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The Economic Efficiency of the Innovation System in the Wood and Furniture Enterprises Branch in the Region of Thessaly – Greece

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Abstract
In the present study, which focuses to the branches of wood and furniture enterprises in the Region of Thessaly, there is an attempt to register the main problems of the enterprises, the best practice applied concerning their operation and the analysis of the economic dimension and efficiency of their innovative activity as well. For the production of new, innovative and quality products, it is necessary to have relative high expenditures for the procurement of modern technological equipment, as long with other production factors, which have to be incorporated into the total production cost. The enterprises of the branch of wood and furniture, seems that they don't produce innovation by their own and they come behind to the extraversion that they have to show for successful innovations they may apply. The efficiency of the enterprises innovation system is judged as adequate, as long as the majority of the firms are using in a satisfactory way the inputs of innovation. However, there are significant margins of improvement, mainly to the sales of products that are a result of some kind of innovative action of the enterprises, along with issues dealing with training of the staff, dissemination activities of innovation and development and application of R&D. The alteration of efficiency shows fluctuations pointing the absence of a clearly specified strategy of the enterprises of the branch in issues dealing with adequate use of production factors of innovative activity and the expenditures that are made for that reason. Finally, there are enterprises that come significant behind related to other firms of the branch and they have to try much harder in order to improve their efficiency and to decrease their expenditures to achieve the best efficiency of their business activity.

Purpose
The study provides important implications for managers and researchers who explore the efficiency among innovation inputs and outputs along with the registration of economics of innovation variables in company performance.

Design / methodology / approach
A 2005 - 2007 empirical study registers economics of innovation of 38 wood and furniture enterprises in the region of Thessaly - Greece. The data collection methodology was based to the guidelines of the Oslo manual. The data analysis techniques are descriptive statistics, frequencies and correlation, using the SPSS package.
Based upon the Data Envelopment Analysis technique, a benchmarking analysis of 17 decision making units was applied measuring simultaneously the efficiency of innovation's system of the branch in the region.

Findings
Wood and furniture enterprises in the region adopt and improve already existing methods of production and products distribution. The proper attention towards the direction of developing and producing of new products and methods of products distribution should be given.

Significant efforts still have to be made for importing innovation in the production process. It is required a relative high cost of modern technological equipment, as long as of several production elements, for the production of new, innovative and quality products, a cost that has been embodied into total production cost of the study's firms. As a result it is accenting the fundamental contribution of innovation in entrepreneurial activity and the meaning that step – by – step the firms of the branch are giving in innovative products and processes. Generally, increment of innovation performance incurs increment of sales. The firms themselves of wood and furniture branch, do not produce innovation by their own and they clearly come behind concerning to the extraversion that have to show for whichever successful innovations they apply.

The efficiency of the enterprises innovation system is evaluated as adequate while the majority of the firms are using in a satisfactory way innovation's inputs and outputs. However, there are significant improvement margins. The variation of efficiency shows fluctuations accenting the absence of a clearly stated strategy of the branch concerning issues of effective use of innovation factors and of the expenditures that are made for that specific reason.

Practical Implications
Industries, struggle to strength their competitive position in the new globalized markets, using innovation activities as their strategic ally for producing products and services of added value. The study provides useful information and data concerning the financial aspect of innovative activity and quantifies this activity in the wood and furniture branch. Furthermore, proves that, the use of innovation inputs and outputs is efficient and benchmarking analysis provides margins for business operation improvements in the branch.

Originality / value
This was the first study focused to the registration of financial data of innovative activity of Greek wood and furniture enterprises. This study expands previous similar studies, using more detailed innovation inputs and outputs and can be used as a guide to the decision makers and to the enterprises, for conducted similar benchmarking studies, offering more insight on the effects and improvements of innovative activity.

1. INTRODUCTION

Although it is difficult to isolate the nature, the sources and the results of innovation, there is a congruency of opinions concerning to the elements that constitute innovation (Gordon and McCann 2005). Innovation is related, beside to the technological evolution, with an expanded system of procedures for knowledge management (Komninos 2001). Scientific research approaches the meaning of innovation as a system and not with the classic linear approach that constrains innovation in specific frameworks and procedures. Enterprises do not innovate by their own but they are in continuous reaction with the rest members of the system, which along with the relations that are developing among them, determine innovative action of enterprises (Komninos et al 2001, Feinson et al. 2002). Meanings and practises, such as the adoption of new technologies and the reduction of total production cost, seem inadequate for the survival of the enterprises, which have to aim in reinvestment of information and applications of benchmarking (Papadopoulos 2005, Karagkouni 2006, Karagkouni and Papadopoulos 2006). Focusing to the branch of wood and furniture enterprises in this study, through the application of specially constructed questionnaires for the study and delineation of the existing innovation system of the branch, it is attempted a registration of enterprises problems, the approach of best practice concerning their operation and the analysis of economic dimension and efficiency of innovative action of these enterprises.

2. LITERATURE REVIEW

2.1 Innovation Systems

Innovation in general, but also business innovation more specifically, constitutes a non linear meaning according to the existing scientific perception and it is examined as a system. It constitutes a complex, interactive system where science, technology and society are interacting in such way that it is often difficult to discriminate the causes from the results of this system's operation (Smits 2002). As till today the linear approach of innovation was focusing to the capability of the enterprises for producing innovative activities, the approach of innovation system sets as a main role, the demand of innovation from the consumers and generally from the final recipients and users of it (Edquist and Hommen 1999, Oudshoorn and Pinch 2003). The significance of dealing innovation as a system can be easily understood if we consider that enterprises are not producing innovation by their own but always through complex relations of reciprocity and feedback (Komninos et al. 2001), specified by the elements of the system and by the relations that are developing among them (Edquist 1997, Edquist and Hommen 1999). The key of success in an innovation system is the way that the above mentioned organizations and enterprises are interacting in such a network (Pittaway et al. 2004) as long as other factors of the system (Klein Woolthuis et al. 2005).

The examination of National Innovation Systems embodies three levels of analysis (Parastakos 2003):

The *macro level* in which economy is comprehensible as a sum of acting and reacting mechanisms that involve enterprises, universities and public and private research organizations along with intermediate supporting organizations. In this level it is with a quite importance the knowledge flows inside the system.

The *mid level* examines the interrelations between enterprises with common characteristics. This is about the meaning of enterprises networks (*clusters*) which deal with alike or interconnected activities, or geographical proximity, or both.

The *micro level*, which is focusing to the individual interior characteristics and capabilities of the firm that are positively related to it's ability to innovate.

