

The Post-implementation Assessment of Advanced Technology Utilization

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Abstract

Efficient utilization of advanced manufacturing technology is usually seen as one of the crucial factors in achieving competitiveness on global markets. On the other hand, there are many problems associated with the advanced technology utilization. These problems could be related to the individual phases of the relevant project life cycle - starting from the early stages of AMT projects preparation and evaluation, through various problems related to the project implementation, its integration within the company environment, up to the issues related to the efficient utilization of the already deployed system. This paper focuses on the final stage of this process when the post-implementation assessment should be carried out in order to determine whether all initial expectations and objectives were met and whether all the originally promised benefits were delivered. Typical problems of technology benefits evaluation together with various methods, concepts as well as metrics used in the process of the assessment will be discussed here in particular.

Key words: advanced manufacturing technology utilization, technology benefits identification and quantification

1. INTRODUCTION

Global competition in manufacturing poses invariably increasing requirements on manufacturing companies worldwide that have to take every opportunity in order to maintain or even increase their position on demanding markets. They strive to reduce the cost of manufacturing, improve the quality of their products, increase the throughput as well as production flexibility and they continually look for new ways on how to achieve it. And of course, it is obvious that manufacturing companies in economically developed countries cannot rely on cheap labor force and therefore massive and effective utilization of advanced manufacturing technology (AMT) is regarded as one of the crucial factors that help to achieve the above mentioned goals. These computer-based technologies include a great variety of tools, machines and devices ranging from isolated systems like CAD, CAM, numerically controlled machines, robots etc. up to the fully integrated systems like CIM or FMS.

On the other hand, it is clear that advanced technology deployment in itself does not automatically guarantee a lower cost of production, higher productivity and better quality. AMT is as a rule rather expensive and it means that there is a need to cover the initial as well as operational expenses before the company can produce any profit. Although managers are usually well aware of the importance of AMT for the company and its competitiveness in general, it is an unquestionable truth that manufacturing companies are under constant economic pressures and their managers are pushed to economize and cut costs whenever possible. Secondly, AMT is very often a long-term nature investment and it takes time to utilize it efficiently, to interlink it with



other company systems and overall manufacturing environment, to train the staff properly etc. And of course, AMT is associated with a higher degree of risk especially if the particular company lacks experience with the specific type of technology.

Based on the facts mentioned above it is clear that there are many problems associated with the advanced technology utilization. These problems could be related to the individual phases of the relevant project life cycle - starting from the early stages of AMT projects preparation and evaluation, through various problems related to the actual project implementation, its integration within the whole company environment, up to the issues related to the efficient utilization of the already deployed system as well as the methods used to determine whether the system meets the originally planned objectives.

Let us assume that the decision related to the particular AMT project was carefully and deliberately taken and its implementation was successful and the particular system is already in the phase of routine operation. We believe that it is a right time to carry out the overall assessment of technology proper and efficient utilization. This assessment should determine whether all our initial expectations and criteria were met and whether and all the originally promised benefits were delivered. We are fully aware of the fact that it is too late to change our former decision. Nevertheless, the problems revealed within this process could be highlighted and perhaps even resolved, new opportunities for system utilization as well as some benefits that were neglected during the preparatory phases could be found. And on the top of it, we will learn more about valuation technology projects that is very important for further AMT adoption. That is why we have decided to study post-implementation phase evaluation processes in greater detail and we will present some of our results here.

2. PREVIOUS WORK

We proudly acknowledge that our research has been inspired especially by the effort of Lefley and Wharton (1993) and Lefley and Sarkis (1997). These authors examined carefully AMT projects evaluation processes in the United Kingdom and the United States of America. They undertook extensive surveys both in the UK and the USA in order to learn more about current practices in respect of capital investment in AMT projects, to identify if there were perceived difficulties in appraising these projects and to elicit the opinions of senior executives on the various issues related to AMT projects evaluation. Among other things they found out that managers do have many difficulties when assessing various benefits of AMT.

The first comprehensive study in this field in the Czech Republic (Lefley et al., 2004) revealed that despite of many differences ascertained especially in the extent as well as the level of evaluated and implemented technology, where Czech manufacturing companies lagged behind their western competitors, there were many problems related to AMT projects evaluation that were common for managers from all the three surveyed countries. These results even fostered our interest to conduct further two surveys in the Czech Republic in 2005 and 2009 focused on specific issues related to AMT adoption and utilization in order to identify the relevant changes in the results that we expected due to the specific conditions of quickly transforming Czech economy.

