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Material Saving Strategies, Technologies and Effects on Return on Sales

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***Abstract*—**Manufacturing companies invest a significant amount of sales into material resources for production. In our sample, 58% of sales is used for manufacturing inputs, while only 24% of sales is used for salaries. This means that if a company is looking to reduce costs, the greater potential is in reduction of material costs than downsizing. This research shows that manufacturing companies in Croatia did realize material savings in last three years. It is also shown by which technologies they achieved materials cost savings. Through literature research, we found research gap as to which technologies reduce material consumption. As methodology of research four regression analyses are used to prove our findings.

***Keywords*—**Croatia, materials savings strategies, technologies, return on sales.

I. Introduction

MOST manufacturing industries have a significant expenses for materials. Also some material's costs raise due to the shortage available materials, like natural resources. Shortage of materials also rises because of natural disasters, raising the materials price. The everlasting question for operations managers is how to lower this cost, without jeopardizing the quality of the produced product. Reference [1] proposes minimizing the consumption of materials. Reference [2] finds that manufacturing companies invest into material resources for production from 50-80% of their sales. Profit is the entrepreneur's reward and in fact, a major motive for doing business. Most often too, it is used as an index for measuring performance [3]. This paper is undertaken to outline materials savings strategies and by aid of which technologies savings are achieved. Through regression analyses, this paper shows which strategy is most beneficial when return on sales or profit is taken into account.

According to [4], materials for use in manufacturing falls under three categories:

1. Raw materials primarily from agriculture and the various extractive industries e.g. mineral resources, fruits, and vegetables sold to processor.
2. Semi-finished goods and processed materials to which some work has been applied or value added e.g. rods, wires, paper, chemicals, etc.
3. Component parts and assemblies that are completely finished products of one manufacture, which can be used as part of more complex product by another manufactures.

Manufacturing companies differ according their production type as, for example craft or job, batch, mass, flow or continuous production [5]. Hayes and Wheelwright Four Stage Model (1979) [6], [7] was the first model to link process type and volume of production. However, the model was updated by Ahmad and Schroeder in 2002 [8], but, the most comprehensive representation is that of Slack et al. [9] who directly link process types to batch size, complexity of the product, variety, that is, if customer's requests are taken into account rather than producing batches of standardized products.

Obviously, mass, flow or continuous production will use more raw materials according to classification of [4]. More complex production will usually be in small batches, according to customers' specifications and usually include component parts and assemblies according to classification of [4]. It is also obvious that different technologies will be used in these manufacturing processes. For example, in mass production there will be significantly more industrial robots. In small batches, different general purpose technologies will be used. Most influential paper on advanced manufacturing technology is that of Boyer et al. [10] replicated later by several others researchers, with Das and Nair [11] being most recent research. However, [11] does not mention the year in which their research was conducted, their AMT is largely based on [10] AMT taxonomy, and conducted in USA, as a developed country. Literature research on technology shows that technology does in fact affect performance in developed countries but not in developing countries [12].

This research has several contingencies, that is, situational factors specific to Croatian settings. Croatia is a developing country, and that means, according to [12], that technology will not benefit Croatian manufacturing companies. The second contingency is framed by findings of [13] who suggests that Croatian manufacturing companies are more likely to focus on specific customers or market niches. Despite important contribution of manufacturing to the Croatian economy, manufacturing companies in Croatia are rarely able to achieve economies of scale [14]. That means that in Croatian sample we will find less large scale production with large usage of raw material. That means that Croatian manufacturing companies use more general purpose technology, produce in medium to small batches using semi-finished or components as inputs into their production processes. General belief is that materials savings are most promising in large scale productions by use of advanced technology.

