Impact of technology use and technology upgrade on new product development in manufacturing companies

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Abstract

The main purpose of this paper is to map the adoption of selected technologies in manufacturing companies and their impact on the ability to introduce new products and generate companies' revenues. Our research is based on the results of European Manufacturing Survey from Croatia and Slovenia. A further objective of our research is to map the production characteristics of manufacturing companies in terms of product complexity, production type and new product development process. The results show that technologies and upgrade of these technologies have impact on revenues, generated by sales of new products.

Keywords: new product development, manufacturing company, technology

Introduction

Today, many market environments are characterized by rising raw material costs, technological and economic uncertainty and decreasing profit margins. In order to maintain long-term competitiveness the improvement of profitability has therefore become a top strategic priority for many manufacturing companies (Schuh, 2014). On the other hand, in order to stay competitive companies are forced to deploy manufacturing technologies, which are best suited to fulfil future requirements (Greitemann, 2014). In this context, the term 'manufacturing technology' denotes all manufacturing processes, which are needed to produce a product and are referred to 'technology' in the following.

In this work only technology oriented initiatives are investigated and their effects on part of revenues (from new and old products). Investment in process technology is vital for a number of reasons. First, it allows the company to increase its capacity, both in scale and scope. Second, it can be essential in order to satisfy market needs that have changed dramatically in recent times. Third, it can provide opportunities for company-specific advances in learning gained by both routine and tacit knowledge that can be accrued over time and which other companies might find difficult to copy (Teece et al., 1997; Brown, 2001).

The main purpose of this paper is to map the adoption of selected technologies in manufacturing companies and their impact on the ability to introduce new products and generate companies' revenues. A further objective of our research is to map the

production characteristics of manufacturing companies in terms of product complexity, production type, customisation and batch size.

Literature review

There is not much literature on manufacturing technologies, their usage and effects on company performance. There are such studies, but they mostly explore a single manufacturing technology (Machusa et al., 2011). Majority of studies take into account production control measures, such as costs, quality, delivery (speed and dependability) and flexibility (Ferdows and DeMeyer, 1990; Ketokivi and Schroeder, 2004).

Investment into technology is specifically important since mistakes relating to the development of new technologies can put the entire existence of a company, particularly SMEs, at risk, since these frequently do not have the capital or adequate alternative technologies required to absorb failures (Verworn et al, 2001). Therefore, the question is which technologies dominantly affect revenues from old products, and which from new products. In order to hold technological leadership and to increase competitive advantages, companies must be aware that technologies are becoming more and more advanced, meaning that companies should upgrade their technologies on a regular basis (Greitemann et al., 2014). Because of that, a question arises, which technologies should be upgraded in order to remain competitive. Even though this paper gives prescriptions as to which technologies contribute the most, readers should have in mind that any technology acquisition or upgrade should be individually explored (Hofmann and Orr, 2005). There is a general trend towards an increase in the use of technology in manufacturing plants, due to the belief that it will improve some performance measures (e.g. reductions in costs or human resources, improved quality or flexibility). However, these investments are often criticized for not creating the desired results, i.e. technology investments often lead to neither effective deployment of new practices nor the desired performance outcomes being reached fast enough. For this to be understood, it is necessary to take into account that the interconnection between technology and performance is influenced by a number of factors, some of which can be controlled, and others which cannot, but, nonetheless, they are all important for the final result (José et al, 2011).

Having in mind that technology per se will not improve financial performance, rather in cooperation with other company specific practices there are two groups of hypotheses that can be laid out:

H1: Technology use will positively affect revenues from new and old products:

- H1a: Technology use will positively affect revenues from new products.
- H1b: Technology use will positively affect revenues from products new to the market.
- H1c: Technology use will positively affect revenues from product sold more than 10 years.