The second source of inspiration originated from several surveys that were carried out in the UK, New Zealand and in Australia (Sohal, 1994; Sohal et al., 1999; Sohal, 1996) in order to assess the anticipated differences between management expectations associated with AMT adoption and real experience. They prepared set of questions designed to examine the extent to which respondents' views of the benefits of investment into AMT has changed as the result of the project implementation. The respondents scored the importance of a list of benefits as perceived at the time of the appraisal investment and then the extent to which these benefits were seen to have been achieved after the new technology has been deployed. The results of the research conducted in the United Kingdom and in Australia (Sohal, 1994) revealed that many desired and expected benefits were not fully achieved after the relevant advanced technology project implementation.

The results of our research that was described in (Hynek and Janeček, 2010) confirmed that there are many disproportions between the benefits expected and the benefits realized and we concluded that this fact could constitute a serious problem for further AMT projects. Overestimation of some expected benefits could cause much lower degree of overall satisfaction with the project when it reaches the phase of routine operation. On the other hand, exceedingly conservative approach to the benefits estimation could be very dangerous too as underestimation of some benefits could easily lead to the unfavorable circumstances when the project proposal could fail in initial phases of the relevant decision making process being unable to balance the total cost of the proposed solution.

Thomas et al. (2008) recently investigated attitudes towards benefits of AMT in 300 manufacturing SME in the United Kingdom. They found that many SMEs were unaware of potential benefits that a new technology can offer and none of them utilized any formal model that would ensure that the implemented technology effectively contributed to the overall performance of the company. As there were no clear benchmarks, many companies were unable to evaluate correctly the success of the new technology implementation.

Summarizing these pieces of work it is clear that there is a need to study further the process of post-implementation assessment of AMT and the pertinent problems. In particular, we will narrow our focus to the relevant methods, concepts, and metrics that are used in surveyed companies in this respect and we will describe the main problems of AMT benefits evaluation here too.

3. METHODOLOGY

Our team carried out three major surveys focused on AMT utilization and exploitation in the Czech Republic within last two decades. Our first postal survey was realized in 1998 and we used the questionnaire that was derived from the original one that was used in the UK and the USA (see Lefley and Wharton, 1993). The goal of this survey was to find out the level of implementation of AMT that had been achieved in the Czech manufacturing companies to date; to determine which techniques and criteria were used in capital project appraisal and what methods, if any, were used to measure and take into account project risk; to determine which measures were used to assess the performance of senior executives as it appears that management in general is reluctant to make long-term risky investments (such as those in AMT) and prefers to invest in

short-term projects that show early profits and low risk; and to explore opinions about the need for AMT investment, the efficacy of the investment criteria used and the extent to which other factors and considerations had a bearing on capital investment decisions.

The second postal survey that was focused on the same issues was conducted in 2005 and we decided to include also the middle sized Czech manufacturing firms this time in order to broaden the scope of our research. Moreover, we added one extra section to the questionnaire that was used in the Czech Republic in 1998. It was devoted to the utilization of EVA (economic value added) indicator in surveyed companies as there were some suggestions that there might be a relationship between utilization of this concept and investment behavior of manufacturing companies. The results of the both surveys (1998 as well as 2005) concerning advanced manufacturing technology benefits evaluation were described at full length in (Hájek et al., 2005).

Our last survey in the Czech Republic was conducted at the end of 2008 and the beginning of 2009. This time a completely new questionnaire was designed and used. Of course, we have partially built upon our previous experience acquired during the former surveys, but as we already indicated above we wanted to enlarge the scope of our research focus too. The questionnaire comprised of five parts. The first one was designed in order to find out which kind of advanced technology is regularly used and/or planned. The second part was devoted to the advanced technology benefits evaluation issues and the following one was focused on measurement of these benefits and the pertinent problems. The fourth section comprised of questions related to the measures used to assess the performance of senior executives and the opinions of top management concerning utilization of advanced technology. Final part of the questionnaire was devoted to the whole company performance measurement and the utilization of EVA concept as we did in 2005.