The present study is dealing with the analysis of the efficiency of the innovation system in the branch of wood and furniture enterprises in the region of Thessaly, focusing to economic efficiency of this system in mid and micro level.

2.2 Measuring efficiency in wood and furniture branch with the use of D.E.A.

Recent approaches concerning the measurement of business performance in innovation have a multidimensional character (Danneels and Kleinschmidt, 2001) without neglecting the fact that, technological evolution plays one of the most fundamental roles in the way that business innovative action is developing (Green et al. 1995, Talke 2007). Fenkel et al. (2000) mention that, «*quantification, evaluation and benchmarking of business innovation is a complex procedure for them, having simultaneously a fundamental role and meaning for academic research*». In this point it has to be highlighted the fact that, measurement of business innovation must not be confused with the measurement of products performance in the market. The first one constitutes a fundamental criterion for the second one (Richardson and Gordon 1980, Sink 1983).

The first application of *Data Envelopment Analysis* (*DEA*) in the sector of forest industries was made by Rhodes (1986). However, studies for measuring efficiency in the specific branch are still limited. Most of them are focusing to the measurement of economic efficiency of the specific enterprises as long as to the efficiency of forest holdings management (Yin 1998, 1999 and 2000). Fotiou (1997) estimated the efficiency of Greek sawmills using a DEA model with two variables for inputs and one variable for outputs. Respectively, Nyrud and Bergseng (2002) have applied the same methodology for measuring productivity of approximately 200 sawmills in Norway. Similar studies have been published by Carter and Siry (2003). Specifically, considering DEA application for measuring innovation efficiency of wood enterprises, Diaz – Balteiro et al. (2006) are using only two variables for inputs and two for outputs of innovation respectively, considering total expenditures for R&D and number innovation collaborations (inputs) and number of innovative products and processes (outputs).

3. MATERIALS AND METHODS

The methodology that has been followed in this study, considering registration of innovation of wood and furniture enterprises in the region of Thessaly, is focusing to economic dimension of their innovative activity through the registration of the expenditures that enterprises have made related to procedures of *Technological Innovation of Products and Processes* (T.I.P.P.) The questionnaire which has been used, was based to the internationally recognized manual of registering business innovation that O.E.C.D. has constructed in 1995, known as *OSLO manual*, of the *Frascati manuals* line. For the purposes of the present study the *subject approach* was selected which deals with the studying of innovative behavior of enterprises and the procedures of the firm as a sum.

For the construction of wood and furniture business innovation budget in the basis of subject approach, another way of approach was used in order to register innovation expenditures, known as bottom-*up approach* (O.E.C.D. 1995). Innovation outputs are dealing with incomes that came through sales of products as a result of some kind of innovative activity and they constitute an estimation of annual incomes as a percentage of annual turnovers of the enterprises, which flows from innovative products and processes, based also to published balance sheets of the enterprises of the study. The target – population of the study are

the 42 firms of the branch in the region with more than 5 employees which are dealing with wood processing and furniture manufacturing. The questionnaire was addressed to all 27 enterprises for which their financial data are published in financial directories of ICAP of 2007 also. Finally, from the sum of enterprises, 38 questionnaires were gathered, namely a percentage of 90,5% of the total population of the study.

For the measurement of wood and furniture enterprises innovation system efficiency in the region of Thessaly, *Data Envelopment Analysis* was used (Charnes et al. 1978). It is a non parametric technique based to linear programming (Cooper et al. 1999). The knowledge of efficiency of a firm and as a result of a system constitutes a fundamental factor for the evaluation of the existing situation as long as for the decision making in micro and micro economic level (Fotiou 1997). The subjects of Data Envelopment Analysis for which the efficiency is estimated, are mentioned as *Decision Making Units* (*D.M.U.*). Data Envelopment Analysis considers Decision Making Unit – enterprise as a productive unit that consumes resources in the form of inputs and produces a total of outputs. In the present study, was used the occasion which the presentation of efficiency frontier is based to the hypothesis for standardized efficiency scale (*constant returns to scale*).

The philosophy of DEA relies to the estimation of efficiency according to the ratio:

Efficiency = Weighted outputs sum/weighted inputs sum

In our research, the efficiency is estimated for a sum of D.M.U's, for that reason the meaning of weights is used, since each firm uses a number of different inputs to produce several outputs. The above mentioned ratio can be presented as:

$$Eij = \frac{\sum WrYrj}{\sum ViXij}$$

Where: **Wr** the weighted output r
Vi the weighted input i
Yij the output i
Xij the input i
with $0 \geq Eij \geq 1$

Each firm has to choose different weights of inputs-outputs of their innovative activity because of the fact that operates in a different way from the rest ones. According to this, maximum input oriented efficiency can be estimated by maximizing the above ratio, with the constraint that it can take values between 0 and 1. This leads to the ratio:

$$\mathbf{max}\, Eij_0(w,v) = \frac{\sum_{r=1}^{s} WrYrj_0}{\sum_{i=1}^{m} ViXij_0}$$

with Eij$\leq$1 and Wr, Vi$\geq$0, j=1…n, r=1…s και i=1…m.

According to this, the efficiency of wood and furniture enterprises innovative activity was estimated, through the estimation of general relative efficiency, the percentage of improvement in using inputs and outputs of innovation (*slacks*), the weighting coefficients of inputs and outputs (*weights*), *cross efficiency* estimation, *lambda* coefficients and through several indicators describing innovative activity of the study's enterprises.

4. RESULTS

4.1 The economic – innovative profile of the enterprises of the study

The major percentage of the study's enterprises, states as main activity furniture manufacturing (42,1%). Wood and wood products trading enterprises follow (21,1%) and with lower percentage the rest of the activities such as wooden products production, wood processing and furniture trading. The major percentage (59,5%) of the study's enterprises has a total invested capital less than 2.000.000€ and those which the invested capital is among 2 till 10 billion € follow (32,4%). Firms with invested capital that exceeds 10.000.000€ constitute the 8,1% of the sum. Similar is the distribution of percentages regarding the total value of fixed investments, showing some small differences.

Regarding annual turnover, the mean for the period 2005-2007 is in major percentage (40,5%) among 1.000.000-2.000.000€ and enterprises with annual turnover less than 1.000.000€ follow with a percentage of 32,4%. These which their annual turnover is among 2.000.000-5.000.000€ and over 10.000.000€ constitute the 24,3% and 2,7% o the sum respectively. The distribution of basic financial data for the period 2005-2007 is presented in the next Table 1.

Table 1: Means of basic financial data of the enterprises for the period 2005 – 2007.

