

# Evaluation of using advanced manufacturing technologies and clusters of advanced technologies.

JAN HRIBIK

Department of Economics  
University of Hradec Králové  
Rokitanského 62, 500 03 Hradec Králové  
CZECH REPUBLIC  
jan.hribik@uhk.cz

*Abstract:* - In monitoring the performance of companies using advanced manufacturing technologies were found meaningful data which were compared with data of companies that do not use advanced manufacturing technologies. For companies that use advanced manufacturing technologies, has been identified the occurrence of clusters of advanced technologies, the results were also subjected to research. It was identify a relationship between companies that use advanced technologies and their economic results achieved, although these results were partially affected by the global economic crisis, still has managed obtain measurable and meaningful results. Significant results were achieved throughout the period in value added per employee in group of companies that use advanced manufacturing technology. In pursuit of profit per employee during the period reflected the crisis, which partly influenced the expected results. Despite this complication, are presented relevant research results which are described in this paper.

*Key words:* Advanced Manufacturing Technologies, AMT, Clusters Of Advanced Technologies, CAT, Profit, Added Value, Test Criterion, Critical Value.

## 1. Introduction

The main focus of this article is to evaluate companies in terms of using advanced manufacturing technologies (AMT) and clusters of advanced technologies (CAT) and their expected impact on economic results examined subjects. Selected economic indicators were monitored in four-year term (2007-2010). There were thoroughly examined two indicators, namely profit per employee and added value per employee. These data were drawn from a database Albertina - Creditinfo Czech Republic Ltd, business register and websites of individual companies.

Research that was conducted on companies of different sizes in the Czech Republic was partly influenced by the global economic crisis, which was negatively affected by the performance of all businesses, especially those burdened with higher debt and focusing its export goods abroad. Advanced manufacturing technologies are actually all manufacturing technologies used in companies. Their implementation is usually expensive, but very beneficial for the company. Acquisition and introduction of new technology can become a competitive advantage that can have a decisive

influence on the competitiveness and the existence of the company. The technology should be naturally applied in enterprises at a particular structure that allows their effective use. It can therefore be assumed that the groups arranged in such technologies complement each other, promote and potentiate the positive synergies achieved. Such groups can be identified by technology cluster technology [1].

This paper aims to compare the benefits of using advanced manufacturing technologies in terms of economic indicators, which are compared in companies that use advanced manufacturing technologies and companies that do not use advanced manufacturing technologies during the four-year production cycle (2007-2010).

## 2. What is advance manufacturing technology?

For advanced manufacturing technology (AMT) can be considered all available production technology currently used in companies that support the operation of the company in terms of production, control, decision making and

administration. For the purposes of research included the following AMT according were companies evaluated. The most commonly used technology for companies resulting from the survey: **CNC (Computer Numerical Control)** - This is a locally programmable machines with their own minicomputers. CNC are very often part of other supporting technologies such as CAD and CAM [2], [3]; **CIM (Computer-Integrated Manufacturing)** - CIM includes complete integration of all computer systems and consolidates all information flow from management, accounting, corporate finance, design products, manufacturing and logistics operations. The system can be extended to companies of suppliers and customers. They are usually integrated technology CAD, CAM, CAE, CAPP, and CAQ [3]; **WF (Workflow)** - This is a management process and workflow activities and documents across the enterprise [3]; **TQM (Total Quality Management)** - The objective of TQM is the supply of products and the quality of service satisfying the customer at the right time and at the right price. The contents of this management system is included in the international standard of quality management and ISO 9000 [3]; **JIT (Just-in-Time Manufacturing)** - This is a method based on the idea of streamlining the supply chain by eliminating inventory and delivery of materials just in time to production; **MIS (Management Information Systems)**, **EIS (Executive Information Systems)**, **BI (Business Intelligence)** - The term decision support systems are usually generally understand the interactive computer systems that help management make use of data and models to solve unstructured problems [3]; **CRM (Customer Relationship Management)** - CRM is a business strategy focused on active management of relationships with customers at all contact points with the purpose of establishing mutually beneficial long term relationship [4]; **SCM (Supply Chain Management)** - These systems include processes that use scientific knowledge and experience to improve the ways in which the company seeks and provides resources and raw material [3]; **EAP (Enterprise Application Portals)**, **EIP (Enterprise Information Portals)** - As enterprise portals are referred to the Internet or intranet site that serves as a gateway to information sources in an enterprise [3].

