING OF PEERS:
  peer   lambda weight
   19      1.000
```
Results for firm: 20
```
Technical efficiency = 0.500
```

```
Scale efficiency     = 0.742  (irs)
 PROJECTION SUMMARY:
  variable           original        radial         slack     projected
                        value      movement      movement         value
 output     1       30000.000     30000.000         0.000     60000.000
 input      1      286480.000         0.000    -66480.000    220000.000
 input      2           2.000         0.000         0.000         2.000
 input      3      412881.000         0.000    -87841.000    325040.000
 LISTING OF PEERS:
  peer   lambda weight
   15      1.000
Results for firm:    21
Technical efficiency = 1.000
Scale efficiency     = 0.626  (irs)
 PROJECTION SUMMARY:
  variable           original        radial         slack     projected
                        value      movement      movement         value
 output     1       14400.000         0.000         0.000     14400.000
 input      1       58000.000         0.000         0.000     58000.000
 input      2           3.000         0.000         0.000         3.000
 input      3      151000.000         0.000         0.000    151000.000
 LISTING OF PEERS:
  peer   lambda weight
   21      1.000
```