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Effects of Advanced Manufacturing Technologies on Manufacturing Company Performance

Jasna Prester[1] – Borut Buchmeister[2] – Iztok Palčič[2,*]
[1] University of Zagreb, Faculty of Economics and Business, Croatia
[2] University of Maribor, Faculty of Mechanical Engineering, Slovenia

Literature findings on the effects of advanced manufacturing technology (AMT) on company performance measures is currently inconclusive. There is also a lack of recent research on this issue from a contingency perspective. It is also a fact that the majority of research is conducted in developed countries. This research is based on the contingency theory perspective, and it attempts to add value to the observed literature gaps by exploring two less developed countries Slovenia and Croatia. Using survey data from 138 manufacturing companies from Croatia and Slovenia, we tested the effects of twenty technologies on different performance measures through five ordinary least squares regression analyses. Contingency factors in terms of company size, batch size, product complexity, included as control variables in analyses, proved insignificant for technologies' use and their effect on profits before tax, decrease in the scrap rate, material and staff costs. On the other hand, AMT has impact on material consumption, scrap rate and profits, but not in a positive hypothesised relationship.
Keywords: advanced manufacturing technology, manufacturing company, operations' performance, contingency theory, European manufacturing survey

Highlights
- *The impact of advanced manufacturing technologies (AMT) use on manufacturing company performance is studied.*
- *The research of AMT use and their impact on company performance is based on the contingency theory approach.*
- *Contingency factors such as batch size, company size and product complexity do not influence staff costs, innovation revenues, scrap rate or profit before tax significantly.*
- *AMT have impact on material consumption, scrap rate and profits, but not in a positive relationship.*

0 INTRODUCTION

Today, many market environments are characterised by the rising costs of raw materials, technological and economic uncertainty and decreasing profit margins. There is a general trend towards an increase in the use of technology in manufacturing plants, due to the belief that this will improve some performance measures (e.g. reductions in costs or human resources, improved quality or flexibility) and profitability [1]. Empirical evidence has shown mixed results of the advanced manufacturing technology (AMT) use on performance, therefore, calling for additional research on this specific field of operations management. Some research showed positive effects, while others demonstrated negative or non-significant effects. For the purpose of our study, we follow Baldwin and Sabourin [2], who defined AMT as "a group of integrated hardware-based and software-based technologies which, if properly implemented, monitored, and evaluated, will lead to improving the efficiency and effectiveness of the firm in manufacturing a product or providing a service".

The discrepant findings in the literature suggest there is a need to identify contingencies that may govern the AMT–performance relationships [3]. Contextual variables are strategic context, company size, production processes type, or product complexity [4]. Except for Raymond [5] who shows positive effects of technology use on the performance of SMEs, no other research focused on differences in performance depending on company size. Therefore, our first question is how contextual variables such as company size, production processes type, or product complexity affect performance through the use of AMT.

Moreover, technology evolves on an almost yearly basis. When analysing literature, it is important to consider the year in which the research was conducted. Analysing current research on AMT through the contingency theory, most research was conducted between 1990 and 2001, with later research not even mentioning the year it was conducted. Additionally, the majority of studies explore a single manufacturing technology [6]. Therefore, these facts present a clear gap in literature and a need to show recent results of different AMT use and their impact on manufacturing company performance.

1 LITERATURE REVIEW ON CONTINGENCY THEORY AND AMT IMPACT ON COMPANY PERFORMANCE

The contingency theory explains that the same set of contingencies will not lead to the same result due

*Corr. Author's Address: University of Maribor, Faculty of Mechanical Engineering, Smetanova ulica 17, 2000 Maribor, iztok.palcic@um.si

to different contextual factors [7]. Contextual factors are often situational factors, usually exogenous to the company. These factors can be changed, but this can happen only in the long run and with substantial effort [8]. The mentioned contextual variables are strategic context, company size, production processes type, or product complexity [4]. The contingency theory suggests that performance should increase when there is a fit between a company's use of practices and dimensions of the organisational context in which it takes place [5] – a better fit yields better performance [9]. Performance variables are the dependent measures, and they measure the fit between the contextual variables and contingency variables for a situation under consideration [8]. As far as performance variables are concerned, there is a plethora of variables used in literature, ranging from growth to operations performance measures, so it is not easy to compare different research studies and their findings. According to Sousa and Voss [8], operations performance measures are not used enough and survey research is appropriate for identifying contingency effects.