The question we address here is: Do Croatian companies realize material savings as a result of used technologies? Taking into account contingencies named, we should

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hypothesize that there should be no material savings in Croatian manufacturing. However, we directly asked companies did they obtain materials savings in last three years through optimization of existing technology, acquiring new technology or by recycling/reduction. These three ways of achieving materials savings, we call materials savings strategies. We then made regression analysis of each material savings strategy (a dichotomous variable yes/no) to technology usage (again a dichotomous variable using/not using). These regression analyses identify technologies that are the best suitable for each material savings strategies. Also, a forth regression analysis was performed that linked return on sales before tax as a dependent variable, and materials saving strategies as the independent variables. This regression analysis shows which strategy gives the overall best performance results since profit is the ultimate goal of a company.

Through this paper, we address three research gaps found in the literature.

1. Technology advances significantly each year, and it is more affordable than ever before. Therefore, research by [11] should be updated with up to date technology.
2. There is a clear gap in researching technology and material savings in developing countries, that is verify the findings of [12] in a developing country.
3. Thirdly, check the findings of [13] and [14] and verify the demographic characteristics of Croatian manufacturing, because Croatia is in recession since 2008. and that should clearly affect the manufacturing sector.

II. Research Methodology

A. Data Collection

Research data was collected through a survey. The European Manufacturing Survey (EMS) is the largest European survey of European manufacturing [15] led by Fraunhofer ISI. The survey covers manufacturing priorities, adoption of organizational and technological concepts in production, cooperation issues, production off-shoring, servitisation, and questions of personnel deployment and qualification. In addition, data on performance indicators such as productivity, flexibility, quality and returns is collected. The survey covers manufacturing companies (NACE codes 10 to 38) having at least 20 employees, otherwise researched operations management fields might not have sense in small companies. The main objectives of EMS project are to find out more about the use of production and information technologies, new organizational approaches in manufacturing and the implementation of best management practices [16]. The underlying idea of question design is to have a common part of questions constantly over several survey rounds, to modify other common questions in the respective survey round corresponding to current problems and topics from the field of innovations in production and to give space for some country or project specific topics. The Survey is conducted on a three-year basis and new concepts are added to the questionnaire, while obsolete concepts are excluded. The survey round in 2012 had extensive changes especially in the technology part.

In order to collect valid data permitting international comparisons, the EMS consortium employs various procedures recommended by the Survey Research Center to avoid problems arising from different languages and national peculiarities in terminology. First, the basic questionnaire is developed in English and then translated, including backwards translation. Second, in each participating country pre-tests are conducted. Third, identical data harmonization processes is applied [17].

Data from EMS is mainly used for research projects on behalf of the EU, but also for scholarly articles. However, the dominant current research streams using EMS data is in area of servitization, energy efficiency and relocation [18].

For each researched technology (all together 19 technologies), five questions about the usage of the technology are asked:

- Do you use the technology (yes/no).
- Plan to use it in the upcoming period of three years (yes/no).
- Year in which this technology has been used for the first time in the factory (year).
- Extent of actual utilization compared to the most reasonable potential utilization in the factory: (low, medium, high).
- Did the company upgrade its technology in the last three years (yes/no) [16].

Companies were asked about savings of raw materials, intermediate goods or operating materials. They had to answer did they realized this saving (in las three years) by answering the following three questions with a yes or no answer:

- materials savings by optimization of previously used production technologies (e.g. near net shape technologies, optimization of processes)
- by substitution of established through new technologies (e.g. new mechanisms of reactions or forming instead of punching for waste avoidance)
- of operating materials by substitution or reduction (e.g. through recycling of water, reduction of lubricants).

They were asked the level of usage of each of the three-above mentioned strategies for material savings, and reasons they engage in pursuit of material savings.

The questionnaire was mailed by post to Chief Executive Officer of 1562 Croatian manufacturing companies in March 2012. It was filled by operation's manager or the plant manager by aid of accounting and finance department of the firm. After two weeks, companies are called by telephone and asked to fill in the questionnaire or to name the reasons why they cannot respond to the questionnaire. The questionnaire was sent to all manufacturing companies (NACE 10-31) in Croatia with over 20 employees (population was 1562 companies so no sampling was needed) and obtained 120 fully filled questionnaires which represent an 8% response rate. Non-response base was tested with $\chi 2$ test between early and late responders and there was no significant difference between responders.