Furthermore the research included these advanced manufacturing technologies, which are used less by companies from the survey: **AGV (Automated Guided Vehicles)**;

**AI (Automatic Inspection)**; **Robotics (Robots)**; **FMS (Flexible Manufacturing Systems)**; **RFID (Radio Frequency Identification)**; **AMHS (Automated Material Handling System)**; **MC (Manufacturing Cells)**; **DW (Datawarehouses)**; **APS (Advanced Planning and Scheduling)**; **MRP 1 (Materials Requirements Planning)**; **MRP 2 (Manufacturing Resource Planning)**; **ERP (Enterprise Resource Planning)**; **CI (Competitive Intelligence)**; **E-learning a E and E-Commerce.**

### 3. Methodology and aims of research

Basic data for this research was obtained through a questionnaire survey. Aim of research was comparison of the profit per employee and added value per employee for all companies that participated in the survey. Obtained a sample of companies was divided into two reference groups of manufacturing companies. The first group was made up of companies that use AMT. The second reference group was composed of companies that do not use any of the below-mentioned AMT (see Chapter 1). The first group was further divided into two subgroups of companies that use clusters of advanced technologies (CAT), and companies that AMT used separately ungrouped in clusters. CAT are seen as clusters of three or more related technologies used together in one company [5]. Monitoring companies took place in term of four years (2007, 2008, 2009 and 2010).

#### 3.1. The survey

The questionnaire, which created Mr Hynek and Mr Janeczek [3], consisted of five parts. The first part focused on the use of AMT. The second and third part was designed to evaluate and measure the benefits of these technologies. The fourth part of the questionnaire focused on performance evaluation and managers views on the AMT. The last part of the questionnaire addressed the issue of corporate performance as a whole.

To select the sample of respondents was used database of companies Albertina - Creditinfo Czech Republic, Ltd. [6]. Further information was obtained from publicly available sources, especially from the Commercial Register.

Companies were included in the research, if meet the following criteria:

1. Subject of their business is a manufacturing activity.
2. Company has more than 50 employees.
3. Company can be contacted by e-mail and it has in the database of Creditinfo recorded most of the required economic characteristics.

In the sample of respondents there were companies

with 50 - 99 employees represented by 61.8%, companies with 100-499 employees represented by 30.1% and companies with 500 or more employees only 8.1%. Enterprises that had fewer than 50 employees were not included in the survey. These differences in the composition of respondents are reflected in the intensity and character of the use of VT.

Questionnaire together with a covering letter were sent by post to companies, which were previously selected on the basis of criteria. The return of questionnaires was further supported by e-mail and phone requests. The final rate of return, however, despite these efforts was around 11.7%. Acquired questionnaires and responses were registered in them were entered into the database.

### 3.2. Acquisition of data

Basic data about technologies used or unused in companies, were obtained through questionnaire, which were detected: company's name, advanced manufacturing technologies that are used in the company, comments and pieces of knowledge of managers. Subsequently there were traced information concerning profit per employee and value added per employee of the companies in the database Albertina, the database of company Creditinfo Czech Republic Ltd. Data that could not be found in that database has been traced from the website of the Czech Commercial Register and the websites of individual companies. Data collection was conducted in the years 2010 and 2011. Profit and added value were allocated on the number of employees due to adjustment differences in sizes of companies and easier comparisons between samples.