BASIC FINANCIAL DATA	MEAN IN €
Net profits (before taxes) during 2005	189.112,76
Net profits (before taxes) during 2007	214.024,48
Salaries and social security contributions during 2005	256.475,96
Salaries and social security contributions during 2007	330.609,41
Raw materials cost during 2005	770.906,04
Raw materials cost during 2007	925.923,77

To the question if they are familiar to the meaning of innovation, the major percentage (86,8%) of the businessmen, have stated that they are familiar with. Similar are the percentages concerning the use or not of innovative products and processes by the enterprises of the study, while the 76,3% stated that are users of innovative products and processes.

Concerning the ways with which the enterprises are embodying innovative action into their economic – entrepreneurial operation, it is remarked that the major percentage (51,5%), adopts and improves already existing methods of production and distribution and enterprises that innovate through the improvement of already existing products and the production of new products, follow with a percentage 39,4%. Enterprises developing new methods of production and distribution follow with relative lower percentage.

As major objectives of innovative action of the firms have been accented the following four: a) the increment of market share that is operated by the firms, b) lower production costs, c) opening of new markets abroad or towards domestic market groups – targets, d) improvement of products quality. Technologically improved products that have been commercialized by the firms during the period 2005-2007, constitute a percentage up to 16,4% of the total sales of the firms and sales of products that are new or technologically improved in relation to market under exploitation by the enterprises and commercializing of products, during the same period, that are technologically unchanged, follow with percentages 12,8% and 12,3% respectively. Technologically new products stands at the last position as a percentage of total sales up to 7,8%, while the participation of processes comes up to a percentage of 10,7%. A characteristic

fact is that, the percentage of products sales that are technologically unchanged and they have been produced through unchanged production methods, constitute only a 8,3% of the total sales, a fact that indicates the effort of importing innovation in production process.

Table 2: Percentage % of sales that are caused by innovative products or processes.

PRODUCTS SALES	PERCENTAGE % OF TOTAL SALES
1. Technologically improved products which were commercialized during 2005 – 2007.	16,3
2. Sales of products that are new or technologically improved in relation to operation market by the enterprises	12,8
3. Products technologically unchanged or simply modified, that have been produced with unchanged production methods and were commercialized during 2005-2007	12,3
4. Sales of products that are new or technologically improved exclusively in relation to the firm	10,9
5. Processes technologically unchanged or simply modified that have been applied during 2005-2007	10,7
6. Products technologically unchanged or simply modified, that have been produced with unchanged production methods during 2005-2007	8,3
7. Technologically new products which were commercialized during 2005 – 2007	7,8

Evaluating the impact of products or processes innovation to the use of basic production factors, it is accented that innovation affects in a quite significant way the consuming of materials and the use of fixed capitals, while labor and energy consumption follow. A significant percentage (32,4%), stated that technological innovations have reduced the average total production cost during 2005-2007. Analyzing the previous question, from the enterprises that have answered positively and in relation to the reduction of average total cost, the major percentage (58,3%) showed a reduction into a range from 5-10% and a percentage of 16,7% into a range from 10-15% (Figure 1).

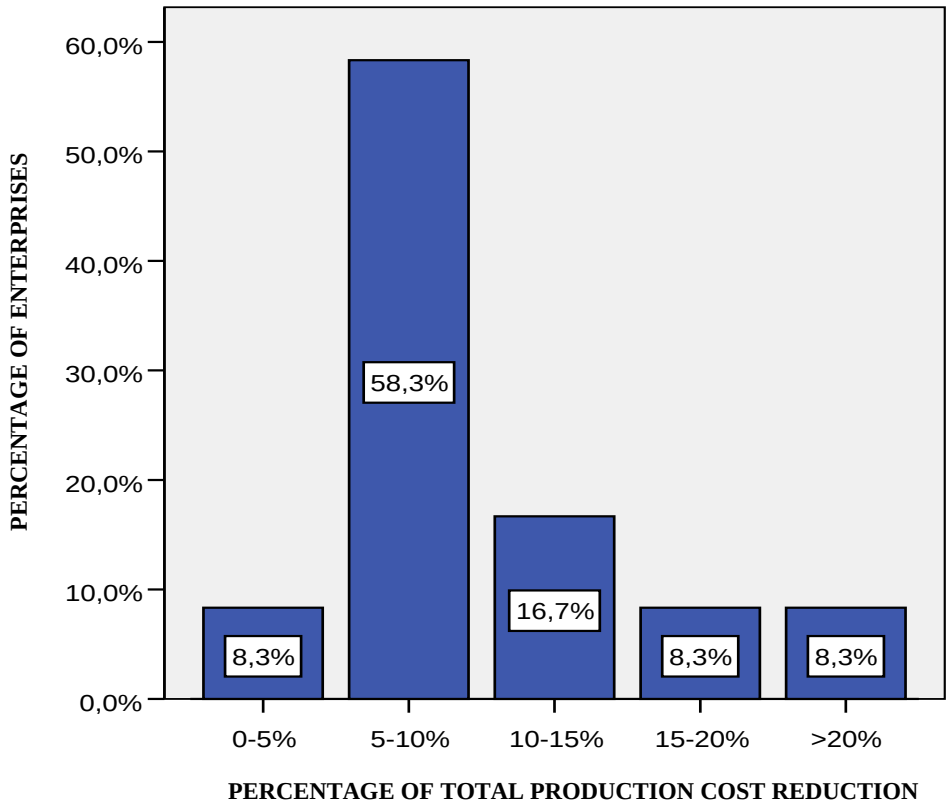

Figure 1: Percentage impact of innovation to the reduction of average total production cost of the study's enterprises.

An encouraging fact is that, the percentage of annual turnover of the firms which is related to innovative products and processes during 2005-2007, has increased significantly. Thus it is accented that, as the rate of innovation increases the percentage of sales increment shows fluctuations. Generally, it is a fact that increment of innovation rate bears sales increment also, as long as the correlation between these two variables is positive (coefficients Kendall's tau-b=0,620 and Kendall's tau-c=0,582).

In Figure 2 it is presented that the major percentage of the enterprises (31,4%), has spent in total more than 50.000€ for developing innovative activities during 2007. Enterprises with total expenditures amount less than 10.000€ follow with a percentage 22,9% and the lower percentage of enterprises (11,4%) has spent from 20.000 – 30.000€.