Manufacturing sector in Croatia contributes with 15,65% to Gross Domestic Product and employs 17,83% of Croatian labor force [19]. For comparison The USA's contribution of manufacturing to the GDP is 20,7%, France 19,4%, Germany 30,8% [20]. The Croatian sample shows that 75% of manufacturing companies are exporters, which makes them competitive also outside the home market. The Croatian market is small and it has to export in order to survive. Croatian manufacturers are producers of finished goods for consumers (51%), producers of finished goods for industrial business (25%), suppliers of parts/components (19%), contract manufacturers (4%), and system suppliers (1%). As far as complexity of the products in Croatian manufacturing concerns, 23,9% of companies produce simple products, 47,9% medium complexity products and 28,2% produce complex products. Representativeness of the sample was checked by size and industry and it shows generalizability for Croatian manufacturing. However, given the fact that GDP contribution by manufacturing in Croatia is lower than in developed countries, there is doubt that results can be generalized without further investigation of data by other countries. This is a limitation, which is also a further line of study.

Regression analysis is most appropriate since we have to evaluate each influence individually. The independent variables were technologies, that is, a dichotomous value (0 – not using it, 1 – using it). The dependent variables in first three regressions are again dichotomous variables (using the material savings strategy or not). For return on sales, as a dependent variable, it had five dichotomous values from negative return on sales to return on sales over 10% of revenues, and independent variables were material savings strategies.

We used control variables; size of the company, the complexity of the product, and process type. It is believed that larger companies have more resources to invest into technology so size should be considered as an important factor. Secondly, the complexity of the product might need technologies that are more advanced so this variable is also used as a control variable. Process type was researched because it is actually connected with business strategy. MTS is generally associated with low cost strategy, while ETO, MTO with differentiation.

B. Descriptive Results

We first present material reduction strategies, and how many companies use it. The second column of Table I shows how many companies plan to use it. The third column presents the current level of usage of each strategy (low, medium, high).

TABLE I
PERCENTAGE OF COMPANIES USING A MATERIALS SAVINGS STRATEGY, PLANNED USE AND LEVEL OF USAGE OF THE STRATEGY

Materials savings strategy	Percentage of companies that reduced material consumption by use of:	Percentage of companies that plan to reduced material consumption till 2015 by use of:	Average level of usage of concepts to save materials (1-low, 2-medium, 3-high)
Material savings by better use of technologies	71,7%	5,8%	2,13
Material savings by substitution of technology	20,8%	3,3%	1,92
Material savings by recycling/reduction	38,3%	10,0%	1,83

As can be seen from Table I, already 72% of Croatian companies reduced their materials consumption by optimizing usage of existing technology, and further 5,8% plan to use this strategy in next three years. The level of application of this strategy is on the average medium (2,13). Also important materials savings are achieved through recycling/reduction (38,3%) with further 10% of companies who intend to pursue this strategy in next three years. Again, level of usage of this strategy is medium (1,83).

The dominant reasons for employing these materials savings strategies are: cost reduction (85,83%), reputation (10%), required by the customer (5,83%), government subsidies (5,83%) and (3,33%) because of scarcity of resources.

Fig. 1 displays technologies that are used for materials savings by use of existing technology, sorted by the percentage of companies using the technology for this material savings strategy. Fig. 2 presents technologies for reducing material consumption through recycling. We do not present technologies that are used for materials saving by substitution of technology because this strategy use only 20,8% of manufacturing companies.

Fig. 1 presents that 27,5% of companies reduced materials consumption by better use of industrial robots, 20% by aid of technology for combined cold, heat and power, 19,2% by Virtual reality for product design, 18,3% by supply chain software with suppliers and customers and 18,3% by better use of technology for safe human-machine cooperation. It is also visible that unsuccessful rates are low, maximum being 4,2% for supply chain management technology. By contrast, in Fig. 2, it can be seen that materials savings through recycling managed to achieve only 15,8% of companies using industrial robots, 15% by use of supply chain management software, 13,3% by technology for combined cold, heat and power, 11,7% by aid of virtual reality for product design. However, unsuccessful rates are high. For example for reduction of materials by recycling using robots, 15,8% companies succeeded, while 14,2% of companies did not. Production characteristics of Croatian companies are displayed in Fig. 3.