### 3.3. Determination of assumptions

Aims of this paper are determinations the development of economic indicators for companies that use and do not use AMT and CAT. To realize the objectives were determined following research assumptions A1, A2, A3 and A4. Assumptions A1 and A2 are made based on expected benefits of the use of advanced manufacturing technologies, which should result in competitive advantages of these companies, which should achieve better economic indicators than companies that do not use AMT. The same premise applies to the A3 and A4, where it is seen as a competitive advantage of the existence of CAT, which should result in higher profit per employee and added value per employee.

A1: Profit per employee is higher for companies using advanced manufacturing technologies than the profit per employee of companies that do not use

any technology in their activities in 2007-2010.

A2: Added value per employee is higher for companies using advanced manufacturing technologies than added value per employee of companies that do not use any technology in their activities in 2007-2010.

A3: Profit per employee in 2007-2010 will be higher for companies with clusters of advanced technologies, than the profit per employee at companies using advanced manufacturing technologies, but do not have clusters of these technologies.

A4: Added value per employee in 2007-2010 will be higher for companies with clusters of advanced technologies, than added value per employee at companies using advanced manufacturing technologies, but do not have clusters of these technologies.

### 3.4. Testing of assumptions

To test assumptions were used statistical method for testing hypotheses about the compliance of two diameters. Hypothesis which validity is verified is called the null hypothesis  $H_0$ . Against the null hypothesis is always built an alternative hypothesis  $H_1$ . Statistical tests are procedures that we check the null hypothesis. On this basis the hypothesis are accepted or rejected. Parts of the testing are two values: Test Criterion (TC) and Critical Value (CV)[7]. If is consider the one sided hypothesis testing, it is necessary to determine the interval of acceptance and interval of rejection. If the value of TC is in the interval  $(-\infty; CV]$  occurs that is not rejected  $H_0$ . If the TC is in the interval  $(CV; \infty)$  leads to rejection of  $H_0$  and acceptance of  $H_1$  at 1% significance level[8]. Significance level means that is less than 1% that is rejected  $H_0$  although it should not be rejected.  $\mu_0$  = diameter of companies using AMT,  $\mu_1$  = diameter of companies not using AMT,  $\mu_{11}$  = diameter of companies having CAT,  $\mu_{12}$  = diameter of companies not having CAT.

### 3.5. Composition of the sample

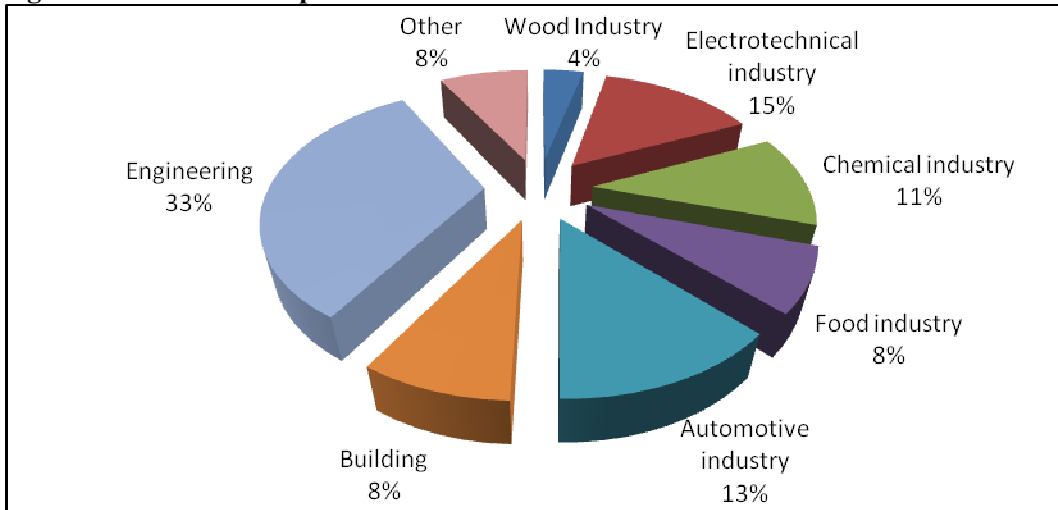
The sample consists of 131 companies, which are divided into two reference groups. The first group consists of 99 companies using AMT. The second group consists of 32 companies that do not use any AMT. The sample consists of 131 companies, which are divided into two reference groups. The first group consists of 99 companies using AMT. The first reference group also consists of two subgroups, consisting of 39 companies that have CAT and 60 companies that do not have CAT.

