The Quality Management System as a Driver of Organizational Culture: An Empirical Study in the Portuguese Textile Industry

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ABSTRACT

Purpose: The purpose of this paper is to analyse the Portuguese textile industry in which way quality culture influences the organization's performance. Thus, it was created an investigation model made up of three hypotheses. The aim was to obtain the interconnection among "error detection culture, error anticipation culture, creative culture, and continuous improvement, and finally performance".

Methodology/Approach: A questionnaire tested before in similar studies (Cameron and Sine, 1999; Costa, 2008; Leal, Roldan and Acedo, 2002), was sent to 71 companies. The questionnaire was structured in three sections. The geographic area chosen for analysis was the North of Portugal. Were received 60 valid answers, which represents a sample with a percentage of 84.5% of useful answers.

Findings: The results show that the existence of strong interconnections for the "error detection culture negatively influences performance" and for the "creative culture and continuous improvement" positively influences performance. Many companies of this research are managed according to reactive quality cultures. They are still oriented by values and attributes that should be improved in the paradigm of quality management.

Research Limitation/implication: The study is limited to a geographic area, designated Northern Portugal.

Originality/Value of paper: From the obtained results it was found the existence of a dominant quality culture (the error detection culture). This means that Portuguese textile industries, and others industries in another countries, with the "error detection culture", are oriented by quality values which must be improved.

Category: Research paper

Keywords: quality culture; performance; textile industry; TQM; Portugal

1 INTRODUCTION

The textile industry has large representativeness in the Portuguese industrial structure, highlighting the important role it plays in terms of employment. This activity represents enormous volatility in the economic performance due to oscillations verified between offer and demand on a global scale (Vasconcelos, 2006). it undergoes. A few years ago, this type of industry had a restructuring phase due to the strong competitive pressure created by cheap labour economies. The change in the economic paradigm, the fast-paced transformation of consumer's preferences and the evolution of technology were another problems. All these factors have demanded from textile companies a new competitive dynamics and flexibility, both in what concerns the products, as well as, the productive processes and management structures according to ATP (Textile Association of Portugal, 2018).

In order to answer to market demands, the textile sector has been registering dynamic and competitive behaviours over the past two years. Advantages of its strengths were highlighted, such as, the geographic and cultural closeness to the European market, "the tradition and textile culture" and know-how, moderate salary costs when compared to European standards, the growing international recognition of products, the execution of several investments of technological modernization and the growing development of a culture of quality.

Quality is identified as a strategic element that generates added value (Santos, Mendes and Barbosa, 2011; Doiro et al., 2017; Murmura and Bravi, 2017; Carvalho, Santos and Gonçalves, 2018). Moreover, the added value that is generated during the activity of quality improvement is recognized as a tool which helps to regulate market share, to coordinate and to satisfy the needs of stakeholders and to receive economic benefit (Daunoriene and Staniskiene, 2016; Santos and Barbosa, 2006; Bravi, Murmura and Santos, 2017; Santos, Bravi and Murmura, 2018). Customer oriented quality fulfils customers' needs and expectations and highlights suitability for use (Hermans and Liu, 2013). All this happens, preserving the environmental issues (Ribeiro et al., 2017; Santos et al., 2015; Rebelo, Santos and Silva, 2017; Barbosa, Oliveira and Santos, 2018), where it appears new business models with new digital technologies (Santos et al., 2018; Bravi, Murmura and Santos, 2018; Santos, Murmura and Bravi, 2018), with the intention of improving the quality of life (Bravi, Murmura and Santos, 2018; Felix et al., 2018). According to several authors (Rebelo, Santos and Silva, 2015; Santos et al., 2014; Santos, Rebelo and Santos, 2017) the integration of quality with others different Management Systems, such as, environmental, safety and others, represent added value both in the present and, fundamentally, for the future, not only for the company, as well as for a whole range of

stakeholders allowing for the enhancement of sustainable development of organizations. The present study aims at identifying which types of quality culture in the Portuguese textile industries profess and how these influences the performance of organizations.

2 THE CULTURES OF THE COMPANY

Quality from fundamental philosophical perspective can be defined as the summary of entity property manifestation in surrounding and time their characteristic functions (Zgodavová et al., 2002). For culture and quality to be linked together, it is necessary to recognize the potential impact that the former, as a system of norms, values, and practices, reflects in the quality system. It can be joined together as a sustainable competitive advantage in organizations. The company culture, textile or not, is made by people. Hence, human resources are the most valuable resource of any company or country, but not always the most valued. Thus, the greatest asset of any organization, of any region or any country, is the people with their know-how (Santos et al., 2013; Rebelo et al., 2016; Santos and Milán, 2013; Marques et al., 2018).

By perceiving quality in a TQM process and its results in performance, derived from its implementation, literature presents divergent opinions, both of success and failure.

In a positive perspective, they have the quality circles, lean production, the production techniques, and the quality control procedures to increase the product quality (Flynn, Roger and Sadao, 1995; Garvin, 1988). Delta Consulting Group (1993) and Easton and Jarrel (1998) analyzed 44 organizations and concluded that the TQM implementation programs positively influence the organizations output.

On the other hand, from a negative perspective, research conducted in several countries reported that initiatives of quality implementation failed to meet their targets (Young, 1992).

Empirical studies in the textiles sector conducted in SMEs indicate the benefits of TQM implementation, but they are referred to a set of difficulties. The component “organizational culture” is highlighted as a means to TQM success too (Middleton, 2004; Towers and McLoughlin, 2005).

In the same line of thought, Green (2012) identifies some problems in the implementation of TQM process and suggests that success depends mostly on the “organization culture”. So he presents four models of organizational culture, which could influence the implementation of TQM and thus get a positive impact on performance.

Cameron and Sine (1999) developed a research work and characterized current company cultures within organizations in quality culture typologies. Leal, Roldan and Acedo (2002) and Costa (2008) tested Cameron and Sine’s model to prove

whether different quality cultures make TQM easier and influence the performance of organizations. The research was conducted following the path of that author.

2.1 Quality Culture according to Cameron and Sine (1999)

Cameron and Sine (1999) conducted a study on the organizational culture of quality on the grounds of clarifying the reasons behind the failure associated with several initiatives of quality and its ambiguous relationship with performance. This study was validated with empirical analysis throughout three years to a universe of 68 organizations.

Due to the incongruence of definitions, dimensions and impact on the performance of organizations, some scholars started to investigate TQM as a cultural phenomenon, more than a set of tools and techniques.

Cameron and Sine (1999) define the quality culture as the "subset of the global culture of the organization" considering that this reflects the general approach, the values and the orientation towards quality that cross-organizational actions.

The authors in the analysis present four different typologies to characterize the quality culture, according to Tab. 1.

Table 1 – Quality Culture Types (Adapted from Cameron and Sine, 1999)

Quality Culture	**Characteristics**
The absence of Quality Emphasis	*Products* Quality is not a priority; Quality is not systematically measured; Quality is not tied to the organizational strategy;
	Customers The organization is not focused on customers; It is not receiving feedback from customers; The organization is not responsive to customers;
Error Detection	*Products* Avoid mistakes; Reduce waste, rework, and repair; Detects problems; The focus is on outputs;
	Customers Avoid annoying customers; Respond to complaints efficiently and accurately; Assess satisfaction after the fact; Focus on needs and requirements;

Quality Culture	Characteristics
Error Prevention	*Products* Expect zero defects; Prevent errors and mistakes; Hold everyone accountable; Focus on processes and root causes;
	Customers Satisfy customers and exceed expectations; Eliminate problems in advance; involve customers in design; Focus on preferences or "nice-to-have" attributes;
Creative Quality	*Products* Continuously improve and escalate standards; Concentrate on things-gone-right; Emphasize breakthroughs; Focus on improvement in suppliers, customers, and processes;
	Customers Expect lifelong loyalty; Surprise and delight customers; Anticipate expectations and create new preferences.

As it can be analyzed on Tab. 1, Cameron and Sine (1999) identify on their typology, a quality culture which would be convenient to call "of non-quality", as it can exhibit a total absence of emphasis on quality. Here one can find some organizations that pay little or no attention to quality as a differentiating element. Quality is not seen as a strategy or organizational goal. Values, habits, and behaviours of this type of organizations do not include quality. Nevertheless, such does not mean that the products or services do not have quality. However, these authors emphasize that from a strictly cultural point of view, there is also a shortage of criteria, such as, norms, rules, procedures, attitudes, aims and principles that characterize an organization and its culture.

When it comes to the quality paradigm, there are three types of culture. One is considered reactive, characterized by "error detection", on which, quality is addressed as a problem to be solved or by a set of potential obstacles to be avoided. Another, which is characterized by "error prevention" and which approaches quality with a proactive attitude concerning problems. The difference is drawn up by avoiding mistakes instead of correcting them after pinning them up.