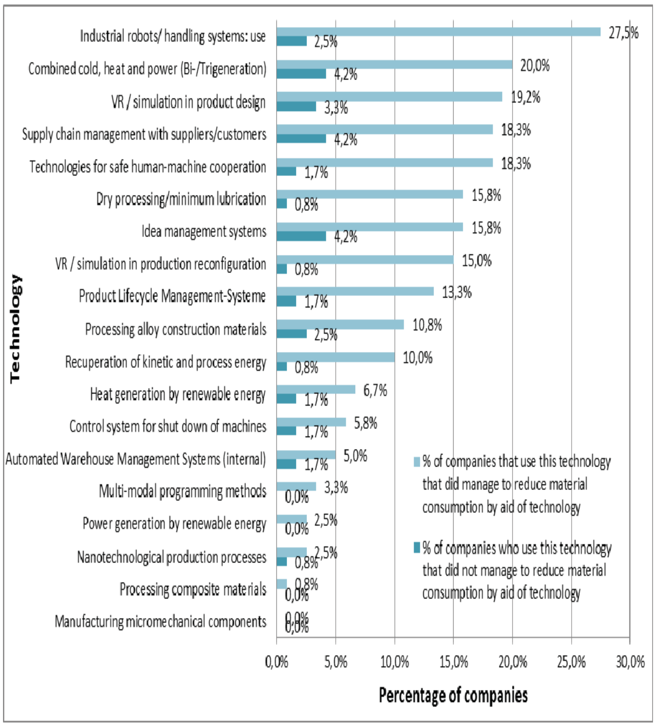

Fig. 1 Technologies for material savings by optimizing usage of existing technology

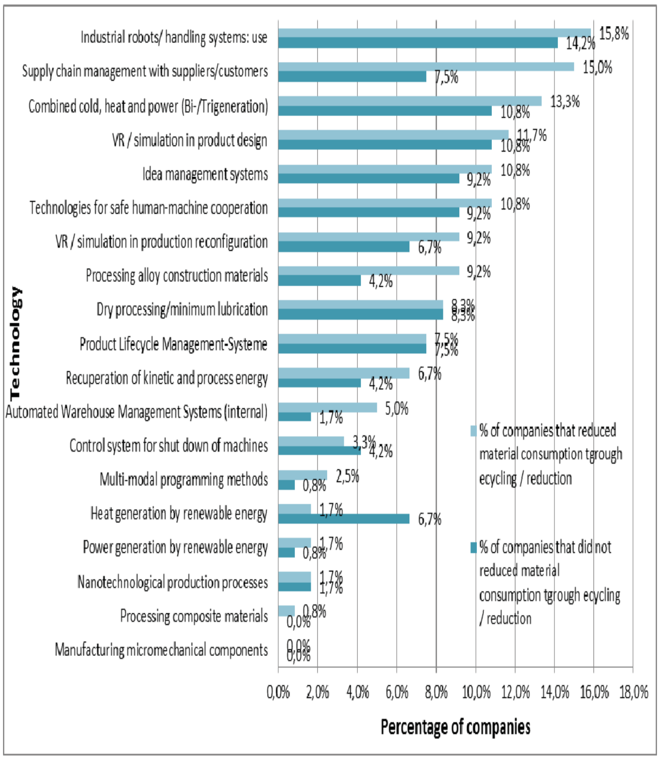

Fig. 2 Technologies for material savings by recycling

From Fig. 3, there are some unexpected findings. It was hypothesized that materials reductions would be most visible in large batches of simple products. However, it can be seen that materials reductions are possible even in production according to customer's specifications, in make to order type of manufacturing process. Most savings are obtained the larger is the production batch, but materials savings are also present in medium and highly complex products. More companies reduce material consumption by better use of existing technology strategy then the other two strategies.