H2: Technology upgrade will positively affect revenues from new and old products:

- H2a: Technology upgrade will positively affect revenues from new products.
- H2b: Technology upgrade will positively affect revenues from products new to the market.
- H2c: Technology upgrade will positively affect revenues from product sold more than 10 years.

Methodology

This contribution is based on the Croatian and Slovenian sub-samples of a European

manufacturing survey described briefly in the followings. The European Manufacturing Survey (EMS), coordinated by the Fraunhofer Institute for Systems and Innovation Research – ISI, collects detailed information on innovations in manufacturing. The main objectives of this research project are to find out more on the use of production and information technologies, new organisational approaches in manufacturing and the best management practices' implementation.

The 2012 EMS edition has been carried out in 15 countries. The Croatian sub-sample had 120 responses and the Slovenian accounted for 89, all together 209 responses. The survey was performed in manufacturing companies having at least 20 employees in the majority of NACE industry codes from 15 to 37. After selecting companies from NACE industry codes, included in the survey in both countries, we have included 163 responses. Croatia and Slovenia have similar manufacturing backgrounds and therefore a generalized result for such types of manufacturing background in developing countries is possible.

The EMS questionnaire covered four technology groups: robotics and automations (4 technologies), process and manufacturing technology (4), digital factory/IT connectivity (5) and efficient use of energy and resources (4). In the final analysis, we have included 12 of these 17 technologies using the criteria of frequent usage. Besides examining the adoption of these technologies, we have also asked the companies whether they upgraded adopted technologies in the past three years.

Field of new products in the survey questionnaire dealt with three issues. The first was asking if the company has launched a significantly improved new product in last three years or has it launched a radically new product in last three years – a product that is new also to the market. In both cases, the additional question was raised on a share of revenues generated by these new products. Besides that we have asked the companies if they still produce products that are present in the company for more than 10 years.

Descriptive and frequency analysis was performed firstly, separately for each country and, secondly, we have analysed both countries together in order to determine if there are any significant differences between them. In addition, we used regression analysis; the results present the relationship between used technologies and revenues for all three product types and between upgraded technologies and revenues for all three product types.

Results

It is also widely known that inside one manufacturing sector or NACE class there might be several different types of manufacturing processes. Therefore, in Figure 1 basic characteristics of Slovenian and Croatian manufacturing companies are displayed, divided into four groups: product development (3 properties), production type (3), the batch size (3) and product complexity (3).

Figure 1 shows that both countries mostly develop products according to customer specification. Second large group of product development type is manufacturing of standard program with alternatives. Chi-Square Test for the difference between two proportions was performed and it revealed a statistically significant difference for populations of companies developing products according to customer specification and standard program with alternatives. No difference in proportion of companies that develop products to a standard program. For both countries the dominant production type is make-to-order (MTO) production and there is no statistical difference between proportions in both countries. Less common are assemble-to-order (ATO) and make-to-stock (MTS) production types and these proportions statistically significantly differ by countries. Interestingly, even though both countries dominantly produce according to

customer specifications, and manufacture to order, companies in both countries dominantly produce a large batch of products. Absolutely no statistically significant difference in proportions of batch sizes was found between both countries. Croatian and Slovenian manufacturing companies dominantly produce products of medium complexity. There is no statistically significant difference in proportions of either type of product complexity between both countries.