A comprehensive review of literature shows there are only few research studies dealing with AMT through contingency theory, among which Boyer et al. [10] appears to be the most influential one. Careful inspection of the researched AMT in Boyer et al. [10] shows that those were the most used technologies at the time of the publication of the paper, and the majority of authors later referred to them in their research. Kotha and Swamidass [11] show that the main reason for employing AMT is the potential to improve business performance, and not to reduce costs. They define AMT as all technologies that use computers or microprocessors. Technology is divided into four groups: Product design technology, process technology, logistics and planning technologies and information exchange technologies. They found that the level of AMT implementation depends on the size of the company, possibly because larger companies have more resources. Swink and Nair [3] provide a thorough literature review, based on which they propose 23 AMTs divided into process AMT and planning AMT, but they, in fact, also researched the technologies shown in Boyer et al. [10].

According to Goyal and Grover [12], manufacturing evolves continuously and the adoption of AMT is usually due to the intention to improve some of the competitive factors, such as delivery, cost, quality, or flexibility, in line with Kotha and Swamidass [11]. Percival [13] finds that, besides the widely stated benefits of improving own performance, AMT can also represent an entry barrier for competition. Her main theoretical findings are that AMT reduces the need for unskilled workers, but it augments the demand for skilled workers, which eventually may not reduce labour costs. On the other hand, due to automation and eliminating human error, there is a decrease in scrap rate [14].

AMT is more present in larger companies than in the small ones, and it is also more present in more innovative industries than in low tech industries, proving that size and industry are contextual factors. Except for Raymond [5], who shows positive effects of technology use on the SMEs' performance, no other research focused on differences in performance depending on company size. We therefore hypothesise that size has impact on performance through AMT use.

Empirical studies have reported non-significant or even negative direct associations of AMT adoption to performance. The discrepant findings in the literature suggest the need to identify contingencies that may govern the AMT–performance relationships. Prior examinations of the AMT–performance moderating factors addressed mainly infrastructural and demographic variables such as worker empowerment, quality programmes, and production process type [3].

All research studies investigated some sort of infrastructural element, which was proven to be a significant predictor of AMT benefits (e.g., quality management practices, workers' training and empowerment). Therefore, there is a clear gap in research as to how technology per se influences materials' consumption, staff costs, scrap rate, innovation and profitability. In this research, we use the [15] notion that the operating characteristics of a company are determined by its production structure, product type and product complexity. Therefore, it is important to look at product type (simple to complex) and production process type, which, in fact, distinguishes between make to order (MTO) versus make to stock (MTS). Also, company size is considered in terms of the number of employees.

Schroeder and Flynn [16] warn that it is better to adopt certain technologies for specific objectives. There is also a warning that the same technology will not lead to the same results in two different plants [17] to [24]. Thus, there is a need to observe the effects of each technology separately. In this paper, the impact of technology on quality, material consumption, labour expenses (cost) and innovation are examined, as those are important manufacturing concerns today. Material consumption is measured through cost of inputs (purchased parts, material, raw materials) as a percent of annual turnover. Staff costs are measured through payroll costs as a percent of annual turnover. We address quality through the scrap rate adapted from Nair et al. [25]. Innovation is measured through revenues from new products that were introduced by the company in the last 3 years. Likewise, we also studied how technology affects the bottom line, that is, returns on sales before tax.

Based on literature research of each technology and its characteristics, we hypothesise relationships for each manufacturing technology on the dependent variables (Table 1).

If a positive relationship is assumed, a plus sign respectively denotes the hypothesised relationship (a minus sign denotes a negative relationship). As can be seen in Table 1, most technologies are intended to reduce costs of production. Robots are supposed to lower staff costs, but also to increase precision and reduce errors [26]. Technologies for safe human-machine cooperation and supply chain management are intended to reduce errors and, therefore, reduce operating costs. Technologies that are supposed to increase innovation are product lifecycle management system, because monitoring of equipment use enables its improvement Moreover, energy and resource efficiency technologies and additive manufacturing technologies are aimed at using resources efficiently. It is hypothesised that they would reduce manufacturing costs, but not necessarily material and staff costs. Therefore, this group of technologies will influence profits directly. Technologies under digital group factory are hypothesised to reduce error of handling, timely information so as to reduce costs of mistakes, not necessarily reducing material or staff costs, therefore we hypothesise that they will affect return on sales before tax positively.