On top of quality cultures identified by the authors comes the "creative quality" in which, all the strategy of the organization is centered on quality. The constant growth of quality patterns, as well as output levels, are the key goals of this type of culture. In these organizations, there is a total involvement from all its members, aiming at promoting a quality culture of excellence. With these

convictions considered at this level, the recognition is promoted by TQM. The global functioning of an organization, or its final result, meet the two last out of seven definitions of quality-focused by Cameron and Sine (1999). Those are consistent with the "Big Q" approach of quality from Juran (1988): "Quality is a system of means to economically produce goods or services which satisfy customer`s requirements" (Japanese Industrial Standards Committee, 1981). Or "Quality means that the organization's culture is defined by and supports the constant attainment of customer satisfaction through an integrated system of tools, techniques, and training" (Sashkin and Kiser, 1993). These different types of quality culture can be considered representative of different maturity levels of quality.

An important conclusion that emerged from this study points out that the most advanced quality cultures had higher performance levels than less developed cultures. Another conclusion of this study reports that each quality culture is characterized by having a single set of tools and techniques.

The changes in organizational culture seem to be both desirable and possible. An essential challenge from leaders in organizations is to manage the cultural change process. A change from a quality culture of "error detection" into an "error prevention culture" can produce better improvements in quality and organizational efficiency than any individual change of techniques.

This empirical study was conducted with the purpose of clarifying the different types of quality culture and its impact on performance. On analyzing the introduction of quality improvement programs or TQM in organizations, without being accompanied by a cultural change, it can be concluded that the probability of failure becomes high.

2.2 Quality Culture according to Leal, Roldan and Acedo (2002)

This study was based on Cameron and Sine's (1999) research about quality culture and on which they decided to analyze 113 Spanish companies, from which 62% are industrial companies and 20% belong to the services sector.

The TQM implementation requires the existence of an organizational culture receptive to change, based on the motivation of both the staff all company to aim for improvement. It is also befitting that people are willing to get involved, understand and later implement a particular group of principles, techniques and TQM practices.

On establishing a parallelism between Leal, Roldan and Acedo (2002) and Cameron and Sine (1999) on quality culture levels, one can observe that they classify their study in "three types of culture", instead of four levels, highlighting "error detection culture, error anticipation culture, creative culture, and continuous improvement".

The organizations that were the object of analysis in this study demonstrated that they all fitted in a type of culture, without the predominance of one of the quality

cultures. However, according to Cameron and Sine (1999) when an organization concentrates more (in relative terms) in a culture of error detection, that is because it is a less developed culture as Tab. 2 demonstrates. On the other hand, when more emphasis is given to error anticipation culture and creative culture and continuous improvement, these are characterized by "cultures with the highest quality level."

Table 2 – Types of Quality Culture (Adapted from Leal, Roldan and Acedo, 2002)

	Concerning Products	**Concerning Customers**
Error Detection	Inspect and detect errors; Reduce waste, the costs of breakdowns and faults; Centered on results and products.	Avoid troubling to customers; Answer complaints rapidly and firmly; Reduce dissatisfaction; Centered on the customers "needs".
Error Anticipation	Anticipate errors; Seek zero defects; Design the first time correctly; Centered on processes and causes of errors.	Satisfy customers expectations; Help customers by avoiding future problems; Obtain customers preferences beforehand and follow them; Centered on customers "preferences".
Creative Culture and Continuous Improvement	Improve normal performance parameters; Create new alternatives; Concentrate on things being done well; Centered on suppliers and customers management as much as on processes.	Surprise and delight customers; Be committed to compensating customers; Anticipate customer's expectations; "Create" customer preferences.

In literature, there is enough evidence about the relationship between TQM and the performance of organizations.

Other authors point out that the TQM implementation system does not quite often produce the expected results because most TQM work is centered on its implementation factors and tools, and forget that a set of values and beliefs underlie all TQM implementations, in other words, some philosophy or cultural orientation. Starting from the hypothesis that the "quality culture is positively related TQM performance programs" three sub-hypothesis arise, according to Fig. 1:

H1. The error detection culture is positively related the TQM program performance.

H2. The error anticipation culture is positively related to the TQM program performance.

H3. The creative culture is positively related to the TQM program performance.

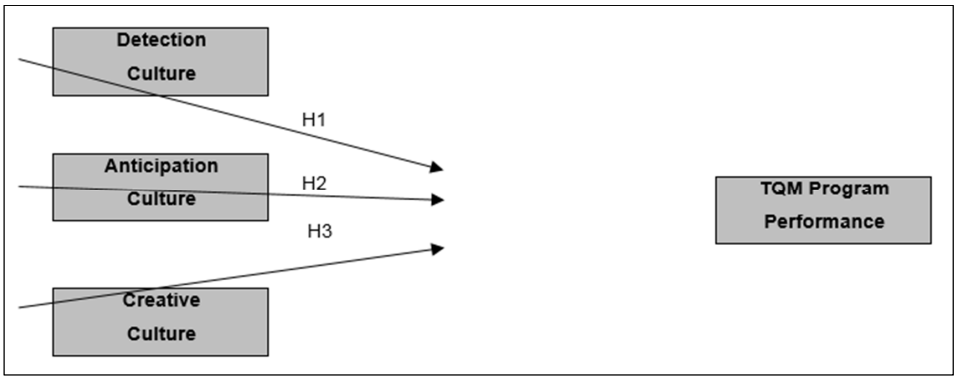

Figure 1 – Model of Investigation and Hypothesis
(Adapted from Leal, Roldan and Acedo, 2002)

On designing the questionnaire to measure the three types of quality cultures, Cameron's model was followed. This allows eight different items to each culture, and these consist in attributes that qualify the way in which enterprises manage TQM principles in search of total quality. Like the original questionnaire, the respondents divided 100 points among the corresponding items to the three scenarios, according to the importance or emphasis they gave them in practice. From Cameron's aims, which consisted in an attempt to identify a dominant culture through an additive operation, the items correlation or their internal consistency was not an assumption. These authors decided to define indicators as formative according to each type of culture, that is, indicators where their reason for cause is not observed in theoretical constructions. On the other hand, the performance of the quality program is associated to a scale adapted from Powell (1995), which consists in five measure points, from 1 "totally disagree" to 5 "totally agree".

From the analysis of the obtained results, one confirms the existence of considerable high cultures (error anticipation 58.9% and creative culture 11.6%); however, there is still a critical percentage of 29.5% companies that emphasize the type of culture known as "error detection", which focus the workers' attention in obsolete values and attributes.

Out of this study, we concluded that organizations should focus their efforts to generate a higher culture as the culture of error detection, negatively influences the performance of the TQM program, which explains 33% of the criterion variation. On the other hand, both cultures of anticipation and creative culture present a connection with TQM programs, showing an explained fluctuation of 10.79% and 11.16% respectively of the dependent variable. The top management must assume an important role in the promotion of more advanced cultures in all levels of the organization and lead the processes of change, both at human resources level and strategies in a way to internalize the values of the "creative culture".

2.3 Quality Culture according to Costa (2008)

An empirical study was also conducted in Portugal, following Cameron and Sine's lines of work, as well as, those of Leal, Roldan and Acedo (2002). The latter author proposed to analyze the quality management systems in Portuguese companies, including the topic of the importance of quality cultures and its impact on performance in his work.

The sample used is formed by 260 certified companies, both industries, and services, distributed through several activity sectors, being that textile, building and metallurgy sectors which represent 24.6%, 15.4%, and 12.7% respectively. It is relevant to mention the importance of the textile sector in the regional economy. The types of culture professed in the questionnaire by this author were, according to Tab. 3, "the error detection culture, the error anticipation culture and the creative culture and continuous improvement."

Table 3 – Percentage of Different Types of Culture (Adapted from Costa, 2008)

Quality Culture Typology	**Percentage**
Error Detection Culture	38.37%
Error Anticipation Culture	51.02%
Creative Culture and Continuous Improvement	10.61%
Total	*100.00%*

The results of the previous study testify the existence of different quality cultures, with emphasis on the majority (51.02%) of the "error anticipation culture", though there is still a relevant number (38.37%) of companies that continue to emphasize the type of "error detection culture", which attests that they are still oriented by values and attributes that can be improved. With a weight of 10.61%, the "creative culture and continuous improvement" culture demonstrate that few organizations develop this type of culture, sustaining the obtained results from other studies (Leal, Roldan and Acedo, 2002; Cameron and Sine, 1999).

The companies with an "error detection culture" adopt a strategy of "results reinforcement" regulating TQM through gradual or incremental changes, implementing small changes in specific parts of its organization, depending on results which are expected to be achieved.

In a different perspective, companies that are oriented by the "error anticipation culture" adopt a "reorientation – activity" strategy, which professes the TQM as a more radical change and in large scale over the whole organization, whose implementation involves a new way of doing, thinking, negotiating, and brings out a cultural change in the whole organization. It becomes necessary to reinvent the organization.

In the same line of action, the "creative culture and continuous improvement" establishes higher proximity with TQM and its consequent positive impact on performance. The same was checked in the study of Leal, Roldan and Acedo (2002), which indicates that organizations should guide their efforts towards this type of culture. This happens as it is advised that organizations find a way of exceeding the performance and standard expectations and put emphasis on startling and delighting the client.