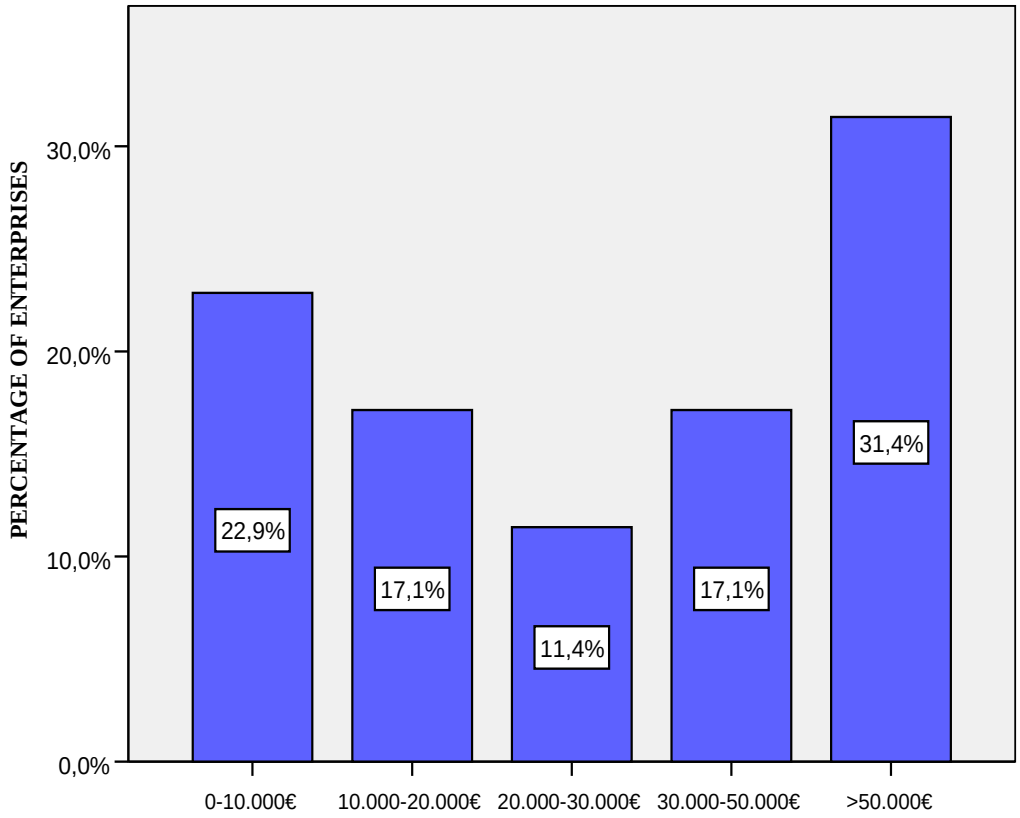

Figure 2: Innovation expenditures distribution during 2007 of the study's enterprises.

The analysis of the unified budget of the enterprises of the study, concerning innovative activities which may have been undertaken by them during the last closed financial period, follows (Table 3). The major percentage of the enterprises (85,7%) has acquired machinery and equipment and the average expenditure was approximately 56.000€. Concerning the percentage of enterprises that were involved in these specific activities, dissemination of innovation (45,7%), innovation's imports into the market (31,4%) and the acquisition of R&D (25,7%) follow, with an average amount of expenditures approximately up to 4.000€, 3.000€ and 9.500€ respectively. In the last position is the participation in procedures concerning training and acquisition of other external knowledge with a percentage of 14,3% of the enterprises and only 1.500€ of average expenditure.

From the total expenditure's amount, the major percentage (95,3%), has to do with expenditures concerning innovation flows towards the firms. The enterprises of wood and furniture branch, are not producing innovation by their own. In relation to the several positions of cost of the enterprises where these expenditure are made, the major amount concerns the acquisition of land and buildings related to innovation's development, the purchase and establishment of machinery and equipment for improving business procedures, while in the last position stand the expenditures concerning salaries such as day wages, other labor cots, financial prizes, financial bonus e.t.c

Table 3: Involvement in innovative activities and distribution of total innovation expenditures of the enterprises during the last financial period into positions of cost.

INNOVATION ACTIVITIES	INVOLVEMENT IN ACTIVITY (PERCENTAGE OF ENTERPRISES %)		ACTIVITY EXPENDITURES (€)
	YES	NO	
R&D expenditures	20,0	80,0	5.142,86
R&D acquisition expenditures	25,7	74,3	9.558,82
Machinery and equipment acquisition expenditures	85,7	14,3	55.728,57
Other external knowledge acquisition expenditures	11,4	88,6	3.228,57
Training expenditures	14,3	85,7	1.571,43
Importing innovation to the market expenditures	31,4	68,6	2.868,57
Design expenditures	17,1	82,9	3.657,14
Total innovation flows expenditures			**81.482,86**
Innovation dissemination activities expenditures	45,7	54,3	4.000,00
Other expenditures			0
Total innovation expenditures			**85.397,14**

COST POSITIONS	MEAN IN €
Day wages	156,67
Annual salaries	3.056,67
Extra financial contributions expenditures	280,00
Labor costs not involving in TIPP activities	666,67
Procurement of materials	8.466,67
Buying of procurements	766,67
Innovative products marketing	3.658,06
Supporting TIPP activities expenditures	5.645,16
Total of current innovation expenditures	**22.219,35**
Acquisition of land and buildings for use in TIPP	28.870,97
Acquisition of basic organs and equipment	7.000,00
Hardware and software supporting activities of TIPP	1.766,67
Establishment of machinery for improving existing products	23.140,63
Establishment of machinery for producing new products	3.533,33
Total of capital innovation expenditures	**60.742,42**

In the next Table 4, innovation inputs and outputs are presented, concerning the enterprises of the study for one financial year, as they were registered according to the used questionnaires (inputs) and were estimated based to the percentages of annual turnover dealing with sales of innovative products and services during 2005-2007 (outputs). In total, available data have to do with 17 from the enterprises of the study. Eight innovation inputs and seven outputs are being used. The results are being used next in order to analyze the efficiency of innovation system with the use of Data Envelopment Analysis technique. As it is presented, the major amount of inputs has to do with the acquisition of machinery and equipment for producing innovative products while from the scope of outputs sales of technologically unchanged or simply modified products that have been produced with the same methods and been commercialized within a year, constitute the majority.