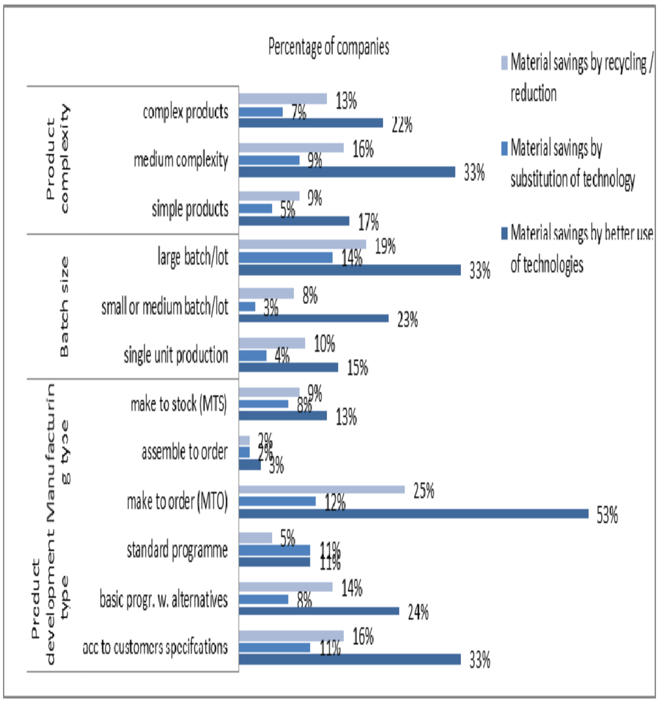

Fig. 3 Production characteristics of Croatian companies

III. Results

In the regression analyses, presented in Table II, are only technologies that are used by more than 10% of Croatian companies, because we want robust results. In addition, it should be noted that verifications of control variables (size of the company, complexity, batch size, manufacturing type and product development type) were performed but turned out non-significant. This means that regression results are valid for all type of production characteristics equally.

Looking into significances of the three proposed models in Table II it can be seen that only the third model is significant. That means that we can say that investigated technologies do significantly contribute to materials savings by recycling/ reduction at the significance level $p<0,05$. It can also be observed from Fig. 3 that most companies realize materials savings through better use of technology, but that model is not significant, meaning that we cannot say with statistical significance that these technologies do in fact reduce material consumption through better use of technology. However, the interesting parts are Pearson's correlations and significances of each technology in our three models. If we look which technologies significantly reduce materials consumption through better use of technology, it can be seen that those are: industrial robots, technologies for safe human-machine cooperation, dry processing and Virtual reality/simulation in production reconfiguration.

TABLE II
RESULTS FROM REGRESSION ANALYSES

Technology	*Model 1. dependent variable Material savings by better use of technologies*	*Model 2. depended variable Material savings by substitution of technology*	*Model 3. Dependent variable Material savings by recycling/reduction*
Industrial robots/ handling systems: use	**0,274 (0,001)**	0,149 (0,054)	**0,184 (0,024)**
Combined cold, heat and power (Bi-/Trigeneration)	0,12 (0,098)	0,184 (0,024)	**0,186 (0,022)**
Supply chain management with suppliers/customers	0,099 (0,144)	**0,16 (0,043)**	**0,307 (0,000)**
VR/simulation in product design	0,145 (0,059)	**0,16 (0,043)**	0,141 (0,065)
Technologies for safe human-machine cooperation	**0,209 (0,012)**	0,148 (0,055)	**0,154 (0,048)**
Idea management systems	0,065 (0,243)	0,148 (0,055)	**0,154 (0,048)**
Dry processing/minimum lubrication	**0,221 (0,008)**	**0,206 (0,013)**	0,099 (0,143)
VR/simulation in production reconfiguration	**0,212 (0,011)**	0,11 (0,12)	**0,167 (0,036)**
Product Lifecycle Management-Systems	0,149 (0,055)	**0,24 (0,005)**	0,093 (0,159)
Processing alloy construction materials	0,07 (0,227)	0,157 (0,046)	**0,24 (0,005)**
Recuperation of kinetic and process energy	0,151 (0,052)	0,015 (0,437)	**0,161 (0,042)**
R	0,361	0,358	0,41
R Square	0,13	0,128	0,168
F	1,434	1,399	1,925
Sig.	0,168	0,183	0,044