In concomitance with this study, Leal, Roldan and Acedo (2002) testified Cameron's structure and also concluded that the "error detection culture" negatively influences performance. On the other hand, the "error anticipation culture" and the "creative culture and continuous improvement" establish a positive correlation with performance. The management of organizations must promote more advanced quality cultures (error anticipation culture, creative culture, and continuous improvement) as these are the ones which promote a more significant impact on performance.

3 METHODOLOGY

The investigation started with the formulation of a questionnaire based on an existing model tested and validated by other authors, such as Cameron and Sine (1999), Leal, Roldan and Acedo (2002), and Costa (2008).

The questionnaire was structured in three sections. In the first section, one questions the number of existing employees within an organization, so that it can fit and define the dimension of industries according to the European Commission (2003). The second section qualifies the quality program on "performance" and is measured through 5 items, each one using the Likert scale of five points, where the first point means "much disagreement" and the last point means "much agreement". Lastly, on section three, how companies position themselves in terms of quality towards TQM demand, (error detection culture, error anticipation culture, and creative culture and continuous improvement) the types of culture were measured through 24 items, where they are represented, the error detection culture, the error anticipation culture, the creative culture and continuous improvement. These measure scales were used by Cameron and Sine (1999), Leal, Roldan and Acedo (2002) and Costa (2008).

The questionnaire was sent to 71 companies. Some companies did not respond. There were also some questionnaires which were not complete. Thus, the sample is formed by 60 textile companies which represent a ratio of the useful answer of 84.5%. The geographic area chosen for analysis was the North of Portugal, namely "Vale do Ave", as there is a strong "textile culture" in this region and a considerable part of Portuguese textile industries. Important institutions connected to the textile sector are located there, namely the Technological Centre of Textile and Clothing Industries of Portugal (CITEVE), the Textile and

Clothing Association of Portugal (ATP) and the Centre of Textile Science and Technology of Minho University.

According to studies from Cameron and Sine (1999), Leal, Roldan and Acedo (2002), and Costa (2008), one confirmed that different types of quality culture mean different levels of maturity in quality. Thus, the higher culture is, the bigger its impact is on performance. These works concluded that being TQM a performance generator process, this has more or less implantation success according to the quality culture emanated by the organisation. Through the formulation of the three hypotheses, the existing types of culture in the Portuguese textile firms were evaluated. It was measured the performance of the quality program, with the aim of understanding which types of quality culture should profess the Portuguese industries, in order to gain raises in performance.

4 HYPOTHESES FORMULATION AND MODEL OF INVESTIGATION

Following the conclusions drawn from the analyzed studies, it can be said that TQM produces positive results and generates value for organizations, causing a rise in the performance of organizations.

From the professed cultures in Cameron and Sine's study (1999), which were used in other researches, such as, Leal, Roldan and Acedo (2002) and Costa (2008) (error detection culture, error anticipation culture, creative culture and continuous improvement), the results were unanimous when it comes to produced effects by culture in the implementation of the TQM program. Thus, companies with an "error detection culture" negatively influence the TQM performance, unlike the "error anticipation culture" and the "creative culture and continuous improvement", positively influence the TQM performance.

Without alluding to performance, managers cannot, in an objective or consistent way, assess the quality of their decisions (Chakravarthy, 1986). In brief, considering that the bigger or, the smaller success of the TQM implementation depends largely on the type of existing quality culture, as this is a management system generator of performance, one assumes that the higher the culture of the existing company is, the bigger its performance is.

Hence, it can be understood if the culture of the company influences performance, specifically on the impact on productivity, on the competitive position, on the improvement of profitability, on profit, among other factors. As such, the following hypotheses were formulated, according to the Fig. 2:

H1. The error detection culture negatively influences performance.

H2. The error anticipation culture positively influences performance.

H3. The creative culture and continuous improvement very positively influence performance.

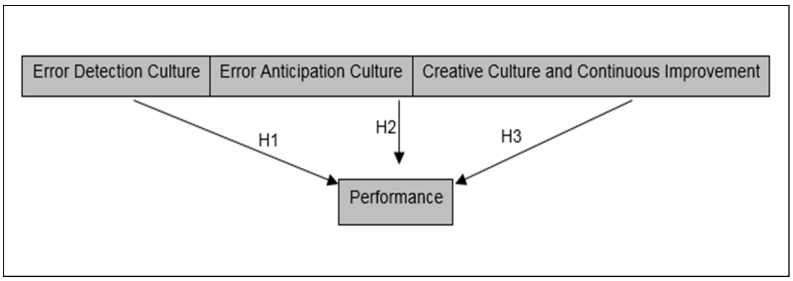

Figure 2 – Model of Investigation and Hypotheses (Araújo, 2014)

5 RESULTS

5.1 Number of Workers

The following analysis allows us to confirm the number of companies: up to 10 workers (micro companies), from 10 to 49 workers (small companies), from 50 and 249 workers (medium companies) and more than 250 workers (big companies).

In the sample, the number of workers of the companies in study presents an average value of 118 employees with a value dispersion of 162%. The values, minimum and maximum are 5 and 900 workers, respectively.

The number of workers of the studied companies is analyzed according to its dimension. To get this rating, one used the number of workers as a reference to compare with other studies, so one resorted to intervals in the European Commission recommendation, from 6 May (European Commission, 2003).

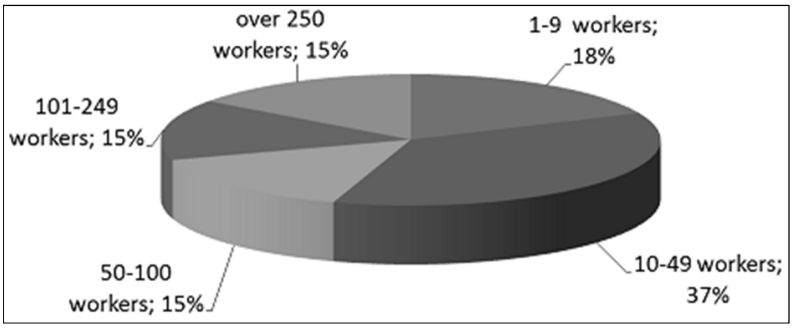

Figure 3 – Distribution of Workers according to the Company Dimension (Araújo, 2014)

In terms of analysis, the enterprise universe is characterized by the dominance of SMEs (85%), according to the sample in Fig. 3, where 18% are micro companies, 37% are small companies, 30% are medium companies, and only 15% are big companies.

5.2 Performance

Fig. 4 shows the observed average values according to the importance of a quality program on performance.

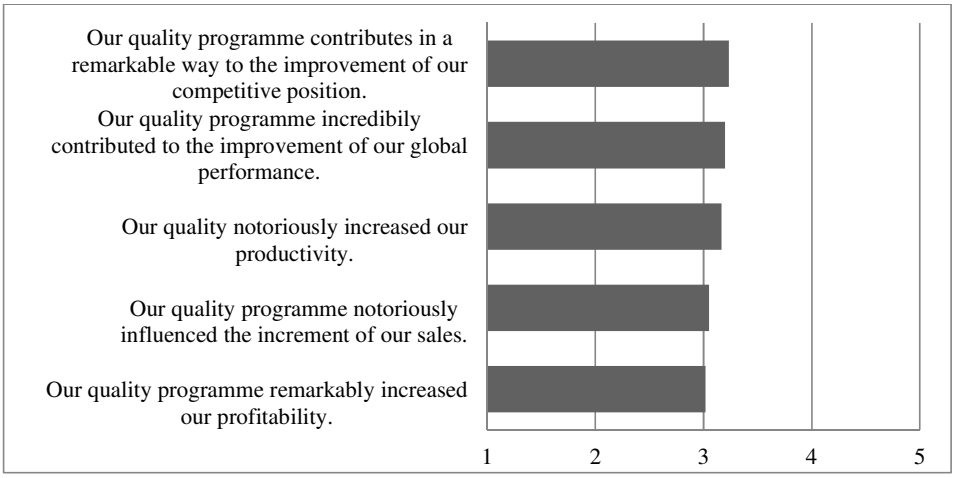

Figure 4 – Distribution of the importance of quality on performance (Araújo, 2014)

From the observed values, one can highlight the three highest average values, which are "Our quality program contributes in a remarkable way to the improvement of our competitive position", "Our quality program incredibly contributed to the improvement of our global performance" and "Our quality program notoriously increased our productivity".

From this analysis, one concludes that a large part of the sample is aware of capital gains of a quality program and its competitive advantages and the impact that this can have on performance.

In the sample, performance holds an average value of 3.24 (in a measurement scale from 1 to 5) with a dispersion of values of 37%. The minimum and maximum values are 1.00 and 5.00 respectively.

The histogram of the Fig. 5 illustrates the value distribution of performance of the organizations in the study.