Table 4: Innovation inputs and outputs of the study's enterprises during 2007

S/N	INNOVATION INPUTS							
	INNER BUSINESS R&D	ACQUISITION OF R&D	ACQUISITION OF MACHINERY & EQUIPMENT	ACQUISITION OF OTHER EXTERNAL KNOWLEDGE	TRAINING	IMPORTING INNOVATION INTO MARKET	DESIGNING/OTHER PREPARATIONS	INNOVATION DISSEMINATION
1	0 €	0 €	30.000 €	0 €	0 €	5.000 €	10.000 €	0 €
2	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €
3	0 €	0 €	0 €	0 €	0 €	10.000 €	0 €	20.000 €
4	0 €	0 €	10.000 €	0 €	0 €	0 €	0 €	0 €
5	0 €	0 €	20.000 €	0 €	0 €	0 €	0 €	5.000 €
6	0 €	0 €	50.000 €	0 €	0 €	5.000 €	0 €	10.000 €
7	0 €	0 €	40.000 €	0 €	0 €	0 €	0 €	0 €
8	0 €	0 €	50.000 €	0 €	5.000 €	10.000 €	0 €	10.000 €
9	5.000 €	10.000 €	30.000 €	0 €	5.000 €	3.000 €	0 €	5.000 €
10	0 €	10.000 €	0 €	0 €	0 €	0 €	0 €	0 €
11	100.000 €	0 €	300.000 €	0 €	0 €	0 €	0 €	30.000 €
12	0 €	0 €	15.000 €	0 €	0 €	0 €	0 €	0 €
13	0 €	0 €	23.000 €	0 €	0 €	0 €	0 €	0 €
14	0 €	0 €	0 €	0 €	0 €	12.000 €	0 €	0 €
15	10.000 €	30.000 €	42.000 €	0 €	5.000 €	0 €	0 €	10.000 €
16	0 €	60.000 €	200.000 €	0 €	0 €	0 €	0 €	0 €
17	0 €	0 €	0 €	50.000 €	0 €	0 €	0 €	0 €
TOTAL	**115.000 €**	**110.000 €**	**810.000 €**	**50.000 €**	**15.000 €**	**45.000 €**	**10.000 €**	**90.000 €**

INNOVATION OUTPUTS						
SALES OF TECH. NEW PRODUCTS COMMERCIALIZED IN 2007	SALES OF TECH. IMPROVED PRODUCTS COMMERCIALIZED IN 2007	SALES OF TECH. NEW OR IMPROVED PRODUCTS RELATED TO THE FIRM'S OPERATION MARKET	SALES OF TECH. NEW OR IMPROVED PRODUCTS RELATED EXCLUSIVELY TO THE FIRMS	SALES OF TECH. UNCHANGED OR SIMPLY MODIFIED PRODUCTS WHICH WERE PRODUCED WITH THE SAME METHODS AND COMMERCIALIZED DURING 2007	SALES OF TECH. UNCHANGED OR SIMPLY MODIFIED PRODUCTS WHICH WERE PRODUCED WITH THE SAME METHODS DURING 2007	PROCESSES TECH. UNCHANGED OR SIMPLY MODIFIED WHICH WERE APPLIED DURING 2007
0 €	530.526 €	0 €	795.789 €	707.368 €	530.526 €	0 €
0 €	124.292 €	0 €	0 €	0 €	0 €	0 €
0 €	0 €	0 €	0 €	271.776 €	0 €	0 €
0 €	0 €	0 €	0 €	0 €	298.007 €	0 €
0 €	140.805 €	0 €	0 €	0 €	140.805 €	0 €
0 €	0 €	0 €	0 €	0 €	0 €	0 €
0 €	313.932 €	0 €	0 €	0 €	0 €	0 €
0 €	150.659 €	112.994 €	0 €	75.329 €	0 €	0 €
0 €	173.103 €	0 €	0 €	259.655 €	346.206 €	86.551 €
118.694 €	59.347 €	296.735 €	178.041 €	593.470 €	474.776 €	356.082 €
100.000 €	100.000 €	100.000 €	100.000 €	100.000 €	100.000 €	100.000 €
0 €	0 €	0 €	0 €	18.465 €	0 €	0 €
36.667 €	0 €	110.000 €	36.667 €	0 €	0 €	0 €
0 €	0 €	0 €	71.240 €	427.441 €	0 €	71.240 €
74.921 €	299.685 €	0 €	0 €	299.685 €	0 €	0 €
0 €	0 €	1.650.610 €	0 €	0 €	0 €	0 €
8.500 €	0 €	0 €	0 €	0 €	0 €	0 €
TOTAL	**338.782€**	**1.892.349 €**	**2.270.339 €**	**1.181.737 €**	**2.753.189 €**	**1.890.320 €**	**613.873 €**

4.2 The efficiency of the study's enterprises system of innovation

Wood and furniture enterprises of the study for which efficiency was estimated, are referenced as *Decision Making Units* – DMU. The Data Envelopment Analysis model that was applied concerns the delimitation of reference units according to inputs decrease of non – efficient units (*input oriented*) and the representing of efficiency frontier based to the scale of constant efficiencies (*constant returns to scale*).

In next Table 5, it is presented the estimation of the efficiency for the total of 17 enterprises which are participating into the analysis. Generally, we can say that enterprises are judged as efficient concerning the ratio inputs/outputs of innovation. Nevertheless non – efficient enterprises have to improve significantly this ratio.

Table 5: Estimation of the wood and furniture enterprises efficiency according to inputs and outputs off innovative action.

	EFFICIENCY	GRAPHIC ESTIMATION	✓
DMU1	100 %	100%	✓
DMU2	100 %	100%	✓
DMU3	76.3 %	76%	
DMU4	100 %	100%	✓
DMU5	100 %	100%	✓
DMU6	0.1 %	0%	
DMU7	100 %	100%	✓
DMU8	85.6 %	86%	
DMU9	36.2 %	36%	
DMU10	100 %	100%	✓
DMU11	100 %	100%	✓
DMU12	100 %	100%	✓
DMU13	100 %	100%	✓
DMU14	100 %	100%	✓
DMU15	17.7 %	18%	
DMU16	60.3 %	60%	
DMU17	100 %	100%	✓

Using the results of Table 5, it is estimated that the average efficiency of the sum of the study's enterprises reaches approximately a percentage of 81%, which can be considered as a quite adequate percentage of using innovation inputs in relation to the produced outputs.

In the following tables (Tables 6 – 9), the above mentioned estimation is more deeply analyzed.

In Table 6, it is presented the margin for improving the use of the inputs and outputs of innovation by the firms of the branch, as a percentage that expresses the margin of usage improvement of the mentioned variables by the non – efficient enterprises in relation to the efficient ones. As it is presented, these margins are wider concerning outputs of innovation in relation to inputs. Specifically, the margins are wider for the sales of products that are unchanged or simply modified and were commercialized during the last three years and for the sales of technologically improved products which were also commercialized during the same period. Of course this has to do with non – efficient enterprises in relation to efficient ones. However, a fact with interest is the estimation of the margin that enterprises could

improve the decrease of inputs use. This is more intense concerning expenditures for innovation dissemination, meaning expenditures related the acquisition of innovation through commercial and other channels by the enterprises and use it for the first time. In general, we could say that enterprises use the rest of the inputs quite efficiently showing small exceptions in staff training and the development and application of internal business R&D.