More specifically, our research seeks to answer the following research questions:

- How do AMT affect certain performance measures?
- How do contingency factors measured through control variables affect certain performance measure?

2 RESEARCH METHODOLOGY

The research data was collected using the European manufacturing survey (EMS), coordinated by the Fraunhofer Institute for Systems and Innovation Research – ISI, the largest European survey of

Table 1. *Hypothesised relationships of technologies on cost, quality and innovation*

Technology		Share of use [%]	Material consumption	Staff cost	Quality	Innov. revenue	Profit
Automation and robotics	Industrial robots for manufacturing processes	28.3	–	–	+		+
	Industrial robots for handling process	22.5	–	–			+
Energy and resource efficiency	Control system for shut down	13.8	–				+
	Control-automation systems for energy efficient production	14.5					+
	Technologies for recuperation of energy	21.0					+
Processing techniques for new materials	Manufacturing technologies for micromechanical components	3.6				+	+
	Nano-technological production processes	6.5				+	+
	Processing techniques for composite materials	4.3				+	+
	Biotechnology / genetic engineering methods	1.4				+	+
	Processing techniques for alloy construction materials	5.8				+	+
Additive manufacturing technologies	Additive manufacturing technologies for prototyping	13.0	-				+
	Additive manufacturing technologies for mass production	15.9	-				+
Digital factory	Software for production planning and scheduling	52.2			-		+
	Near real-time production control system	31.2					+
	Digital exchange of product/process data	28.3					+
	Systems for automation and management of internal logistics	13.0					+
	Devices for programming and handling of machines	13.0					+
	Product lifecycle management (PLM) systems	12.3				+	+
	Technologies for safe human-machine interaction	8.7					+
	Digital visualization	11.6					+

manufacturing activities. The survey is conducted among manufacturing companies (NACE Rev.2 codes from 10 to 32) having at least 20 employees. The survey is conducted on a three-year basis and new concepts are added to the questionnaire, while obsolete concepts are excluded. The 2015 survey round had extensive changes, especially in the technology part. A basic questionnaire is developed in English and then translated, including backwards translation. Second, pre-tests are conducted in each participating country. Third, identical data harmonization processes are applied.

Questionnaires were sent to Chief Executive officers of manufacturing companies, and they were completed by several persons, usually by operations management and accounting staff. After two weeks, companies which did not respond were called by telephone and asked to fill in the questionnaire, or they were asked to specify the reasons why they could not respond. In Croatia, 106 responses were collected, representing an 8 % response rate. A non-response base was tested with the χ^2 test between early and late responders and there was no significant difference between responders. The same procedure was applied in Slovenia, obtaining a sample of 91 manufacturing companies with a 13 % return rate. The representativeness of the sample was checked by size and industry, and it shows generalizability for Croatian and Slovenian manufacturing. However, we included in the analysis only sectors that are equally present in both countries, resulting in a decrease of the sample from 197 to 138 companies.

For each researched technology presented in Table 1 we asked about its use (yes/no) – use frequency is presented in the second column. The analysis was performed using five independent ordinary least squares regression analyses in order to find the impact of each technology on a specific parameter, that is, on a dependent variable. The dependent variables are profits, revenues from new products, scrap rate and costs (material and staff). Therefore, five independent regressions are made. The independent variables were technologies, that is, a dichotomous value (0 – not using it, 1 – using it).