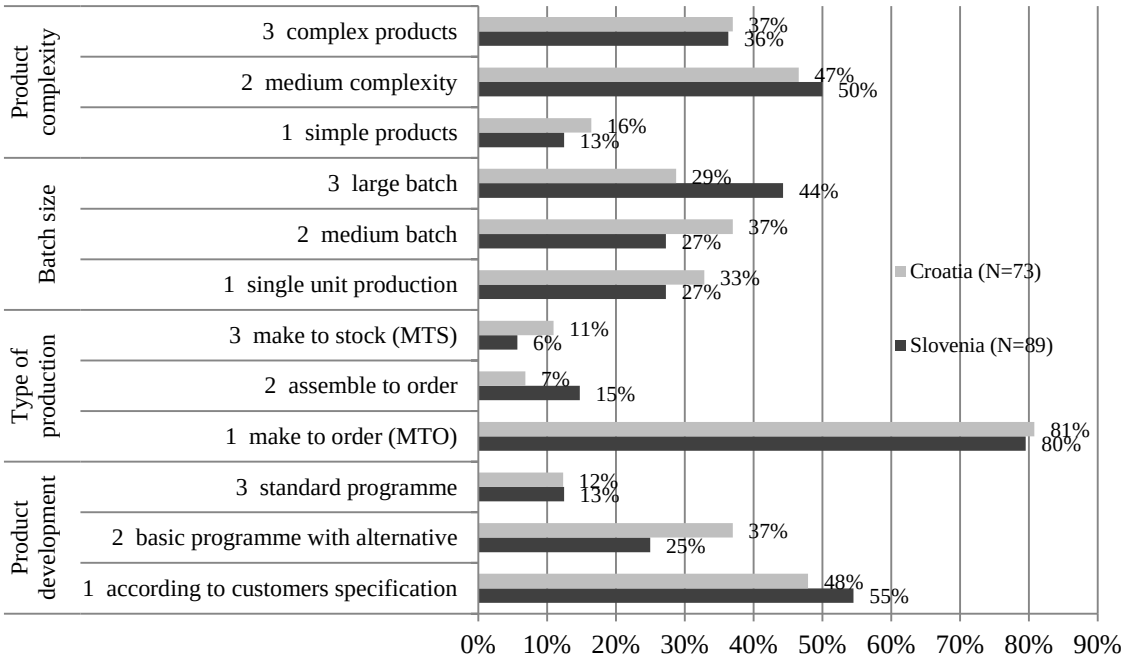

Figure 1 – General characteristic of Croatian and Slovenian manufacturing

Figure 2 presents the average diffusion rate of selected technologies in Croatian and Slovenian manufacturing companies. We must point out that for the majority of selected technologies Slovenian manufacturing companies show a higher adoption rate.

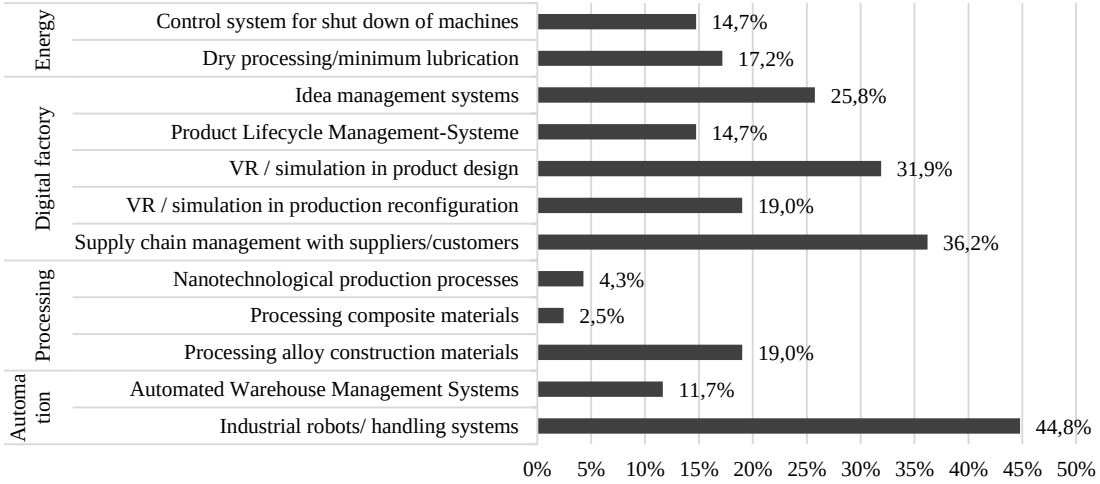

Figure 2 – Adoption of selected technologies in Croatian and Slovenian manufacturing companies