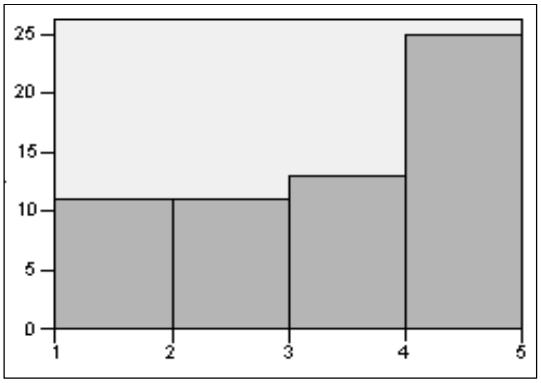

Figure 5 – Histogram of the Number of Companies Relative to Performance (Araújo, 2014)

It can be observed that the distribution of performance values is confirmed mainly between 4 and 5 followed in a relatively uniformed way for the other unit intervals.

According to the theoretical revision of the companies in the analysis, a large part of them refers that the performance of organizations depends on the impact of the quality program and how it is implemented and managed.

5.3 Culture

In Tab. 4, the mean values observed are presented, according to the distribution of the characteristics of the three types of quality culture.

Table 4 – Distribution of the Characteristics of the Three Types of Quality Culture (Araújo, 2014)

Quality Culture	**Typology Description**	**Mean**
Error Detection Culture	1a. Inspect and detect errors	**9.25**
	2a. Reduce waste, the costs of breakdowns and faults	**7.33**
	3a. Correct errors	5.80
	4a. Centred on results and products	3.70
	5a. Avoid troubling customers	5.83
	6a. Answer complaints rapidly and firmly	4.97
	7a. Reduce dissatisfaction	5.20
	8a. Centred on the customers “needs”	2.20
	Total points	*44.28*

Quality Culture	Typology Description	Mean
Error Anticipation Culture	1b. Anticipate errors	**9.52**
	2b. Seek zero defects	3.52
	3b. Design correctly the first time	4.17
	4b. Centered on processes and causes of errors	3.85
	5b. Satisfy customers expectations	**9.13**
	6b. Help customers by avoiding future problems	2.27
	7b. Obtain customers preferences beforehand and follow them	2.10
	8b. Centered on customers "preferences"	2.22
	Total points	*36,78*
Creative Culture and Continuous Improvement	1c. Improve normal performance parameters	6.20
	2c. Create new alternatives	2.22
	3c. Concentrate on things being done well	1.50
	4c. Centered on suppliers and customer's management as much as on processes	2.25
	5c. Surprise and delight customers	1.40
	6c. Be totally committed to compensating customers	0.53
	7c. Anticipate customers' expectations	2.20
	8c. "Create" customer preferences	2.65
	Total points	*18.95*

The four mean values more often observed belong to the types of the culture of "error detection and error anticipation" were, according to Tab. 4, 1b. anticipate errors, 1a. inspect and detect errors, 5b. satisfy customers expectations and 2a. reduce waste, the costs of breakdowns and faults.

One can see in Fig. 6 that the dimension of the dominant culture is the "error detection culture", followed by "error anticipation culture" and lastly by the "creative culture and continuous improvement" culture. It was determined for each company the dimension of the dominant culture, choosing the dimension that presents the higher average value.

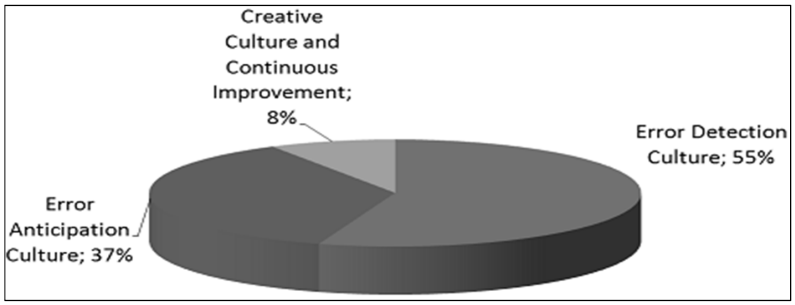

Figure 6 – Percentage of Companies Related to the Type of Dominant Culture (Araújo, 2014)

In terms of target analysis on the sample, there are 33 companies that use the "error detection culture", which corresponds to 55% of companies; 22 companies use the "error anticipation culture", which corresponds to 37% of companies; and 5 companies use the "creative culture and continuous improvement", which corresponds to 8% of companies.

This analysis follows the described studies where one finds a predominance of the error detection culture and error anticipation culture using the same measurement scales.

In this research, considering the 55% of companies with error detection culture and according to with the described literature, it is understood that most companies advocate reactive quality cultures, which denotes that they are still oriented by values and attributes that should be improved in the paradigm of quality management. We are talking about cultures, which do not promote TQM, so the impact of this culture negatively influences the performance (Leal, Roldan and Acedo, 2002; Costa, 2008).

5.4 Existing Correlation between the Types of Culture and the Performance (Hypothesis Checking)

All variables whose relation one aims to study are quantitative variables, so they can be analyzed using Pearson's R correlation coefficient.

In Tab. 5, for each line that relates the variables, one shows the Pearson coefficient value and evidential value of the test. The correlations between the types of culture and performance are presented.

Table 5 – Correlation between Types of Culture and Performance (Araújo, 2014)

		Performance
Error Detection Culture	Coeff. Correlation	-0.420(**)
	Proof Value	0.001
	N	60
Error Anticipation Culture	Coeff. Correlation	0.081
	Proof Value	0.537
	N	60
Creative Culture and Continuous Improvement	Coeff. Correlation	0.456(**)
	Proof Value	0.000
	N	60

*Notes: ** Strong correlation to a significance level of 0.01.*

Meaningful correlation between the two variables is pointed out (present a proof value inferior to 5%). The two statistically meaningful correlations can be:

- Positive, meaning that an increase of a variable corresponds to a significant increase of another.
- Negative, meaning that an increase of a variable corresponds to a significant decrease of another.
- One sees a statistically meaningful relation between:
    - Error detection culture and performance;
    - Creative culture and continuous improvement and performance.

The checking of hypothesis of the investigation are:

H1. The error detection culture negatively influences performance: One confirms H1, as the error detection culture negatively influences performance, with a correlation coefficient of -0.420.

H2. The error anticipation culture positively influences performance: This hypothesis cannot be confirmed as the error prevention culture is not related to output in a statistically meaningful way and the correlation coefficient is 0.081.

H3. The creative culture and continuous improvement very positively influences performance: One confirms hypothesis H3 as the creative culture and continuous improvement positively influences performance, with a correlation coefficient of 0.456.

Thus, one confirms that the Portuguese textile companies must change their management paradigm, abandon the "error detection culture" and adopt the "creative culture and continuous improvement", so as to positively influence performance.

6 DISCUSSION

Considering the weaknesses of definitions, dimensions and inconsistent impacts on performance, Cameron and Sine (1999) investigated TQM as a cultural phenomenon, rather than a set of tools and techniques, realizing that the successful implementation of TQM techniques depends on the internal quality of the organization.

This internal quality of the organization is conditioned by its culture. The key advantage of handling quality as a cultural variable is that the ambiguity and the inconsistency associated with multiple definitions and TQM definitions diminish. To Cameron and Sine (1999) the different types of quality cultures can be considered as representative of different levels of quality maturity (Costa, 2008).

In line with this vision, Leal, Roldan and Acedo (2002) tested Cameron's structure having also concluded that the error detection culture negatively influences the performance of the TQM program.

On the other hand, the error anticipation culture and the creative culture and continuous improvement have a positive correlation with the TQM program. In Portugal, Costa (2008), in his investigation to industries, obtained the same results.

The hypotheses presented in this study, represent the different types of quality culture, as representing the different degrees of maturity of the organization when it comes to the way these positions in terms of quality. The hypotheses that the culture of error detection has a significant and very negative impact on performance is confirmed, ratifying H1 hypothesis with a coefficient of -0.420.

An error anticipation culture has a positive impact, though not meaningful, on performance, not confirming the H2 hypothesis. The non-significance of this hypothesis can occur from the fact that the sample size of companies is reduced.

On the other hand, the creative culture and continuous improvement influence very positively and in a meaningful way the performance, confirming H3 hypothesis with a coefficient of 0.456. These results meet other studies such as Leal, Roldan and Acedo (2002), Cameron and Sine (1999) and Costa (2008).

Thus, one can say that according to the type of quality culture that comes from each organization, it affects either negatively or positively the output of the organization.

From the developed investigation, it can be concluded that:

The error detection culture negatively influences performance; the creative culture and continuous improvement very positively influences performance;

It is hardly possible to confirm in a meaningful way the hypothesis, which connects the error prevention culture with performance. This hypothesis must be deepened in further studies.

7 CONCLUSIONS

At the present, companies are confronted with constant changes in the markets where they operate. Thus, management philosophies, such as TQM are management processes that should be proactively applied, so that textile industries can remain and compete in more and more demanding and globalized markets.

In this study, a model of investigation formed by 3 hypotheses is exposed, so that they can be used as the reference for the Portuguese textile industries, aiming at improving quality in management to make it bear fruit with a positive impact on performance.