Company size, product complexity, and production process type were used as control variables. It is believed that larger companies have more resources to invest into technology, so size should be considered as an important factor. Moreover, more complex products might require more AMT, therefore complexity is also used as a control variable. Production process type was included,

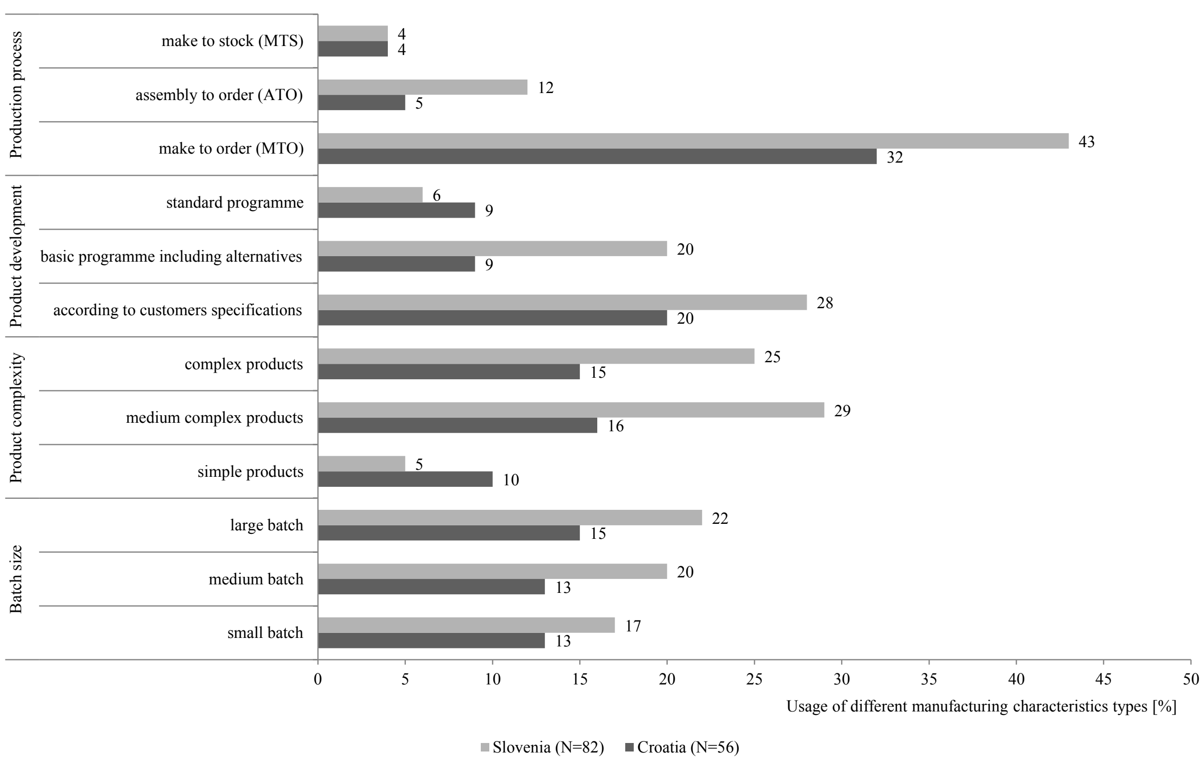

Fig. 1. *Manufacturing characteristics of the Croatian and Slovenian sample*

since it is connected with business strategy. MTS is generally associated with low cost strategy, while MTO with differentiation. Those control variables are also contextual factors from the contingency theory perspective.

3 RESULTS AND DISCUSSION

Our sample includes 28 % small companies (less than 50 employees), 53 % medium-sized companies (between 51 and 250 employees) and 20 % large companies (more than 50 employees). According to the industry structure, 39 % of companies are from NACE 25 (metal products except machinery), 20 % from NACE 28 (machinery), 12 % from NACE 22 (rubber and plastics), 9 % from NACE 27 (electronic equipment), 8 % from NACE 23 (Non-metallic), etc.

It is known that there might be different types of manufacturing characteristics inside each manufacturing sector. Fig. 1 therefore displays the four groups of the basic characteristics of Croatian and Slovenian manufacturing companies: Product development (3 properties), production process type (3), batch size (3) and product complexity (3), observed by the company size.

Measurement results are presented in Table 2. The Table 2 shows the results from five independent regression analyses, standardised regression coefficients, model characteristics (R, Adjusted R2, F and Sig.) as well as the hypothesised relationships presented in Table 1. Covariance and correlations between variables was also checked, as it is a standard output of the SPSS software package. Those data are all available on demand because of a lack of space in the paper. The data show that inter-correlations are not high. Multicollinearity diagnosis shows the highest condition index of 13.207 (lower than 30) and all the variance proportions are less than 0.5 in accordance with the prescriptions by Meyers et al. [27]. Variance inflation factors (VIF) are all less than 2.