In Table 7, the weighted means of innovation inputs and outputs of the enterprises are presented and have to do with the way that the firms will select to weight these specific factors in order to accent their efficiency in the most extended way. In other words, Table 7 presents the best practice for the enterprises. As it is presented this weighting deals mainly with the inputs of innovation, showing several improvement alternatives in relation to the acquisition of extra-firm R&D and of other basic knowledge, with the acquisition of machinery and technological equipment to follow.However, expanding the analysis and applying *cross – efficiency*, aiming to the limitation of the subjectivity that is enclosed to the weighted means analysis, new values of the efficiency index are calculated (Table 8). In this way we can estimate the benchmark position of non – efficient units in relation to efficient ones, based to the results of the table's lines, as long as and the variation of efficiency based to the results of the table's columns. As it is observed this variation shows great fluctuations, confirming the above mentioned results.

Finally, in Table 9 *lambda (λ)* coefficients were estimated, according to which innovation's outputs of the enterprises will alter if inputs decrease by the same coefficient, in order to achieve best practice by the non – efficient firms in relation to the use of innovation's variables. This combination shows also, a significant variance as a percentage (from 1% to 524%) pointing the existing margins of improvement in the use of innovation activity between the enterprises of the study in the region.

Table 6: Improvement margin concerning use of innovation's inputs and outputs by the enterprises.

	R&D	ACQUISITION OF R&D	MACHINERY & EQUIPMENT	OTHER EXTERNAL KNOWLEDGE	TRAINING	IMPORTING INNOVATION INTO MARKET	DESIGNING /OTHER PREPARATIONS	INNOVATION DISSEMINATION	TECH. NEW PRODUCTS COMMERCIALIZED IN 2007	TECH. IMPROVED PRODUCTS COMMERCIALIZED IN 2007	TECH. NEW OR IMPROVED PRODUCTS RELATED TO THE FIRM'S OPERATION MARKET	TECH. NEW OR IMPROVED PRODUCTS RELATED EXCLUSIVELY TO THE FIRMS	TECH. UNCHANGED OR SIMPLY MODIFIED PRODUCTS WHICH WERE PRODUCED WITH THE SAME METHODS AND COMMERCIALIZED DURING 2007	TECH. UNCHANGED OR SIMPLY MODIFIED PRODUCTS WHICH WERE PRODUCED WITH THE SAME METHODS DURING 2007	PROCESSES TECH. UNCHANGED OR SIMPLY MODIFIED WHICH WERE APPLIED DURING 2007
DMU1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DMU2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DMU3	0	0	0	0	0	0	0	15,26	0	0	0	45,29	0	0	45,3
DMU4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DMU5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DMU6	0	0	0	0	0	0	0	0,01	0	0	0,3	0,14	0	0,22	0,04
DMU7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DMU8	0	0	0	0	4,28	0	0	8,56	37,66	0	0	88,51	0	229,74	50,84
DMU9	1,81	0	0	0	1,81	0	0	1,81	42,95	41,63	107,37	70,86	0	0	48,73
DMU10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DMU11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DMU12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DMU13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DMU14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DMU15	1,78	0	0	0	0,89	0	0	1,77	0	15,63	193,23	106,45	252,25	15,77	189,19
DMU16	0	0	0	0	0	0	0	0	621,79	2147,49	0	836,54	1717,99	2148,36	1288,39
DMU17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 7: Weights of innovation inputs and outputs of the study's enterprises**.**

	R&D	ACQUISITION OF R&D	MACHINERY & EQUIPMENT	OTHER EXTERNAL KNOWLEDGE	TRAINING	IMPORTING INNOVATION INTO MARKET	DESIGNING/OTHER PREPARATIONS	INNOVATION DISSEMINATION	TECH. NEW PRODUCTS COMMERCIALIZED IN 2007	TECH. IMPROVED PRODUCTS COMMERCIALIZED IN 2007	TECH. NEW OR IMPROVED PRODUCTS RELATED TO THE FIRM'S OPERATION MARKET	TECH. NEW OR IMPROVED PRODUCTS RELATED EXCLUSIVELY TO THE FIRMS	TECH. UNCHANGED OR SIMPLY MODIFIED PRODUCTS WHICH WERE PRODUCED WITH THE SAME METHODS AND COMMERCIALIZED DURING 2007	TECH. UNCHANGED OR SIMPLY MODIFIED PRODUCTS WHICH WERE PRODUCED WITH THE SAME METHODS DURING 2007	PROCESSES TECH. UNCHANGED OR SIMPLY MODIFIED WHICH WERE APPLIED DURING 2007
DMU1	0	0,059	0,001	0,117	0	0,028	0,083	0	0	0	0	0,001	0	0,001	0
DMU2	0	0,477	0,063	10	0	0	0,237	0	0	0,008	0	0	0	0	0
DMU3	0	0,167	0,003	0	0	0,1	0,138	0	0	0	0	0	0	0,003	0
DMU4	0	0,159	0,1	0	0	0	0	0	0	0	0	0	0,003	0	0
DMU5	0	0,402	0,05	6,742	0	0	0,227	0	0	0,005	0	0	0,002	0	0
DMU6	0	0,149	0,02	0,002	0	0	0	0	0,013	0	0	0	0	0	0
DMU7	0	0,189	0,025	3,959	0	0	0,094	0	0	0,003	0	0	0	0	0
DMU8	0	0,275	0,02	3,167	0	0	0,075	0	0	0,003	0,004	0	0	0	0
DMU9	0	0,081	0,002	0	0	0,047	0,068	0	0	0	0	0	0	0,001	0
DMU10	0,002	0,1	0	0	0	0,017	0	0	0	0	0	0	0	0	0,003
DMU11	0	0,306	0,003	0	0	0,047	0	0	0,002	0	0	0	0	0	0,008
DMU12	0	3,215	0,067	0	0	1,929	2,666	0	0	0	0	0	0	0,054	0
DMU13	0	0,324	0,043	0,005	0	0	0	0	0,027	0	0	0	0	0	0
DMU14	0	0,157	0,003	0	0	0,083	0,115	0	0	0	0,001	0	0	0,002	0
DMU15	0	0,028	0,004	0	0	0	0	0	0,002	0	0	0	0	0	0
DMU16	0	0,011	0,002	0	0	0	0	0	0	0	0	0	0	0	0
DMU17	0	1,396	0,188	0,02	0	0	0	0	0,118	0	0	0	0	0	0

Table 8: Cross efficiency of the study's enterprises.