In this perspective, Cameron and Sine (1999) presented four typologies of quality cultures: "absence of emphasis on quality, error detection, error prevention, and creative culture". In further studies, such as Leal, Roldan and Acedo (2002) to 113 Spanish companies, and Costa's (2008) to 260 Portuguese companies, quality cultures were analyzed in three typologies: "error detection culture, error anticipation culture, and creative culture and continuous improvement". From the confirmed results, one concluded in these studies that companies must promote high-quality cultures, such as creative culture and continuous improvement, that facilitate the implementation of continuous improvement tools. It is also relevant that the higher the quality culture is, the higher the positive impact on the performance of organizations it has. On the contrary, the error detection culture negatively influences performance.

This study results point out a predominance (55%) of the "error detection culture", that is, it focuses attention in values and attributes that must be improved in the paradigm of quality management. 37% of companies emphasize the type of error anticipation culture and only a few organizations developed a quality culture up to the level of creative culture and continuous improvement. This is in line with other studies (Leal, Roldan and Acedo, 2002; Cameron and Sine, 1999; Costa, 2008).

The most advanced quality cultures ("error anticipation culture" and "creative culture and continuous improvement") are more related to performance than a less developed culture (error detection culture). The latter presenting a significant negative influence of -0.420. In the opposite direction, the creative culture and continuous improvement have a positive significance of 0.456.

This study contributes to conclude that different types of quality cultures are representative of different levels of maturity in quality and have an impact on the performance of the organization (Cameron and Sine, 1999; Costa, 2008; Leal, Roldan and Acedo, 2002). Conclude also that performance is influenced by the level of the predominant quality culture and quality cultures act as the engine of the quality management process due to the effects they exert on performance.

This study allows us to take a set of useful conclusions for the management of the Portuguese textile industry so that the top management will assume an important role in the promotion of more advanced quality cultures at all levels of the organization. These must evolve to creative culture and continuous improvement values.

In practical terms, this study can allow managers to identify the practices that add value to products/services and consequently, positively influence performance.

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To Lead Change - To Work and Study with Creativity and Structure - A Course Design for Deeper Learning Outcomes within a Course in Quality Technology

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ABSTRACT

Purpose: In this paper a new course design as a case study is presented. The course was given at bachelor level at Uppsala university, campus Gotland, within the division of quality technology. The purpose of the case is to give students an opportunity to practice acquired theoretical knowledge by offering them the opportunity to create an organization of their dreams, working in small groups.

Methodology/Approach: This paper builds upon a case study approach, combining a literature review, document studies over the performed course and evaluations over the course.

Findings: The case study shows that course design can be an important inspiration and a bridge between theory and practice for the students. Course design seems to support students' learning processes according to evaluations of the course. Course design offers benefits of the collective learning, especially for distance students. It increases independence, understanding of one's mission and accountability for it. Students are given the opportunity to practice the theoretical knowledge in their education in a creative and inspiring way. Still, there are further demands and challenges left of improvement in the course design.

Research Limitation/implication: The research limitation is that this study consists of only one course in Quality Technology.

Originality/Value of paper: This study contributes to the discussion about learning at university level through a case study.

Category: Case study

Keywords: change management; collective learning; responsibility; project management; agile methods; case study

1 INTRODUCTION

The concept of change management has become one of today's most widely used and controversial concepts. It is therefore important to develop activities within university course about organizational context in order to increase students understanding of the goals for more sustainable practice (Kotter, 2012; 2014). Society and organisations change more and faster than ever, and the impact on organizations' competiveness today is greater than before. A successful organization is one that adapts to change, anticipate future needs and aim for high added value in the long term (Foley and Zahner, 2009). There is not only the product but also the organizational structure and management that have to adapt to change.

There is a lot of literature and research of different kind of about changes, as well as models for change and how changes should be conducted. However, even if active leaders say the majority of their work is connected to change management, according to Forslund (2013), managers apply change management models to a relatively small extent. Managers do not have incentives, focus and ability to apply theoretical models in practice. Hence, there is a gap between theory and practice, which could be a knowledge transfer problem which occur as one of the main obstacles to improved competitiveness (Hallencreutz, 2012). Furthermore, are many organizations only passive adapters of the changes instead of being active change managers.

Students at the universities do study different theories about change management but have limited knowledge on how to bring it into practice (Oxenswärdh, 2017; Taylor, 1999). The Department of Engineering Sciences at Uppsala University/Campus Gotland offers undergraduate courses in quality, management and organization. The courses try to meet the need to develop students' ability to work in different organizations outside university. Students are offered opportunities to develop professional skills in a collegial and mutual cooperation with different organizations. In this course, though, students created a fictive organization by themselves around some important organizational themes. In this creation the agile methods were adopted as tools to assist and structure the change and organizational development.

Any planned and directed change by individuals or collectives is built on learning. Learning can be defined more generally as the process of acquiring knowledge, skills, norms, values, or understanding through experience, imitation, observation, modelling, practice, or study; by being taught; or as a result of collaboration (Illeris, 2007). The learning process activates several other processes: processes of understanding the assignment and its responsibilities (Minsky, 1988; Argyris and Schön, 1978; Lundgren, Säljö and Liberg, 2014).

Being able to develop one's professional competence to match the practical needs is a viable path to learning where the motivation is greatest among professionals (Ellström, 2011). In this light, the organizational and collective

competence development measures alone are not sufficient (Schein, 1993; Schön, 1995).

Highlighting and being able to discuss, reflect, and learn more about the profession specific areas, both individually and collectively, is of great significance for professional development. Based on this reasoning, the learning process provides the professionals with their knowledge and sharpens their tools (Bruffee, 1993; Dillenbourg, 1999).

Organizations can thus be continuously improved through the professionals' own power. This process as a model for enhancing aspects of the professionals' competence can become an important part of their development, where professionals themselves shape and continuously revise their know-how in their work by relying on their own and their colleagues' competence and professionalism (Granberg and Ohlsson, 2016; Goldstein, 1981).

Responsibility issues are a part of the ethical competence in organization and a vital part in the work towards sustainable organization. Without ethical discussions at a deeper level, professionals deceive themselves and can deceive their customers. This leads to ethical stances being taken on unethical grounds (Oxenswärdh, 2011).

The balance between freedom on the one hand and responsibility on the other is upset, and the result is an organization like a stage with a nicely designed set but with a play that does not affect anyone. Organization development can be regarded as a force whereby the diversity, through refection and dialogue, results in new solutions that can be beneficial to everyone. Responsibility of the mission thus becomes a matter of debate among the professionals. Discussions intend to jointly interpret the responsibilities that the task contains (Granberg, 1996; Ohlsson, 1996; Wilhelmson, 1998; Döös and Wilhelmson, 2005; Granberg and Ohlsson, 2005; Oxenswärdh, 2011).

As the road to the mission and responsibility for understanding and accountability can be seen as a learning process, both in individually and collectively, emphasized the psychological and pedagogical dimension of the concepts of responsibility and change (Oxenswärdh, 2011). Regarding to mission and responsibility understanding, these can be seen as formed by learning processes. Factual knowledge base uses the familiarity of knowledge that in turn helps to shape and create understanding of the mission and the responsibility, within the change (ibid.).

The ideas, practices and methodologies how to handle requirements in an all changing world had been around for years when a group of computer industry experts come together in order to define general development values and principles for agile methodologies. The goal was to improve the software development process for companies around the world, and to give an alternative to the popular traditional heavyweight methodologies (Martin and Micah, 2006; Agile Alliance, 2018). These agile values and practices defined offer the ability

to handle dynamic and non-deterministic changes in the environment that characterizes organisational changes.

The agile values stipulated highlights individual and interaction, working solutions, customer (stakeholders) collaboration, and being able to quickly and gracefully respond to change (Agile Alliance, 2018). These values are supplemented by the defined twelve principles (Agile Alliance, 2018) which form the guiding principles for the methodologies and that act as the characteristics for agile practices (Martin and Micah, 2006). These principles focus on bringing development into alignment with business and customer needs, a culture in which change is welcome, and the motivated skilled and engaged team members.

To appropriate knowledge and gain experience from agile methodologies and area of agility is essential for students to be well prepared for future labour market as indicated by the research and advisory company Gartner (2015).

This is due to the accelerating changes in not only related to organisations but to the general business and social environment that require dynamic and flexible way of working today and in the future.

In order to increase the motivation among students and to strengthen their ability to acquire effective agile project methods in the development of new products and services it is essential that the students are also actively working with these methods to solve a problem within a defined area (Devedzic' and Milenkovic, 2011; Zapater et. al., 2013). Problems that are used in the course should be linked to the involvement of students in solving their own identified problems. Like the student working with their fictive company in this course act as stimulus and provide the student with activities that offer them to develop a professional behaviour according to Boud and Feletti (1997). Therefor it was a necessity that the design of the course engaged the students and that the lectures are guiding and supporting them in their endeavour.

In summary, mission and responsibility understanding, are both processes formed by individual and collective learning. The process starts as an individual learning process. Subsequently, involved group reflections together with individual reflections create a collective learning. If students are given a possibility to clarify and discuss issues of change in collective, it also activates other processes of understanding their assignment and its responsibilities. These processes are important to be taken into consideration already while students are studying at the university.