Looking into the first regression, where the dependent variable was material consumption, one can observe that contextual factors do not play a significant role. Industrial robots for manufacturing do decrease material consumption, although not significantly. On the contrary, it was hypothesised that industrial robots for handling would decrease material consumption, but the sign is positive, although not significant, meaning that robots for handling use more material resources usually for packing. It was hypothesised that control system for shut down would decrease material consumption by automatically shutting down the machine, but this was also proved non-significant.

Additive manufacturing technologies for mass production augments material costs, which is contrary to our hypothesis, because this technology was designed to build products layer by layer instead of the need to drill, scrape and carve from material, and should therefore contribute to material savings. However, current research on 3D systems shows that 3D manufacturing is still slow and expensive, and time will pass before it gets used for mass production. The augmentation of material use might be resulting from companies experimenting with the technology, not necessarily using it for mass production. Eleven out of twenty AMT reduce material consumption, although not significantly. Six AMT have almost no impact on material consumption but are also not significant. This first regression (Table 2) shows this model is not overall significant and, therefore, cannot be generalised. It can only be concluded that some of AMT do in fact reduce material consumption, but there is a significant raise in material consumption using 3D technologies for production, even though this technology is still not widespread, rather more used for building prototypes.

Percival [13] concluded that the need for unskilled workers may have diminished with the use of robots, but the need for skilled personnel has risen, so in effect there would be no change in staff costs. Our analysis indeed shows that contribution of AMT on staff cost is indeed non-significant. Robots do, in fact, decrease staff costs, but the reduction is not significant. Thirteen AMT out of twenty reduce staff cost, but the significant reduction is in using software for production planning and scheduling which was done manually before and is now replaced by software. A near real-time production control system shows a significant increase in staff costs, and that is in line with Percival [13] for the need of skilled personnel even though much of the manufacturing is computerised.

The third regression (innovation revenues) is significant, explaining 42.8 % of innovation revenues. Here one contingency (country) plays an important role, showing that Slovenian companies obtain significantly higher revenues from innovation. Especially profitable technology for innovation is processing techniques for composite materials, which shows a significant positive effect. On the contrary, devices for programming and handling of machines in innovation show a negative impact, probably due to a lot of work for each new product. Half of AMT do affect innovation revenues positively, but

Table 2. *Results of the regression analyses (in parenthesis are hypothesised relationships)*