	Efficiency	DMU1	DMU2	DMU3	DMU4	DMU5	DMU6	DMU7	DMU8	DMU9	DMU10	DMU11	DMU12	DMU13	DMU14	DMU15	DMU16	DMU17
DMU1	100	100	100	67,599	100	100	0	85,142	20,589	30,079	100	52,722	100	100	100	13,364	0,002	0,001
DMU2	100	100	100	Infinity	0	89,704	0	100	38,393	20,883	100	4,247	0	0	Infinity	14,203	0	0
DMU3	76,299	100	0	76,299	0	0	0	0	18,032	35,206	100	27,078	100	0	100	16,35	0,003	100
DMU4	100	59,342	-Infinity	-Infinity	100	23,624	0	0	0	25,293	100	1,119	0	0	-Infinity	0	0	-Infinity
DMU5	100	100	100	-Infinity	100	100	0	85,142	32,688	27,554	100	4,735	0	0	-Infinity	11,49	0	0
DMU6	0,125	0	0	Infinity	0	0	0,125	0	0	0	100	20,909	0	100	Infinity	17,71	0	100
DMU7	100	100	100	-Infinity	0	89,704	0	100	38,393	20,883	100	4,247	0	0	-Infinity	14,203	0	0
DMU8	8,645	100	100	-Infinity	0	89,704	0	100	85,645	13,155	100	11,217	0	100	-Infinity	8,392	33,639	0
DMU9	36,183	100	0	76,299	100	23,624	0	0	18,032	36,183	100	28,197	100	0	100	15,842	0,003	100
DMU10	100	100	100	0	100	23,642	0	0,02	0	22,448	100	100	0	100	100	0	0,005	100
DMU11	100	0	0	0	0	0	0,052	0	0	20,71	100	100	0	100	100	1,678	0,004	100
DMU12	100	100	0	76,299	0	0	0	0	18,032	35,206	100	27,078	100	0	100	16,35	0,003	100
DMU13	100	0	0	Infinity	0	0	0,125	0	0	0	100	20,909	0	100	Infinity	17,71	0	100
DMU14	100	100	0	76,299	0	0	0	0	24,994	31,902	100	34,048	100	100	100	14,533	9,959	100
DMU15	17,71	0	0	-Infinity	0	0	0,125	0	0	0	100	20,909	0	100	-Infinity	17,71	0	100
DMU16	60,309	0	NaN	NaN	0	0	0	0	47,252	0	100	6,97	0	100	NaN	0	60,309	NaN
DMU17	100	0	0	Infinity	0	0	0,125	0	0	0	100	20,909	0	100	Infinity	17,71	0	100

Table 9: Lambda coefficients.

	DMU1	DMU2	DMU3	DMU4	DMU5	DMU6	DMU7	DMU8	DMU9	DMU10	DMU11	DMU12	DMU13	DMU14	DMU15	DMU16	DMU17
DMU1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DMU2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DMU3	0	0	0	0	0	0	0	0	0	0	0	0	0	0,636	0	0	0
DMU4	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
DMU5	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
DMU6	0	0	0	0	0	0	0	0	0	0	0	0	0,003	0,001	0	0	0
DMU7	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
DMU8	0	0	0	0	0	0	0,48	0	0	0	0	0	1,027	0,714	0	0	0
DMU9	0	0	0	0,585	0	0	0	0	0	0,362	0	0,333	0	0,09	0	0	0
DMU10	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
DMU11	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
DMU12	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
DMU13	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
DMU14	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
DMU15	0	0	0	0	0	0	0	0	0	0,531	0	0	0,323	0	0	0	0
DMU16	0	0	0	0	0	0	0	0	0	3,619	0	0	5,244	0	0	0	0
DMU17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

In order to have more specific results in relation to the efficiency of innovation, the *Efficiency Variance Coefficient* was estimated, through the estimation of the average, standard deviation and interval of cross efficiency of the reference units (Table 10, Figures 3 and 4). Based to the variance of this coefficient we can conclude about the "health" of the enterprises and the variance of their efficiency. As we can see there are significant margins of improvements, confirming the above mentioned results. At a single firm level, these that keep the efficiency variance near to 1, show a better behavior regardless the weights that has to use for the inputs and outputs of innovation.

Table 10: Indicators of Innovation Efficiency Variance of the study's enterprises.

DMU	DMU1	DMU2	DMU4	DMU5	DMU7	DMU10	DMU11	DMU12	DNU13	DMU14	DMU17
1	100	100	100	100	85,142	100	52,722	100	100	100	0,001
2	100	100	0	89,704	100	100	4,247	0	0	Infinity	0
3	100	0	0	0	0	100	27,078	100	0	100	100
4	59,342	-Infinity	100	23,624	0	100	1,119	0	0	-Infinity	-Infinity
5	100	100	100	100	85,142	100	4,735	0	0	-Infinity	0
6	0	0	0	0	0	100	20,909	0	100	Infinity	100
7	100	100	0	89,704	100	100	4,247	0	0	-Infinity	0
8	100	100	0	89,704	100	100	11,217	0	100	-Infinity	0
9	100	0	100	23,624	0	100	28,197	100	0	100	100
10	100	100	100	23,642	0,02	100	100	0	100	100	100
11	0	0	0	0	0	100	100	0	100	100	100
12	100	0	0	0	0	100	27,078	100	0	100	100
13	0	0	0	0	0	100	20,909	0	100	Infinity	100
14	100	0	0	0	0	100	34,048	100	100	100	100
15	0	0	0	0	0	100	20,909	0	100	-Infinity	100
16	0	NaN	0	0	0	100	6,97	0	100	NaN	NaN
17	0	0	0	0	0	100	20,909	0	100	Infinity	100
AVERAGE	**89,83**	**66,66**	**33,33**	**63,23**	**61,71**	**100**	**28,01**	**66,66**	**33,33**	**100**	**33,33**
INTERVAL	**100**	**100**	**0**	**89,70**	**85,14**	**100**	**27,08**	**100**	**0**	**100**	**0,001**
STD. DEVIATION	**17,60**	**47,14**	**47,14**	**44,91**	**44,058**	**0**	**19,80**	**47,14**	**47,14**	**0**	**47,14**
VARIANCE COEFFICIENT	**0,19**	**0,70**	**1,41**	**0,71**	**0,71**	**0**	**0,71**	**0,71**	**1,41**	**0**	**1,41**