2 OBJECTIVES OF THE STUDY

The course, *Leadership for Change*, (10 points) is divided into two main but interrelated sections: a project management section and the section related to change management. The project management section was planned in focusing

on the agile methods that are common in both private and public sectors in organizations. It was further designed as a part of the course offering the tools for students in meeting challenges of creating an imaginary organization. The theme section, in turn, was highlighting important cornerstones of organizations' daily life in general and within organizational change, in special. Students were offered an opportunity in creating an organization of their own. In this section student really created a fictitious organization, working in small groups or teams, studying the following themes: the structure of the organization, human resources (HR), leadership, conflict management, change management and long-term development of the organization. The course consisted of different tasks carried out during the period 29 August 2017 - 13 January 2018.

Literature studies and inspirational lectures on six organizational themes were varied with knowledge of agile methods such as Scrum and Kanban within project management. After designing the foundation for their dream organization, the students were assigned small cases to work and solve with. The course was run both as a campus course and a separate course at distance. Students were working in small groups, some studying on campus and others at distance, during whole semester. Students then presented orally and through written reports their learning outcomes and processes continuously during the course. Evaluation of the processes were performed and documented by teachers as well as assessed several times during the course.

The project management section comprised of two phases. The first consists of six compulsory lectures on the philosophy and thoughts behind agile methods and a review of the two most common methods: Scrum and Kanban (Sutherland and Schwaber, 2017; Kniberg and Skrin, 2009).

The following phase consisted of applying these two methods as they performed their tasks related to the different themes, during the course. The first two thematic tasks were planned and implemented accordin g to their normal way of performing this kind of activities however some of them used Kanban that the found suitable, while the two following had to be performed according to Kanban. The final two theme assignments were performed according to Scrum. In other words, before students begin their work on the different themes, they needed to plan how to implement these, and then follow up the changes in addition to analysing and evaluate the agile method used. Students were also expected to be active and involved in the planning, implementation and follow-up of these small agile projects that aimed at to generate the result for the second part of the course that was about leading change divided into different themes. This work should be documented on a regular basis (once or twice per week) to show how student managed to implement the methods. This documentation should form the basis of the mandatory follow-up meetings. For follow-up meetings should students appoint a chairman who chaired the meeting, convened and documented the meetings. An exam was conducted over the internet after the initial lectures in the initial phase of the course to validate that they had the fundamental knowledge required to carry out the themes.

To sum up, the course consisted of two interconnected parts. The overall aim of this course design was to combine both structure and creativity in order to be able to create an organization corresponding to students' dreams. The course would also serve as a positive and creative ending on program studies, where the different study themes on quality technology, organizational theories and tools in project management would harmonize and create a whole that could enhance students' learning for current and future working life.

3 STORY TELLING

Introduction

Students' learning and teaching at the university level, is often focused on the theoretical knowledge. On campus Gotland, Bachelor Programme in Leadership, Quality and Improvement and Bachelor Programme in Quality Engineering and Management among others are offered. Both programs apply contacts with different external organizations and companies in different student tasks to provide insight into the practical activities. Many of these contacts contain problem solving of existing problems in these organizations. There are seldom opportunities for a more creative and imaginative approach, though. It is not often students have the opportunity to create something new and own using their theoretical knowledge, creativity and fantasy.

Students on these programmes at Uppsala university did have a need of strengthening their skills in project management and especially in using the agile methods. In this course we wanted to merge these two aspects: creativity and structure. We believe that these characteristics and tools are increasingly needed within organizational development in general and especially in change management. The course was given on bachelor level at Uppsala university, campus Gotland, within the division of Quality Technology. The course was conducted both as a campus course as well as a distance course online. The aim of the case is to give students an opportunity to practice acquired theoretical knowledge by offering them to create an organization of their dreams while working in small groups.

To enhance and deepen the students' learning process in the course, they are offered broadened knowledge of organizational aspects and cornerstones within change management, using a number of themes and agile methods.

Literature studies and inspirational lectures on six organizational themes were varied with knowledge of agile methods such as Scrum and Kanban within project management. After designing the foundation for their dream organization, the students were assigned small cases to work and solve with. Students were working in small groups, some studying on campus and others at distance, during whole semester. Students then presented orally and through written reports their learning outcomes and processes continuously during the course. Evaluation of

the processes were performed and documented by teachers as well as assessed several times during the course.

The case study shows that course design can be an important inspirer and a bridge between theory and practice for the students. Course design seems to support students' learning processes due to evaluations of the course. Course design offers benefits of the collective learning, especially for distance students. It increases independence, understanding of one's mission and accountability for it. Students are given the opportunity to practice the theoretical knowledge in their education in a creative and inspiring way. Group processes sharpened their own tools and supported their ability to individual and collective learning.

Some of the parts of the course follow the structure of the so-called PPB, project and problem-based learning. The demands of studying using scientific articles as a course literature, also seemed to prepare students for a bachelor degree, which was planned to be a course, following this course.

This paper gives an example of how one university course can be designed in order to create deeper understanding for organizational change. The study makes a contribution to the discussion about learning within the university course as case study. Still the improvement of the course design is highly needed: there is a need of tightening up the relation between the theme section and the agile methods. Students were experienced them too much as two separate parts of the course.

4 COURSE DESIGN AND ASSIGNMENTS

Campus and distance learning

The students in the course comes from two separate programs in Engineering Sciences, Department of Quality Technology, Uppsala University, on campus Gotland: Program for Bachelor Programme in Leadership, Quality and Improvement and Bachelor Programme in Quality Engineering and Management. Both programs use to apply contacts with external companies and organizations at different student assignments for the purpose of expanding students' understanding of the practical work. Course, Leadership for Change was given both as a campus course and distance course. On campus were 19 students and at distance 36 students attending the course. Both course groups used the digital learning platform called Moodle as a support and meeting place in the course. Both E-classrooms were designed of course leader to give a structure for the course. Adobe Connect and Skype were used as communication channels on distance courser.

Homepages consisted of course information in the form of a schedule, syllabus, course literature, lecture material, places for submission of the course assignments and assessment, evaluations, open discussion forum and forum for the news. The website also contained several communication tools for the

students. Course participants on campus come from both programs and were generally younger than distance students. The distance students again were all from the Bachelor Programme in Leadership, Quality and Improvement and were already working with side of their studies. They also were slightly older than campus students.

The course design

Students were offered live and distance online and recorded lectures. The course required team or group work that could be performed through physical or virtual meetings, such as via Adobe Connect, Skype, Face Time, Wiki, chat, conference call, etc. The group was free to choose the meeting form. The course also included group presentations of the various course assignments. These were done on the campus or via Adobe Connect. After each theme and group presentation, a written group report was to be submitted. In following figure course design in whole is presented, Fig. 1.

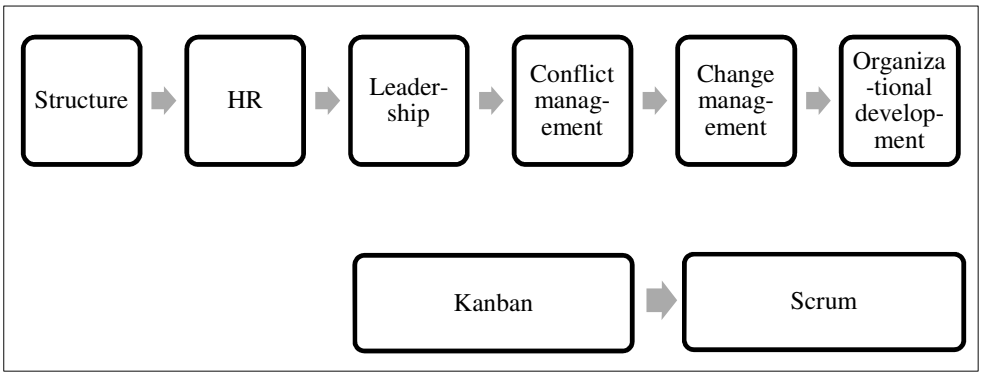

Figure 1 – Structure of the Course in Short Where the Themes and Their Relations Are Presented above and the Two Agile Methods Are included below

The course consisted of two interconnected sections: section related to change management and project management section. Six themes in the course can be seen as cornerstones and fundamental aspects of the life of any organization and important arenas in change management. In order to enlarge the tool box of project managers, agile methods, Kanban and Scrum were used as tools in the course. In the following the schedule of the course is presented.

In the Tab. 1 the overall schedule of the course is presented. Themes in the course were varied by lectures and workshops in agile methods in order to support students' learning outcomes on organizational change and offer structure on studies with own imaginary organizations. The design followed the structure where themes were first presented by theoretical lectures, often performed by guest lectures. After that students got a task of designing the theme in their own organizations, which was then presented in group. A written report was finalizing all themes.