Variables	Material consumprion	Sig.	staff costs	Sig.	innovation revenue	Sig.	scrap rate	Sig.	profit	Sig.
	Stand. Beta		Standard. Beta		Standard. Beta		Standard. Beta		Standard. Beta	
Country (Slovenia, Croatia)	0.021	0.857	0.031	0.769	–0.482	0	0.036	0.673	0.096	0.391
Batch size	–0.122	0.302	–0.089	0.408	0.037	0.736	0.053	0.543	–0.097	0.407
Complexity	0.05	0.651	0.048	0.637	0.189	0.071	0.097	0.252	0.1	0.356
Product development	0.021	0.865	–0.122	0.277	–0.144	0.188	–0.016	0.86	0.037	0.753
Production process type	–0.005	0.964	0.01	0.927	–0.131	0.252	–0.131	0.144	–0.112	0.347
Number of employees	–0.016	0.893	–0.006	0.955	–0.012	0.921	–0.07	0.448	0.138	0.246
Industrial robots for manufacturing processes	–0.119 (–)	0.322	–0.033 (–)	0.76	0.026	0.815	–0.006 (+)	0.944	0.105 (+)	0.37
Industrial robots for handling process	0.039 (–)	0.766	–0.027 (–)	0.82	0.092	0.453	0.017	0.861	0.028 (+)	0.825
Control system for shut down	0.084 (–)	0.455	–0.06	0.56	–0.015	0.885	0.305	0.001	0 (+)	0.997
Control-automation systems for energy efficient production	0.07	0.606	–0.021	0.862	0.041	0.751	0.242	0.02	–0.105 (+)	0.431
Technologies for recuperation of energy	0.02	0.883	0.276	0.029	0.069	0.574	–0.062	0.544	–0.15 (+)	0.252
Manufacturing technologies for micromechanical components	–0.187	0.129	0.005	0.967	0.019 (+)	0.865	0.09	0.296	–0.193 (+)	0.103
Nano-technological production processes	0.014	0.908	–0.13	0.236	–0.167 (+)	0.114	–0.009	0.923	–0.041 (+)	0.734
Processing techniques for composite materials	–0.19	0.159	0.11	0.372	0.275 (+)	0.022	–0.604	0	0.118 (+)	0.416
Biotechnology / genetic engineering methods	0.175	0.165	–0.144	0.21	–0.079 (+)	0.504	–0.255	0.008	–0.269 (+)	0.037
Processing techniques for alloy construction materials	–0.06	0.602	–0.08	0.444	0.002 (+)	0.985	0.201	0.02	0.066 (+)	0.567
Additive manufacturing technologies for prototyping	0.051 (–)	0.664	0.096	0.378	0.118	0.262	–0.097	0.261	–0.191 (+)	0.119
Additive manufacturing technol. for mass production	0.306 (–)	0.014	–0.062	0.578	–0.065	0.553	–0.178	0.053	–0.052 (+)	0.667
Software for production planning and scheduling	–0.06	0.601	–0.219	0.038	0.249	0.017	–0.011 (–)	0.899	–0.018 (+)	0.871
Near real-time production control system	–0.112	0.359	0.258	0.021	–0.093	0.392	–0.142	0.116	–0.139 (+)	0.241
Digital exchange of product/process data	–0.035	0.766	0.104	0.335	–0.108	0.354	0.007	0.94	0.006 (+)	0.955
Systems for automation and management of internal logistics	–0.04	0.75	–0.212	0.067	-0.054	0.624	0.008	0.931	-0.101 (+)	0.402
Devices for programming and handling of machines	–0.077	0.5	–0.133	0.201	-0.227	0.033	-0.062	0.471	0.113 (+)	0.303
Product lifecycle management systems	0.13	0.25	–0.086	0.404	–0.049 (+)	0. 647	0.073	0.383	0.119 (+)	0.267
Technologies for safe human-machine interaction	0.008	0.946	–0.168	0.136	–0.145	0.221	0.161	0.083	–0.015 (+)	0.899
Digital visualization	–0.087	0.497	0.376	0.002	0.244	0.049	0.168	0.079	0.245 (+)	0.055
R		0.375		0.533		0.654		0.731		0.516
R^2		0.141		0.284		0.428		0.534		0.267
F		0.612		1.48		2.27		4.192		1.23
Sig.		0.924		0.088		0.003		0		0.235
Max *VIF*		2.098		2.098		2.065		2.144		2.489

only processing of composite materials increases revenues significantly. It was hypothesised that nano-technological production processes and biotechnology/genetic engineering methods enhance innovation revenues but, in fact, we obtained a negative, although non-significant sign. This might be because these technologies are not widespread and mostly in the trial phase.

The fourth regression (scrap rate) is significant, although there are no important contingencies. However, there seems to be a trade-off between AMT for different purposes. For example, a control system for shut down and control-automation systems for energy efficient production in fact augment scrap rate, probably due to the abrupt shutting down of machines. Processing techniques for composite materials and biotechnology/genetic engineering methods decrease scrap rate. On the other hand, processing techniques for alloy construction materials augments scrap rate significantly. These technologies are still not widespread and they are probably still used on a trial basis.

The fifth regression (profit) shows that none of the AMT increases profits significantly. Thirteen out of twenty AMT affect profit before tax positively, although not significantly. This fifth model is non-significant and thus cannot confirm our hypotheses from Table 2 that the majority of AMT will actually affect profit before tax positively. We do not find evidence in line with Kotha and Swamidass [11], according to whom AMT is more beneficial to larger companies. With some exceptions, we do not see profit benefits of AMT for manufacturing companies in Slovenia and Croatia, and that might be because it is in line with Zhou et al. [28], claiming that AMT adoption shows positive results in developed countries but not necessarily in less developed countries.