Figure 2 shows that industrial robots are the most frequently adopted technology in Croatian and Slovenian manufacturing companies, followed by the computer data

exchange with suppliers and virtual reality technologies in product design. Comparing Slovenia to Croatia in the usage of industrial robots and automation clearly shows advantage for Slovenian manufacturing companies, as the ratio is 55% to 30%. Because of that Slovenian companies should be more capable to reduce production costs and allow for better precision and fewer mistakes. They should also show greater added value per employee and greater profits from older products, which are now through automation technology routinely produced. Digital factory, on the other hand, should lead more to innovative products, therefore Slovenian manufacturing companies' advantage in the use of those technologies should be evident in revenues from new products. Chi-Square Test for the difference between two adoption rates shows a clear difference in the usage of those technologies in both countries.

Figure 3 presents the percentage of companies that upgraded adopted technologies included in the survey. In terms of technology upgrading in the period from 2009 until 2012, we took into account that each technology must be used in at least 10% of companies. This means that we excluded from further analysis those technologies that are used in less than 10% of companies. The analysis showed that on average around 40% to 60% of companies upgraded previously installed technologies in their production in the observed period. The biggest share of upgrading can be seen in the field of industrial robots (almost 70%), followed by virtual reality in product design and computer data exchange with suppliers. Slovenian manufacturing companies are more active in technology upgrading than the Croatian ones. If technology upgrading and constant renewal implies greater revenues and added value, Slovenian companies should perform better with revenues from new products developed with the help of digital factory technologies, and better revenues from old products and greater productivity aided by industrial robots and automation.

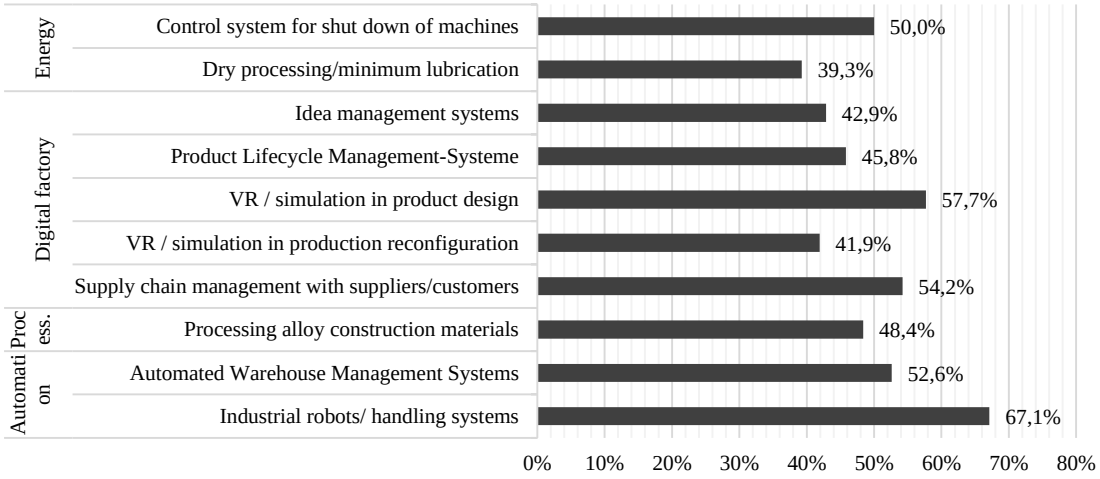

Figure 3 – Upgrade of selected technologies in Croatian and Slovenian manufacturing companies

Figure 4 presents turnover from new and old products as a percentage of total companies' turnover. We can see that even with lower automation and lower digitalization of the factory Croatian manufacturing companies manage to perform better in streams of turnover from new products, even though the difference is not statistically significant. On the other hand, there is statistically significant difference in return on sales (ROS) which is higher for Slovenian companies. Therefore, we will exclude ROS from further analysis.