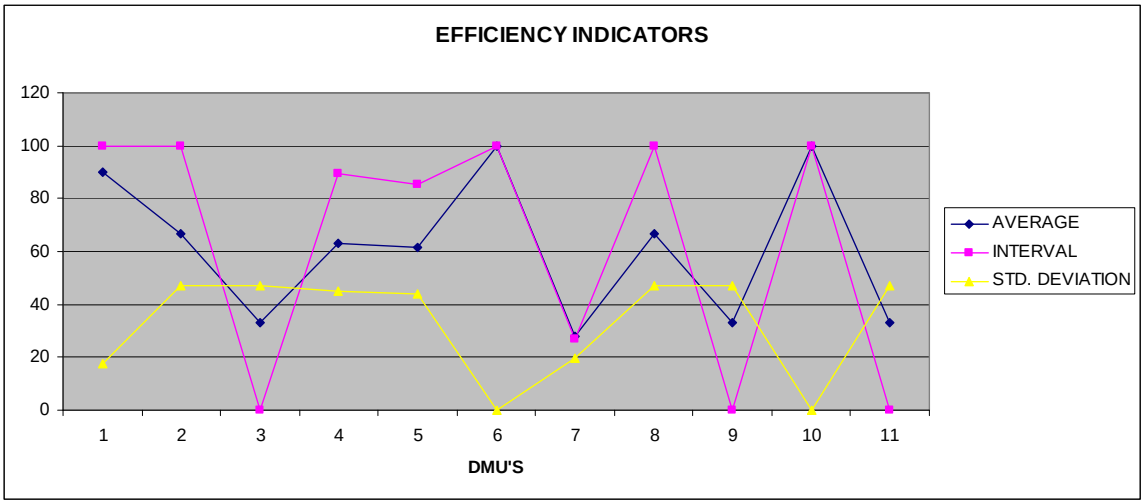

Figure 3: Indicators of Efficiency Variance of the study's enterprises.

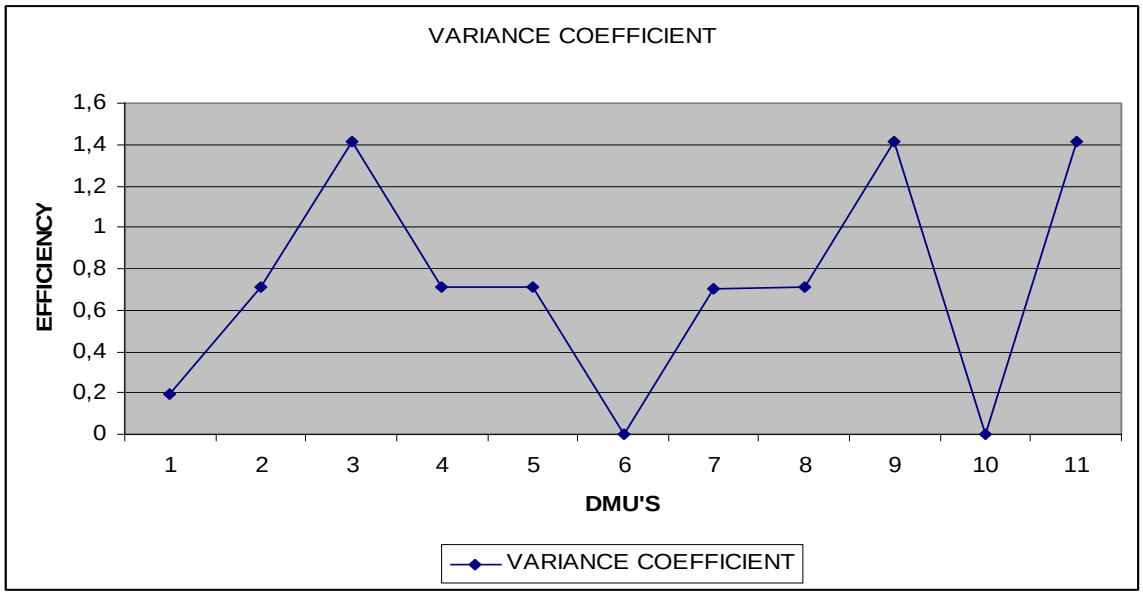

Figure 4: Efficiency Variance Coefficient of the study's enterprises.

5. CONCLUSIONS

The major percentage of the branch's enterprises adopts and improves already existing methods of production and products distribution while the enterprises which innovate through the improvement of already existing products and the production of new products, follow. Relative fewer is the number of the firms which develop new methods of production and products distribution. For that reason, it should be given the proper attention towards the direction of developing and producing of new products and methods of products distribution.

The major percentage of innovative products sales of the branch's enterprises comes from sales of products which are technologically improved and embody new methods of production and distribution, a fact that accents the effort for importing innovation in the production process. It is required a relative high cost of modern technological equipment, as long as of several production elements, for the production of new, innovative and quality products, a cost that has been embodied into total production cost. The positive results of applying innovation require a reasonable time in order to be represented to the financial data of production process.

It is quite encouraging the fact that the amount of annual turnover of the enterprises which comes from innovative products and services during the period 2005 – 2007, has been significantly raised. As a result it accents the fundamental contribution of innovation in entrepreneurial activity and the meaning that step – by – step the firms of the branch are giving in innovative products and processes, in the framework of improving their competitive position in domestic and international market. It is a matter of course that generally, increment of innovation performance incurs increment of sales while the correlation between these two variables is positive. Furthermore, a significant number of enterprises don't have the capability to invest significant amounts in activities of developing and applying innovation.

From the sum of the innovation expenditures, the majority (95,3%) concerns expenditures of innovation flows towards the firms. This fact accents the existing need for acquiring know how from the enterprises of the branch and the innovation gap, which exists in relation to the rest of the business activity of several other professional branches. The firms themselves of wood and furniture branch, do not produce innovation by their own and they clearly come behind concerning to the extraversion that have to show for whichever successful innovations they apply.

The efficiency of the enterprises innovation system is evaluated as adequate while the majority of the firms are using in a satisfactory way innovation's inputs and outputs. However, there are significant improvement margins, mainly concerning sales of products which are a result of some kind of business innovative activity, along with issues of training, innovation dissemination activities and developing and applying R&D mainly through the acquisition of external R&D and technological equipment.

The variation of efficiency shows fluctuations accenting the absence of a clearly stated strategy of the branch concerning issues of effective use of innovation factors and of the expenditures that are made for that specific reason. Finally, enterprises exist which come far behind in relation to the rest of the firms of the branch and they should make intense efforts for improving the reduction of expenditures and the best possible effectiveness of their business activity.

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