4 DISCUSSION AND IMPLICATIONS

Our main results show that contingency factors such as batch size, company size and product complexity do not influence staff costs, innovation revenues, scrap rate or profit significantly. Only contingency was for innovation revenues, which is significantly higher for Slovenia. So, context is important for innovation results but not for profitability. That is in line with Zhou et al. [28] which shows that developed countries have higher benefits from AMT than less developed countries. We did not find evidence of the positive effects of AMT use on the performance of SMEs as Raymond [5] found. Our control variable of company size was non-significant in all five regression analyses. Our findings concur with the findings of Abd Rahman and Bennett [29] that less developed countries have lower benefits from AMT.

On the other hand, the researched AMT are really advanced, and they have impact on material consumption, scrap rate and profits, but not in the positive hypothesised relationship. For example, additive manufacturing technologies for mass production increase material consumption significantly. This might be because this technology is not yet widespread in mass production, so companies are probably using it on a trial basis. This trial basis then, affects profits negatively, although not significantly.

Biotechnology / genetic engineering methods – this technology is really in its infant stage, so the negative relationships to profits for now is understandable. Probably in current conditions, companies are only experimenting with the technology, but the negative impact on profits is due to investment into technology, which might bring benefits in the long run.

This research shows that investments into AMT do not have a positive effect on profits, that is, seven out of twenty AMT decrease profit before tax (but not significantly). This may be explained by the unfavourable economic conditions in the two countries in the research period, and that acquiring AMT actually demands investments, which may even be substantial, but might bring positive results in the long run. A longitudinal research would be beneficial to see whether AMT would bring benefits in time, when market conditions are more favourable.

However, as shown in Table 2, the same technology might hinder some other operative measures, so in terms of adopting a new technology one should follow the advice of Sahin [30] that investment into technology should be accompanied with continuous improvement. This is in line with Swink and Nair [3] who said that AMT requires a significant amount of overhead resources, including highly trained engineering, maintenance, and other technical staff. Costs associated with these resources, as well as significant capital equipment costs, may offset the direct cost efficiencies offered by AMT. The importance of aligning organisational processes with strategy through AMT is stressed in Gouvea da Costa and Pinheiro de Lima [31] and their integrated approach, which actually reinforces the concluding remarks of Swink and Nair [3]. In our case, control system for shut down and control-automation systems for energy efficient production are supposed to diminish material use, but they also increase scrap rate. That is a clear trade off which managers should be aware of.

This research represents an empirical examination of how twenty AMTs affect operational and performance measures of the company. It should be noted that merely having AMT will not necessarily produce the desired results. There is still a substantial worker input, so workers' skills can increase positive effects arising from technology. This means that the implementation of AMT has to be planned carefully [32]. This work shows that AMT help companies in today's globally competitive market, but not in terms of profits. It was shown that AMT in fact augments the use of materials. This might be in accordance with Kotha and Swamidass [11] that technology should primarily be used for achieving growth and increasing revenue and not for cutting costs. Processing techniques for composite materials show a significant positive increase in innovation revenues and the whole model is significant. Processing techniques for composite materials and biotechnology / genetic engineering methods, even though still not in widespread use, do in fact reduce scrap rate significantly and the whole model is significant.

5 CONCLUSION AND LIMITATIONS

Our research studied company characteristics and contingencies, which was not done in previous literature. In this paper, five regression equations were performed, identifying the positive or negative impact of AMT on the researched variables. Our first research question, which contingencies affect technology use, did not turn out to be important for technology use and their effect on profits, decrease in the scrap rate, material and staff costs as a percentage of revenues. However, we did find a significant difference in innovation revenue by countries, and Slovenia is more developed than Croatia [33].

The technology section of the EMS instrument is displayed here and can be used to test the results on a larger scale. Our sample contains 138 companies, which may be considered relatively large. However, all the companies are from two neighbouring countries – Croatia and Slovenia – severely hit by recession, and both with very small markets, depending thus on exports. Moreover, Croatian and Slovenian manufacturing companies do not have large-scale production, but they rather embrace niche differentiation strategy. Therefore, there is a need for a study which would also involve companies with other strategies (such as cost leadership).

There are a limited number of papers researching the contingency theory in operations' management literature, but the problem is that, even articles having "AMT" in their title, still talk about technologies from the 1990 that were first categorised in Boyer et al. [10]. We add to the literature by researching real AMT, which are not even used widely in western developed countries.

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