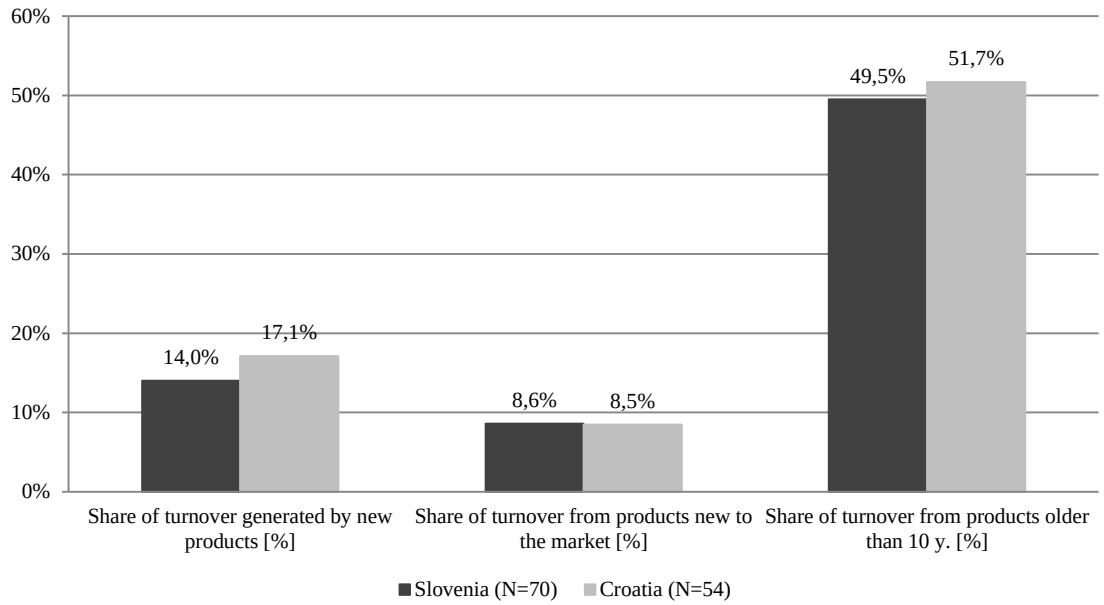

Figure 4 – Turnover from new and old products in Croatian and Slovenian manufacturing companies

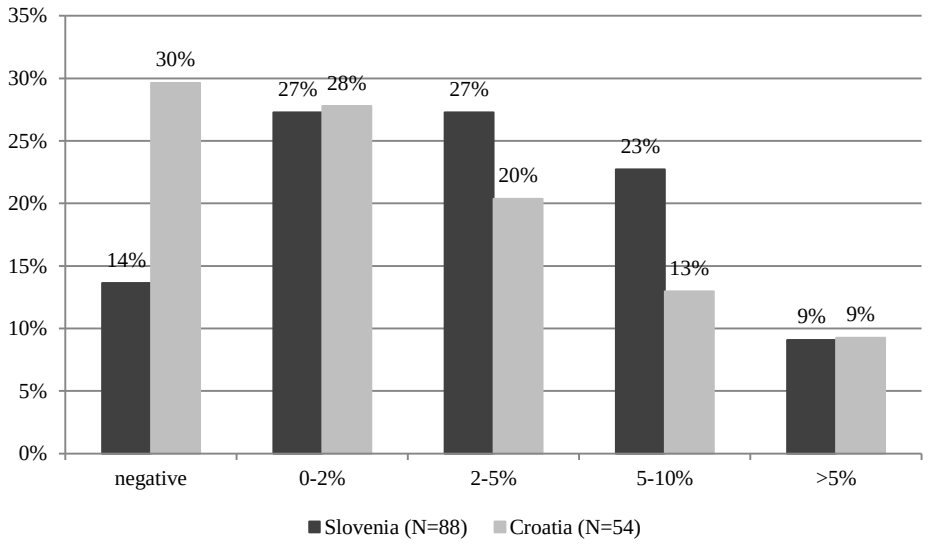

Figure 5 – Return-on-sales in Croatian and Slovenian manufacturing companies

Discussion

Following the initial scanning of technology diffusion, the trends in technology upgrading and selected performance criteria, we have used multiple regression models to find out the relationship of selected technologies and companies turnover from new and old products (Figure 6).