The business activity of all 131 companies is the manufacturing activity. The highest incidence of covered

companies is in 7 industries: Wood Industry, Electro-technical Industry, Chemical Industry, Food Industry, Automotive Industry, Building, Engineering and group Other, which captures the remaining industries that were

represented by fewer than three occurrences. The composition of all industry is shown in Figure 1.

**Fig. 1: Distribution of companies in different sectors**



Source: Own study

#### 4. The research results

Research results are summarized in Tables 1-4. Tables 1 and 3 are tables in which summarized data are collected from a survey. Tables 2 and 4 are

processed by statistical calculations of the acceptance and rejection of hypotheses about the compliance of two diameters.

**Table1: Profit and Added value of companies using and not using advanced technologies in €**

	2007		2008		2009		2010	
	Profit per 1 employee	Added value per 1 employee	Profit per 1 employee	Added value per 1 employee	Profit per 1 employee	Added value per 1 employee	Profit per 1 employee	Added value per 1 employee
Use AT	6100,8	23419,2	6139,2	23462,4	3523,2	21600	7387,2	27907,2
Do not use AT	3508,8	12633,6	6374,4	17616	4060,8	15120	4742,4	17092,8

Source: Own study

**Table 2: Testing of assumptions A1 and A2 -  $H_0: \mu_{11} = \mu_{12}$ ;  $H_1: \mu_{11} > \mu_{12}$**

Year	Critical Value	Profit per 1 employee			Added value per 1 employee		
		Test Criterion	$H_0$	$H_1$	Test Criterion	$H_0$	$H_1$
2007	2,61388	5,56300	Rejected	Accepted	4,93214	Rejected	Accepted
2008	2,61388	-0,24589	Not rejected	Rejected	4,57453	Rejected	Accepted
2009	2,61388	-0,92661	Not rejected	Rejected	3,12178	Rejected	Accepted
2010	2,61388	7,08262	Rejected	Accepted	6,23877	Rejected	Accepted

Source: Own study

During the verification the assumption A1 is possible to see in Table 2 that in 2007 confirmed the assumptions, which rejected the null hypothesis and accept alternative hypothesis. The view to the table 1 below shows a big difference between profit per employee for companies having AT and not having AT. Between 2008 and 2009 failed to confirm the assumption of a higher profit per employee for companies having the AT, where in both years the difference between the two groups, both negative and low, which is not at 1% significance level statistically meaningful. The year 2010 is the year when we have confirmed the assumption A1, as shown in Table

2. The difference in profit per employee this year is almost € 2,645, which is a noticeable difference, which clearly confirms the A1.

Assumption A2 for higher added value per employee for companies having advanced technologies are able to confirm the entire period 2007 - 2010. The highest differences were measured between 2007 and 2010, the years that have not been negatively affected by global economic crisis. Between 2008 and 2009 the difference in measured values although smaller, but at 1% significance level is clearly rejected the null hypothesis and adopted alternative hypothesis, see Table 2.