Agile methods

The agile values and principles together with two agile methods that were given in number lectures/seminars to all students. The campus students were offered the opportunity to practice the two methods using a minor exercise, something that could not be offered over internet to distant students. For two themes (leadership and conflict management) they used the agile method Kanban and in the following two themes (change management and organizational development) they practiced the method Scrum. The student groups submit their progress using established practices within the two agile methods so that they could be with provided appropriate scaffolding to facilitate their learning. The students had to write a final report after exercising each of the two methods.

They presented in detail how they had executed the method and discussed their thoughts about how the work had progressed and submitted their subjective opinions regarding the two methods. These reports were presented and discussed with the lecture in a follow-up meeting.

Table 1 – Course Schedule

Themes	When?	What?	How?
Introduction	w 35	Grouping, task sharing	Introduction lecture seminar
Project management	w 36	2 half days	Lecture and seminar
Project management	w 37	2 half days	Lecture and seminar
Project management	w 38	2 hours examination	Online examination
Structure HR	w 39	Form/type structure, vision production/service management system, quality system Who works here? What do they have for professional competencies? What does organizational culture look like? Basic values? Competence?	Presentation of organization must be submitted in writing Presentations of organizations
HR	w 40	Inspirational lecture of HR in practice guest lecturer	Lecture Group work and seminar
Leadership	W 41	Inspirational lecture of Leadership Project part: According to Kanban.	Write and submit report, follow-up meeting Seminar

Themes	When?	What?	How?
Leadership in practice	w 42	Management / leaders. Leader profiles and responsibilities.	Presentations in groups, submitted group report Discussions
Conflict management	w 43	Inspirational lecture of Conflict management, guest lecturer Project part: According to Kanban	Lecture Seminar Small cases are handled out
Conflicts in practice	w 44	Suggest solutions for cases	Report at least three solutions. Submit written report
Leadership & Conflict management	w 45	Write and submit final report Kanban Follow-up meeting to present and discuss experience using Kanban	Report Kanban Presentation Kanban
Change Management	w 46	Guest lecturer Project part: According to Scrum	Seminar + discussions in groups Write and submit report, follow-up meeting
Change Management in practice	w 47	Assigned changes in your organization are to be presented, what do you do, plan, act, manage! Suggest solutions	Report at least three solutions Presentations and discussions
Organization development	w 48	Guest lecturer. Project part: According to Scrum	Seminar + workshop
Organization development in practice	w 49	Design for continuous development plan for organization Write and submit final report Scrum Follow-up meeting to present and discuss experience using Scrum	Presentations Report Scrum Presentation Scrum
Presentation of the organization on the recruitment fair	w 50	Organizations are to be presented in whole / at the fictive recruitment fair. Write and submit report and attend into follow-up meeting.	Presentations in groups, discussions and oral evaluation of the course

Assignments

Logbooks - throughout the course

Students were expected to write logbook reflections throughout the autumn. They were supposed to individually document the group's work processes throughout the course. This logbook should then be highlighted in the final written assignment and be included in it as an attachment. The logbook notes described thoughts on the different processes about the course and how these could be linked to the course literature and the chosen scientific articles. Students were encouraged to write down after each course session their own thoughts about the processes they had observed in their group during the group work.

They were asked: What kind of group processes can you distinguish? (e.g. power distribution, culture, conflict, consensus, compromise, decision, reward, group think etc.?)

1st Assignments (a-c) in Project management section

- Written exam - Friday 22/9 to Sunday 24/9. (Score: 3, 4 and 5);
- Perform the theme work according to the predetermined agile method (Kanban). Describe the planning, implementation and results of a project report and active participation in follow-up meeting (mandatory) where the group reports were verbally;
- Perform the theme work according to the predetermined agile method (Scrum). Describe the planning, implementation and results of a project report and active participation in follow-up meeting (mandatory) where the group reports presented verbally about how they worked, problems and advantages and disadvantages.

2nd Assignments in theme section

- Oral group reports and written reports over the different themes (six);
- Containing descriptions of how students had applied the theme in their fictitious organizations. They should also have references to the course literature and to at least three scientific articles per theme;
- Rating: G / U;
- Final report: Written assignment - final exam (3 hp) Grading scale: U, 3,4,5;
- Deadline: 13/1 2018.

This individual written and final assignment aimed at to summarize the different parts of the course. Students was to present their fictional organization based on the different themes of the course. The analysis of themes should contain a theoretical review of the choices that the group made when creating their organization. They also should analyse and interpret the processes that they had undergone during the work with the organization.

The form of the assignment was as follows: the work was to contain 8 chapters: Introduction, Organization Structure, HR, Leadership, Change, Conflicts, Organization Development and Discussion. Each chapter (except 1 and 8) should follow the draft: results - analysis - reflection.

In Chapter 1, students should present the organization by portraying the organization in its entirety in order to provide the best possible image of it. In the final chapter, then summarize these different chapters and discuss the group process and their individual learning process by adopting a more objective approach. Additionally, they should use quality tools where needed. In the analysis they should describe the structure by using theories and refer to the

literature. They also were expected to describe how they had used their quality tools. Finally, in the reflection section, students should add their own thoughts about the processes involved (logbook notes as a support). Work scope: about 15-20 pages, reference system Harvard Anglia.

The course consisted of two interconnected parts. The overall aim of this course design was to combine both structure and creativity in order to be able to create an organization of students' dreams.

The course would also serve as a positive and creative finish on program studies where the different study themes on quality technology, organizational theories sand tools in project management would harmonize and create a whole that could enhance students' learning for current working life. Processes of learning by working in teams in this project seem to strengthen students' knowledge of organizational change in many ways. Students could in better way combine the theoretical knowledge of processes within organizational changes with the practical being active change mangers themselves and using the agile methods, Kanban and Scrum. They witnessed, through evaluations and different tasks, how even processes of understanding the mission and its responsibilities where highlighted by the course design.

Still an improvement of the course design is highly needed: there is a need of tightening up the relation between the theme section and the agile methods. Students were often experiencing them as two separate parts of the course. In the following section a solution for the case study is discussed.

Solution of the case study

One possible solution to the course can be represented by a change in the course design. The new design was planned to include better link between theory and practice but also encourage students to use more of their creativeness and problem-solving skills. In addition, it was thought that, with this new course design, students would better be able to repeat the various aspects of the entire program and gain experience and insight onto how agile methods can be used especially in change management, prior to graduation.

The course was evaluated continuously and orally during the course by formative evaluation and in the end of the course by summative evaluation. Evaluation results show following results: The summative evaluation was answered by 32% of the campus students (6/19) and by 28% or (10/36) of the distance students. The general appreciation of the course was very positive. Course design was experienced by the majority as inspirational and useful for the future's working life. Weaknesses of the course, experienced by students, were mostly connected to project section and/or to the connection between these two sections of the course. Teachers were not cooperating enough with each other, the sections were experienced as two separate parts instead of properly interconnected, as they were expected to do by students. The best part of the course has been the course design and problem solving in groups. The students have practiced the theoretical

knowledge from the entire education through the six themes. In general students found it stimulated and it supported them to collaborate in a constructive way. Students at the distance course experienced working in groups even more satisfactory. This because they often are not offered many group activities online.

Improvement suggestions from the students can be summarizes as follows: Communication between teachers has to be improved. Clarity in the course design, better structure for the e-classroom is proposed. Minimize a number of course assignments. Evaluations and student statements show though that course design, the completed change in it, is experienced by majority of the students as interesting and something what can increase their learning outcome in the programme. But at the same time there are shortcomings which are to be taken seriously. The course structure will be revised to better meet student needs and further enhance learning in the course.

Plan for future improvements of the course

The following improvement are to be included in the course design:

- A closer cooperation between the teachers in the course, in order to better weave the two course moments into a whole according the principle of constructive alignment.
- Reduce the number of course assignments in order to give more time and space for the creative problem solving in the course.
- The constructive alignment can be performed on different levels: on teaching/learning level, on task/assignment level, on assessment level and on evaluation level.

Summary

It is obvious that the students have enjoyed this new course design and that it has supported their learning outcomes. It has further helped to reduce the gap between theory and practice as well as prepare students for collective learning in teams at future work. However, after course evaluation, it can still be noted that the course design has some shortcomings. The students have experienced that the course parts are more or less separate.

This can be seen as trying to put together two separate scientific disciplines in one course. The project part has been experienced by the students as something which belongs more into the natural sciences approach of solving problems. In addition, this includes some kind of instrumentalism, more technical and solution-oriented views on change management. On the other hand, the students felt that the theme part offered more understanding-oriented solutions, creativity and imagination.

Courses in Quality Technology are characterized by different scientific views: on the one hand, technical, numerical and static tools and models are highlighted for problem solving; on the other hand, people, their activities and members of

organizations are focusing on the subjective approaches, offered by humanism. Specially in order to cope with changes in the organizations, it would be an asset to reconcile these approaches for more successful work.

In order to bridge the gap between these two different scientific perspectives, further didactic measures are needed. First and foremost, the teachers in the course should see each other's parts as equivalent and something that complements each other in a good way. In practice, the different parts of the course should not appear as two separate parts but something intertwined in the different didactic parts of the course. Perhaps the course could be performed simultaneously on both parts. The course's tasks could contain both parts at the same time and assessment should also be based on the same material. It will also be possible to conduct joint evaluations on the course.