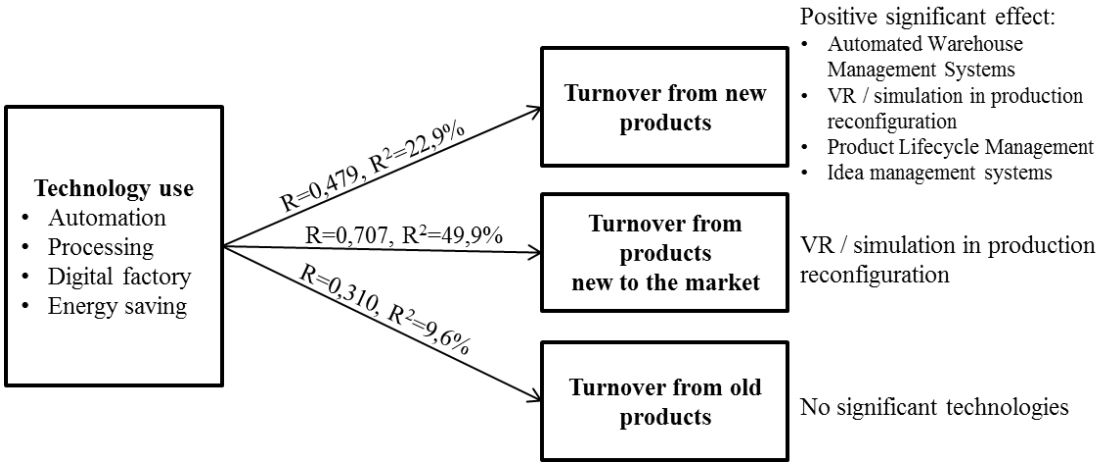

Figure 6 – Technology use and turnover from different types of products

Technology use dominantly influences turnover from radically new products. The dominant technology is virtual reality /simulation in production design. This can be explained with the fact that it is better to simulate production of new products then to do costly mistakes. It is probably not done in large batches so automation technology does not play a significant effect.

New products for the company, but not new to the market, also heavily depend on technology, but several technologies greatly affect turnover from these modified products. Those are automated warehouse systems, virtual reality /simulation in production design, product life cycle management and idea management systems. Automated warehouse systems can be explained by the fact that in order to obtain the largest possible market share from those new products, means it should be produced in larger quantities, and therefore automated warehouse systems reduce costs of delivery. Product life cycle management might be important with these new products because keeping records about products, helps companies to obtain new information about usage and other interesting information, which are than a basis for more new products. Idea management system helps create new products, and it correlates highly with product life cycle management (correlation is 0,92)

For technology use and turnover from old products a regression coefficient of 0,310 was found, but with no significant technologies.