Due to the economic problems caused by the global financial crisis we have decided to further increase the set of respondents up to 1360 manufacturing companies. Unfortunately, many questionnaires returned back as undeliverable, some companies were closed down and several companies reported termination of their manufacturing activities, which restricted the original larger pool into 1127 virtual respondents. The questionnaires were sent out in two rounds within a time span of six weeks and then we started a wide campaign based on individual attempts to get the results by means of individual e-mails and telephone calls. Altogether we have managed to collect 132 usable questionnaires out of 1127 respondents. The response rate 11.7% is slightly lower than in 2005 but taking into account the current economic circumstances it should be considered favorably.

In addition to the postal survey we have also visited 12 selected companies and we held structured interviews with the top managers of these companies in order to validate some specific results learn more about some specific issues and problems related to the AMT utilization in general and AMT benefits evaluation in particular the Czech Republic.

4. POST-IMPLEMENTATION ASSESSMENT OF AMT

It is quite natural to assume that if there was a proper, full-scale, and methodical evaluation process, regardless it was based on economic, analytical, or strategic basis, or some combination of these approaches, there should be various sound criteria that could be used in order to assess

whether the implemented solution meets original expectations that were declared at the initial stages of AMT project planning (Chan et al., 2001). It is not always the case, but even if we are in such a favorable situation we still need some methods, concepts, methods and particular metrics that are suitable for evaluation of AMT benefits.

Concerning general purpose methods and concepts that are used in Czech manufacturing companies as a framework for the AMT post-implementation assessment, the most popular concepts are ISO standards (claimed to be used by 66.7% of respondents), Total Quality Management (27.3%), and benchmarking (24.2% of respondents). It should be stressed that many companies use more than one concept and that is why the total percentage of three most popular methods only is greater than one hundred percent.

It was not a big surprise to find out that utilization of ISO standards is so widespread because these regulations are internationally recognized and routinely used by many manufacturing companies worldwide. Nevertheless, it is rather questionable whether this concept is a suitable and appropriate one for the evaluation of AMT benefits. The other two concepts named above ranked with a considerable distance but on contrary to ISO standards we can imagine rather broad utilization of TQM and benchmarking concepts for the purpose that is under our consideration here. We were a bit disappointed to see that other concepts that are usually regarded as popular and well known, as Balanced Scorecard, Six Sigma, or technologically more focused COBIT, were utilized by insignificant number of manufacturing companies only. And finally, it should be stressed that every fourth respondent did not name a single concept that is used in their company.

Very important issue is the proper choice of metrics that can help us to assess the degree of fulfillment of a particular goal, efficiency of individual processes and level of utilization of relevant resources. We discriminate between hard and soft metrics. While the hard metrics are objectively quantifiable indicators, soft metrics are usually based on some qualitative aspects that cannot be easily identified or measured but still provide us important pieces of information in relation to the evaluated issue.

We have realized that number of companies that use hard metrics (69.7%) in the context of AMT assessment is slightly higher than number of companies that use soft metrics (60.0%). This ascertainment is in conformity with our assumptions and amongst huge variety of different metrics increased productivity, number of reclamations, cost savings, as well as customer satisfaction were the most popular ones. The surprising fact comes up when we make an attempt to interpret the above mentioned results in a directly opposite way. It is clear that 30.3% of respondents were unable to name a single hard metric that is used in their company and the similar fact is true regarding soft metrics where 40.0% of our respondents did not put forward any soft metric. It is difficult to imagine that there is a serious post-implementation evaluation process of an AMT project and there is no need for any soft nor hard metric.

We created a long list of various soft and hard metrics and we asked the respondents to point out the specific metrics that are used in their company. Labor productivity (56.1%), number of complaints (56.1%), costs saving (55.3%), customer satisfaction (52.3%), payback and meeting delivery terms (both scored 49.2%) were among the most often examples of particular metrics used in surveyed companies. On the other hand, change in production structure (12.1%) and rate of change in production size (15.9%) were utilized by few companies only.