**Table 3: Profit and Added value of companies having and not having clusters of advanced technologies in €**

	2007		2008		2009		2010	
	Profit per 1 employee	Added value per 1 employee	Profit per 1 employee	Added value per 1 employee	Profit per 1 employee	Added value per 1 employee	Profit per 1 employee	Added value per 1 employee
<b>Have clusters of AT</b>	6537,6	24052,8	6081,6	22351,7	2092,8	21268,8	10848	33710,4
<b>Do not have clusters of AT</b>	5664	20428,8	6196,8	21525,1	4953,6	23572,8	3926,4	22104

Source: Own study

**Table 4: Testing of assumptions A3 and A4 -  $H_0: \mu_0 = \mu_1$ ;  $H_1: \mu_0 > \mu_1$**

Year	Critical Value	Profit per 1 employee			Added value per 1 employee		
		Test Criterion	$H_0$	$H_1$	Test Criterion	$H_0$	$H_1$
<b>2007</b>	2,73848	2,99523	Rejected	Accepted	3,12554	Rejected	Accepted
<b>2008</b>	2,73848	-0,02483	Not rejected	Rejected	0,34896	Not rejected	Rejected
<b>2009</b>	2,73848	-0,22517	Not rejected	Rejected	-0,42577	Not rejected	Rejected
<b>2010</b>	2,73848	6,32211	Rejected	Accepted	5,35694	Rejected	Accepted

Source: Own study

Assumptions A3 when are expected higher profits per employee in firms having CAT, is confirmed only in 2007 and 2010, when the 1% significance level rejected the null hypothesis and accept alternative hypothesis, see Table 4 Above all, the difference between profit per employee is significantly higher in the year 2010, see Table 3. Differences in profit per employee is between two groups in 2008 and 2009 negative which speaks in favor of companies non having CAT, which is A3 unconfirmed. The reason for poor results in these years has been mentioned global economic crisis.

Assumptions A4 are related to higher added value per employee at companies which have CAT. A4 could not be confirmed in 2008 and 2009 as shown in Table 4. In 2008, while the added value per employee was higher, which would correspond

to the assumption A4, but the statistical test showed that at 1% significance level this difference is not statistically significant. In years 2007 and 2010 it managed to prove the assumption A4 which is evident both from the difference between the measured values in Table 3, so the statistical tests in Table 4.

## 5. Conclusion

In pursuit of companies that participated in research on the use of advanced technologies managed to find a relationship between profit per employee and the use of advanced technologies, as well as the relationships between added value per employee and the use of advanced technologies.

Unfortunately, the period was unexpectedly affected by global economic crisis that affected the financial performance of all companies in all sectors of the economy.

Overall, all the assumptions confirmed in years 2007 and 2010. The year 2007 was quite a normal year, compared to 2010, which marked the start of a new economic growth, when the companies managed to reduce costs while increasing sales volume. The year 2010 is from the perspective of the most successful year of research, the differences between companies using advanced manufacturing technologies is clearly the highest. The year 2008 is year when the crisis broke out, which was reflected in the financial results of companies monitored, confirmed only when the assumption A2 are related to higher added value per employee at companies using AT.

The year 2009 was the worst year in the research. In this year was the global economic crisis in the boom, which resulted in gross influence of the results of all investigated companies. Although the results for 2009 within assumptions A1-A4 is negative, the data obtained can point to an entirely different result, and the result reversed when it became clear that during the ongoing global economic crisis is profit per employee higher in companies that do not have any AMT or any CAT. Put simply: "Companies that do not use any advanced technology, could achieve higher profits than firms that use advanced manufacturing technology" or "The less technology

the company uses, this leads to higher profits per employee in the economic crisis." The main reason for this finding will be high costs of acquiring the advanced production technology, which is reflected in the results of the management companies. It would be interesting in future to submit the results of the 2009 years with the results, which will take effect the next global economic crisis.

Put simply: "Companies that do not use any advanced technologies, could achieve a higher profit per employee than companies that use advanced manufacturing technology" or "As less technologies the company uses, as leads to higher profits per employee during the economic crisis." The main reason for this finding will be high costs of acquiring the advanced manufacturing technologies, which is reflected in the results of the management companies. It would be interesting in future to submit the results of the 2009 years with the results, which will take effect the next global economic crisis.

In overall terms are results of the research divided into two parts, the successful and affected by the crisis. If did not became affect of the years 2008 and 2009, it is very likely that the assumptions A1, A2, A3 and A4 could be confirmed throughout the period. This research will continue for analyzing longer period.

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