In parenthesis are significances, coefficients that are significant are bolded

For reductions in materials by new technology the significant ones are:

1. Supply chain management (SCM) with suppliers and customers. This is actually, a software that connects electronically the company and its suppliers and buyers and probably due to less human error there are savings in materials.
2. VR/simulation in product design. This is actually a software that models new products, including rapid prototyping which than naturally reduces material consumption in comparison to previous methods.
3. Dry processing naturally reduces material consumption because of lesser usage of lubricants.
4. Product Lifecycle Management-Systems are again software programs that enable tracking the usage of the product the company sells and in that way obtain information either about malfunctioning or information how to improve the product and, thus, realize materials savings.

Technologies in the strategy for reduction of materials usage through recycling/reduction, are all significant but three technologies. The technologies that reduce materials consumption through recycling are: Industrial robots/ handling systems, combined cold, heat and power generation, SCM, Technologies for safe human-machine cooperation, Idea management systems, VR/simulation in production reconfiguration, Processing alloy construction materials, Recuperation of kinetic and process energy.

In Table III, there is the results of the forth regression model that looked how each of these three material reduction strategies affect final goal of the company, that is, how it affects returns on sales.

From the significance of the model we cannot state that these materials savings strategy increase profits with statistical significance $p<0,005$. However, looking again into Pearson's correlations, it can be seen that the strategy of material reduction through recycling/reduction does in fact have the highest influence on ROS, and with statistical significance in the $p<0,05$ level.

TABLE III
REGRESSION OF RETURN ON SALES ON MATERIAL SAVINGS STRATEGIES

Independent variables	*Model 4: Dependent Variable: Return on sales before tax (ROS)*
Material savings by better use of technologies	0,006 (0,476)
Material savings by substitution of technology	0,07 (0,250)
Material savings by recycling/reduction	**0,214 (0,019)**
R	0,215
R Square	0,046
F	1,455
Sig.	0,232

IV. DISCUSSION AND CONCLUSION

In Figs. 1 and 2, researched technologies are presented. Compared to [10] paper, some technologies that they mention are now included into a single software program. There is a further need to analyze advanced technologies per se, and how they contribute to ROS.

Regression models in Table II clearly indicate which technologies have more potential for materials savings. We can conclude, that, even though, Croatia is a developing country, technologies do in fact contribute to materials savings. The strategy of reducing material costs through recycling/reduction has the most important impact. Technologies that aid these materials savings are: Industrial robots/handling systems, combined cold, heat and power generation, SCM, technologies for safe human-machine cooperation, Idea management systems, VR/simulation in production reconfiguration, processing alloy construction materials, recuperation of kinetic and process energy. This is not in line with [12] stating that developing countries do not reap benefits from usage of advanced technology.

The forth regression model with ROS as the dependent variable and materials saving strategies as independent variable is not significant, meaning that we cannot state that these materials reduction strategies will affect the bottom line, that is, return on sales. It is a cost saving strategy but a better strategy is to try to maximize revenues and in that way increase return on sales. That means that, materials reductions strategies are necessary, but not enough to enhance return on sales.

Finally, looking into Table III., we can confirm findings of [13] and [14] that Croatian companies do not pursue low cost strategy with mass production, rather work with their clients according to the client's specifications, in medium to small batches and medium to complex products. The recession in Croatia had the effect on manufacturing companies to pursue their niche strategies, enhance their quality and price, and in that way stay competitive on the market.

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