We are aware of the fact that managers in economically developed countries admit serious problems related to advanced technology benefits identification and quantification (Lefley et al., 2004). Moreover, these problems are in common for much wider class of computer-based technologies. Remenyi (2003) concluded that the four important factors that substantially influence the problems related to information technology benefits assessment are identification of the relevant benefits, identification and quantification of intangible benefits, complex impact of implemented system on individual parts of organization as well as the organization as a whole, and evolution and versatility of benefits and their importance in time. Similar but more detailed analysis of the problems associated with information and communication technologies can be found in (Ballantine and Stray, 1999). They identified eleven problems that could be viewed as relevant for AMT assessment too. That is why we have built on their research and we wanted to confirm this assumption. We presented these problems to our respondents and we asked them whether they regard each of them relevant in the process of AMT post-implementation assessment. The problems that were acknowledged by more than half of our respondents are listed in table number 1.

We can see that the most difficult problems are related to benefits identification (70.4% of respondents) and their subsequent quantification (70.7%). This ascertainment is fully conformable with the results that were mentioned above (Ballantine and Stray, 1999; Remenyi, 2003; Lefley et al., 2004). Moreover, it is a very anxious fact to realize that two out of three managers (65.4%) admitted lack of interest in using project appraisal and evaluation techniques. And on the top of it, we can see that the fourth most important problem identified in the table number 1 is unfamiliarity with project appraisal and evaluation techniques as 59.5% of respondents supported this statement. The combination of these factors creates extremely unfavorable environment not only for the post implementation project evaluation but for adoption of AMT projects and efficient utilization of advanced technology in general.

Tab. 1 - Problems of advanced technology benefits evaluation. Source: authors

Problems of advanced technology benefits evaluation are associated with:	Agree [%]
Quantification of relevant benefits	70.7
Identification of relevant benefits	70.4
Lack of interest in using project appraisal and evaluation techniques	65.4
Unfamiliarity with project appraisal and evaluation techniques	59.5
Quantification of relevant implicit costs	58.8
Identification of relevant costs	53.8
Difficulty with interpreting results	51.9
Identification of relevant implicit costs	50.7

And finally, we would like to return to the already mentioned differences between benefits expected during the planning stage of AMT project and benefits derived after the project completion when the technology is in routine operation. In accordance with Sohal's methodology (Sohal, 1994) our respondents were given a list of benefits and we asked them to score the importance

of each benefit as perceived at the time of the appraisal investment and then the extent to which the benefit was seen to have been achieved after the new technology has been deployed. The number of points allocated to each benefit was summed up and then all the benefits were ranked according to their importance. The whole ranking is rather long and it can be found in (Hynek and Janec̃ek, 2010) and that is why we present here just top five expected benefits in table 2.

We can see there that the first four expected benefits (reduced cost, improved quality, increased throughput, and obtaining competitive advantage) preserved their position within top five benefits realized. It is clear that the most desired benefit “reduced cost” has not been fully achieved as it scored on the fourth place amongst benefits realized. Moreover, the item “increased sales” lost even more places as it went from the fifth position on expectations list down to the eleventh place on the experience list indicating that implementation of advanced technology facilitated much lower degree of salability than managers originally expected.

Of course, there are many more interesting changes in both directions and while some benefits were overestimated as we could see above, there are many benefits that were underestimated too. To make these differences more explicit we created table 3 where all the benefits where the difference between expectations and reality was three and more places are lined up.

Tab. 2 - Expectations and experience of the benefits of AMT investments in CR. Source: authors

Benefit:	Expectation Ranking	Experience Ranking
Reduced cost	1	4
Improved quality	2	2
Increased throughput	3	1
Obtaining competitive advantage	4	5
Increased sales	5	11

The lowest descent has been associated with “improved workforce attitudes” which went down from the twelfth place to the twenty-first which resulted in nine positions difference. On contrary it should be noted that “improved response in variations in product volume” went up by nine places and “widening product range” marked even higher leap as it jumped from the twenty-fourth position up to the thirteen which means eleven position difference. Furthermore, it is interesting to realize that there are 11 benefits (out of 26) where the difference of 3 and more points in ranking was found. Furthermore, there are 5 benefits (out of 26) in table 3 where the difference of 5 and more points in ranking was observed.

Based on these ascertainments it is clear that the above described problem with relevant benefits identification and quantification is magnified by management unrealistic expectations. There is a clear lack of experience that is partly caused by the nature of AMT and its new features that cannot be understood to the same detail as it could be expected when implementing traditional and well-known technology.