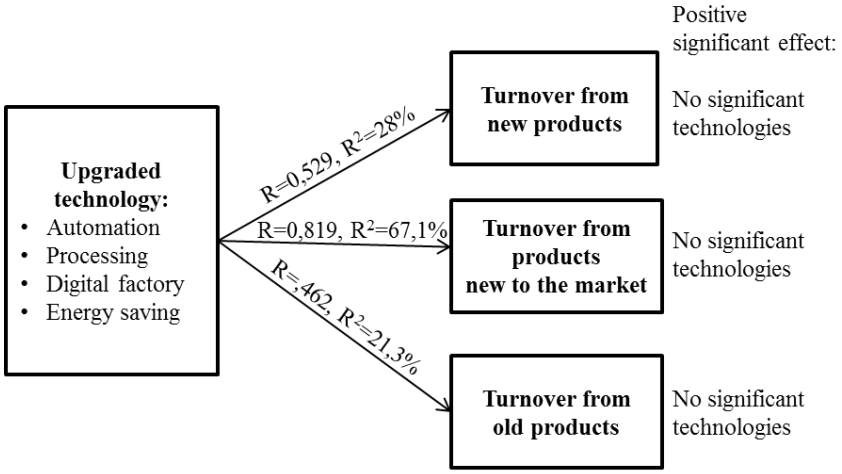

Figure 7 – Technology upgrade and turnover from different types of products

Several findings regarding the technology upgrade are significant. It seems that technology upgrade is dominantly used to produce radically new products. Being able to produce radically new products, that ability also enhances revenues from products new to the company. Again, as in the previous model technology upgrade has the least effect on revenues from old products. Semi-high regression coefficient (technology upgrade on revenue from old products) might be due to the fact that new technology will help reduce production cost and in that way augment revenues from old products (Figure 7). However, there is one additional interesting finding: absolutely all upgraded technologies negatively correlate with revenues from old products as seen in Table 1.

Table 1 – Technology upgrade and share of turnover from old products

Technology upgrade in the period from 2009 to 2012	**Share of turnover from products older than 10 years [%]**
Share of turnover from products older than 10 years [%]	1
Industrial robots / handling systems (automation)	-0,168
Automated Warehouse Management Systems	-0,199
Alloy construction materials	-0,069
Composite materials	-0,104
Nanotechnology	-0,185
Supply Chain Management systems	-0,299
Virtual reality / simulation (production)	-0,223
Virtual reality / simulation (product)	-0,260
Product Lifecycle Management	-0,101
Idea management systems	-0,148
Dry processing/minimum lubrication	0,056
Control system for shut down of machines	-0,062
Energy recuperation	-0,268

One explanation might be that although technology upgrade might have positive effects on revenues by savings generated with upgraded technology, but maybe these new productions methods might lose some features that customers valued.

Also interesting were partial correlations between different turnover types (Table 2). It seems that by investing into technology in order to be able to produce radically new products, companies are also able to manufacture new products new to their company that might not be necessarily new for the market. Positive other correlation effects show that indeed, launching new products, some customers might also start purchasing old products from that company.

Table 2 – Partial correlations between different turnover types

	Share of turnover generated by new products [%]	Share of turnover from products new to the market [%]	Share of turnover from products older than 10 years [%]
Share of turnover generated by new products [%]	1	0,745***	0,132
Share of turnover from products new to the market [%]		1	0,187
Share of turnover from products older than 10 years [%]			1

Conclusion

There is a missing link in operations management literature in examining the impact of different technologies' use and technologies' upgrade and their impact on the ability to develop new products and introduce them to market. Our paper gives some explanations in the selected field of manufacturing industries and for specific technologies. We have identified several technologies that have a significant impact on the development of new products for companies and for the market, while technology has just a weak positive effect on revenues from old products. Technology upgrade also contributes to revenues from new and old products, where the upgrade is especially important for generating revenues from products new to the market. Aaltogether, investing into new technology is beneficiary.

Our research has several limitations: not all industry branches are included but only branches heavily embedded in mechanical engineering industry. Our research also focuses just on two countries, where technology state-of-the art is not at its highest possible level.

Nevertheless, based on the positive results of the research, company management can reinvestigate the functioning of their companies and decide on whether (and which) technology use and upgrade can be profitable for generating revenues from new product development.

Further research should analyse the data using structural equation modelling revealing correlations among constructs, because with regression and accompanying correlation tables, presenting results is cumbersome and messy. Therefore, we will include data from other countries participating in European Manufacturing Survey.

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