Nevertheless, it would be too easy to blame everything on the specific character of new and emerging technology. The results of our research indicate that there is also an evident lack of

technology assessment and evaluation skills on the side of managers of manufacturing companies. Altogether, as we have already mentioned that post-implementation assessment of AMT projects could serve as an important source of experience for further and perhaps even more efficient investment into AMT, we have one additional and very strong argument for doing the assessment properly and thoroughly.

5. DISCUSSION

The ascertainments described and discussed here constitute just a small portion of the overall results acquired within the frame of our research and our latest survey. Narrowing our focus on selected issues, we have demonstrated that there are many problems related to AMT benefits evaluation in Czech manufacturing companies and our results are in compliance with research results in other economically developed countries. However, from the point of view of manufacturing companies, it does not mean that we shall just accept it nor to be pleased with the facts presented here. Especially the recognition that every fourth respondent were unable to name a single general concept or framework that is used for relevant project evaluation, and that two thirds of our respondents acknowledged lack of interest in using project appraisal and evaluation techniques is a very disappointing and alarming matter that should not be underestimated.

Tab. 3 - Differences between expectations and experience ranking (three and more places).
Source: authors

Benefit:	Expectation Ranking -Experience Ranking
Improved workforce attitudes	-9
Increased sales	-6
Improved integration of manufacturing information systems	-5
Improved integration of information systems across functions	-4
Reduced cost	-3
Improved management attitudes	-3
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Reduced product development time	3
Improved response to variations in product mix	3
Increased flexibility	4
Improved response in variation in product volume	9
Widening product range	11

Concerning limitations of our research, we are aware of the fact that the collected data and results of our survey could be influenced by the current difficult economic situation. It would be very interesting to find out whether and to what extent are the management attitudes towards AMT projects influenced by the stage of business cycle. Therefore we plan to further continue

with our investigation to be able to observe the behavior of Czech manufacturing companies from the advanced technology utilization point of view during the whole period of business cycle. It should help us to answer the question stated above but it will also allow us to examine the ability of manufacturing companies to face the situation of economic downturn and the specific role of advanced technology in this process shall be thoroughly investigated. We shall be able to determine whether companies that were more successful in advanced technology adoption before the economic downturn were better prepared for hard times to come. And of course, we have to admit that the opposite assertion might be true and that high level of investment that is commonly associated with the advanced technology implementation created even more difficult economic problems to the relevant companies. On the top of it, we would like to learn whether companies utilizing AMT possess significant advantages during the period of economic recovery. In particular, we would like to determine whether the process of recovery is fast and rapid enough to cover conceivable losses sustained during the period of economic recession.

6. CONCLUSIONS

Based on the results described in this paper we can confirm an uncomfortable conclusion that Czech manufacturing companies struggle with internationally accepted problems related to insufficient abilities to identify and quantify benefits of AMT. In addition to this fact, we have shown that there is a widespread lack of interest in using relevant project appraisal and evaluation techniques together with extensive unfamiliarity with the relevant methods and techniques. And on the top of it, we have proved that managers have some unrealistic expectation and regardless the overestimation or underestimation of the relevant benefits, it is clear that these differences could be jeopardous not only for the actual project success but they can put into ruins the prospects for further AMT projects too. The combination of all these factors creates an environment where a serious post-implementation evaluation process of AMT investment is very difficult or even impossible.

Of course, many managers and technology promoters would say that there is no need for post implementation assessment of AMT investment – the project has been implemented, technology has been deployed and its benefits are already visible or they will emerge soon. We have to take into account that any technology investment competes for limited company resources with other alternative projects and inability to demonstrate clear and measurable outcomes could easily discredit not only the already implemented project but it can create a very difficult situation for any further technology investment.

It would be too optimistic to assume that the problems discussed here could be easily solved. Based on the results presented here we can see that it is necessary to change the whole way of thinking about technology and the relevant projects consideration. We believe that universities can play an important role in this process as there is a lot of space in the area of the technology evaluation and assessment methods dissemination. Moreover, especially technical schools and universities should pay much more attention to the education of technology specialist who definitely need more skills in the field of identification of particular technology benefits from various points of view. Their awareness of various benefits associated with the particular type of AMT should help them to identify the benefits and even asses their importance and magnitude.

Their prospective ability to describe the benefits in terms that are comprehensible for managers can significantly improve the chance of the AMT project to get approved. And that is the only way to see more advanced technology projects efficiently implemented in our manufacturing companies.

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