Procedures for applying in the classroom

In the following the procedures in the classroom theme by theme are presented. This didactic plan includes processes of teaching and learning as well as objectives or goals for learning outcomes.

Theme studies are designed as a support for students creating an imaginary organization. During the first five weeks the students shall be familiarized to agile methodologies and the two methods that will be introduced in the course as depicted in Fig. 2.

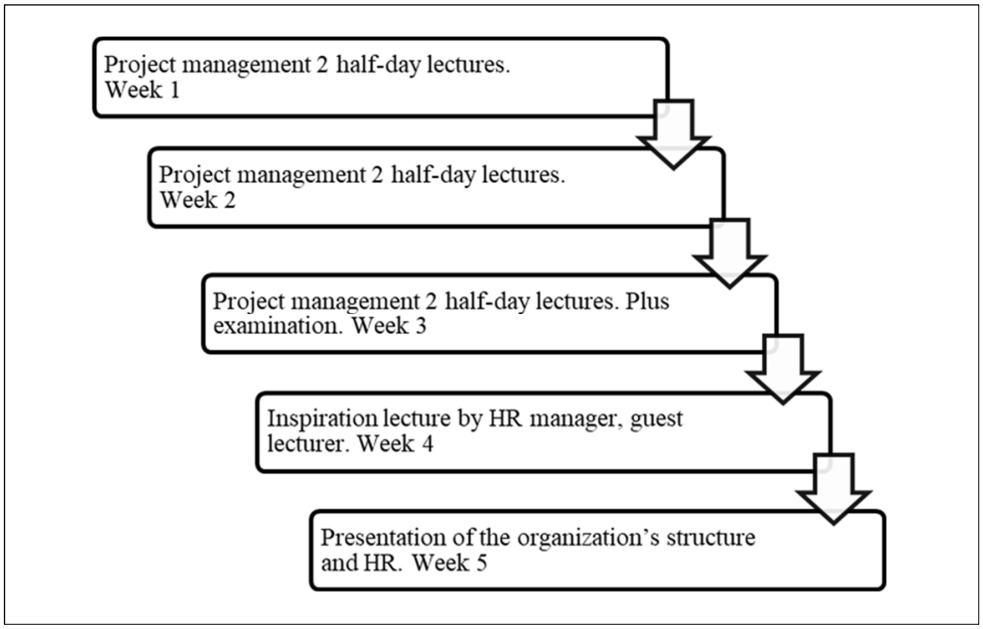

Figure 2 – The First Two Themes, in the Course, Together with Introduction to Agile Methodologies, Kanban and Scrum Are to Be Presented

Themes 1 and 2: structure and human resource

Goals for the theme structure and HR: Students should start creating the structure of their dream organization in small groups including the vision, production/service/size etc. They should add design of management and quality systems in the organization. Describing who works in the organization? What do they have for professional competencies? How does their organizional culture look like? What are their basic values? How is HR organized and managed? The base processes that exist in the organization related to resource staff? An oral presentation over their dream organization's structure and HR are required. A written report is to be submitted with references to the course literature and three scientific articles of their choice.

Assessment criteria: General assessment criteria for both oral group presentations and written reports are: The theme has been adequately addressed through group presentations and the written report. The group members have shared the work in the group and are actively participating in the presentations. They also participate in discussions and reflections over the their own but even other groups presentations. In the written reports, theory of the subject should be used in the form of course literature and the chosen articles.

The theme should be studied in deeper perspectives than in previous courses by making relevant theoretical references and connections into their organisation building. Both tasks are graded as Approved - Not approved.

Project content: It is left up to the studnet to choose how they would like to structure their way of working.

Themes 3: Leadership

Leadership is to presented by repeating previous gained knowlegde in the programme. Leadership History and today's leadership influences are to be discussed. Inspiration lecture should take up leaders and mangers as well as project leaders daily work in practice. Guest lecturer is preferred.

Students work in small groups: Organization's management system is presented in more detail. Leaders' profiles, responsibilities and powers, the work of the board, leadership views and visions, leadership strategies and practical work are lit.

Tasks: Students are to present the organization's management system in groups both orally and with the written report.

Assessment criteria: Same as above.

Project content: During the theme the agile method Kanban will be introduced. The method is extended with a practice normally associated with the other agile method, Scrum, namely the time-boxing practice. This is done to provide adequate scaffolding for students om regular basis.

Project Assessment criteria: The student groups have to submit their progress report weekly using established practices within the method, e.g. via cumulative flow diagram and Kanban-board. It is a formative assessment aimed at give the students support so that they will learn the method and its associated tools and practices.

Themes 4: Conflict Management

Inspiration lecture takes up the theoretical aspect of conflict management and presents some models and strategies in coping the conflict in practice. Students are then given small cases for each group to be discussed and solved. Conflicts are constructed suiting every organization individually. At least three solutions must be presented. A written report over the solutions are to be submitted.

Assessment criteria: Same as above.

Project content: During the theme the agile method Kanban with its extended practice will be used to its fully extent.

Project Assessment criteria: The students shall continuously report their progress using established practices. In addition they have to write a final methodreport, including planning and follow-up of the themes and students' subjective opinions regarding the method.

Themes 5: Change management

Change management. Inspiration lecture over the theme, change management, should be given in order to update the area of knowledge. The cases of change distribute for the students to be solved in groups. Students are reporting at least three solution proposals, both orally and written.

Assessment criteria: Same as above.

Project content: During the theme the agile method Scrum will be introduced to structure the students work with the theme.

Project Assessment criteria: The student groups have to submit their progress report twice a week using established practices within the method, e.g. via burn down chart and Scrum-board. It is a formative assessment aimed at give the students support so that they will learn the method and its associated tools and practices.

Themes 6: Organisational Development

Organisational Development it introduced through an inspiration lecture. The aim of the theme is to draw students' attention to the long-term process of developing their organization. Organizational learning for continued development becomes important in order to see obstacles but also opportunities in their own organizations.

Task: Students are to be attending a fictive recruitment fair. Their task is to promote their organization to attract new competencies. They shall then present their organizations briefly by summarizing the chosen parts of it.

Assessment criteria: Same as above.

Project content: During the theme the agile method Scrum will be used to its fully extent.

Project assessment: The will continuously report their progress twice a week using established practices. In addition they have to write a final methodreport, including planning and follow-up of the themes and students' subjective opinions regarding the method

Final grading: The grades from written agile method exam and the final written assignment for the themes was weighted together to form the final grade (30% project and 70% change management). Grading scale: U, 3,4,5.

5 SUMMARY

This case study is based on the introduction of new university course design for teaching change management to students however it is also suitable for professionals at various positions to learn more about the subject. The course was a mandatory part of the curriculum for last year bachelor students in two programs, Bachelor Programme in Leadership, Quality and Improvement and Bachelor Programme in Quality Engineering and Management, at Uppsala University Campus Gotland. The course was given both as a campus course as well as distance course during autumn 2017.

The course was designed in such a way to offer the students the possibilities to use their creativity and their accrued knowledge from previous courses in their bachelor studies to get a deeper understanding of organizations in general and change management in particular. The way to achieve this was through letting them in a structured manor take part of scientific literature and inspiration lectures given by experts in their fields. The various student groups created their own fictive organization that was subjected to exogenous stimulus that the organization had to handle in an appropriate way this to emulate change management situations.

Structure to their creativity was brought by introducing them to agile methods that offer a structured however also a dynamic and flexible framework for designing products and services. These characteristics make them suitable in a dynamic environment where successful organization is one that adapts to change, anticipate future needs and aim for high added value in the long term.

The basic ideas behind the design of the course and the foundations were 1) important to develop activities within university course about organizational context in order to increase students understanding of the goals for more

sustainable practice 2) individually and collectively learning progression, emphasizing the psychological and pedagogical dimension of the concepts of responsibility and change 3) integration of two separate scientific disciplines (project and change management) 4) the importance of actively working with agile methods to solve a problem within a defined area to strengthen their ability to acquire understanding of the methods.

Formative evaluation is recommended orally and continuously during the course to address various topics and in the end of the course by summative evaluation. The summative evaluation was answered by 32% of the campus students (6/19) and by 28% or (10/36) of the distance students. The general appreciation of the course was very positive.

Course design was experienced by the majority as inspirational and useful for the future's working life. They were in general appreciative of being able to practice their earlier acquired knowledge and to the collaborative learning in their groups something that was elaborated by using the agile methods based on team work and thereby support this kind of learning. The main weakness was the integration of the two disciplines leading to the feeling that the course consisted of two courses instead of one integrated course. The evaluation will lead to enhanced collaboration and coordination between the two disciplines especially in regard to the theme phase where the themes are executed using the agile methods. It means that common report structure is recommended to implement instead of to separate structures one for each discipline (project and change management). Finally, the number of assignments should be reduced so that students will be able to elaborate their knowledge.

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Base Principles and Practices for Implementation of Total Productive Maintenance in Automotive Industry

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ABSTRACT

Purpose: IATF 16949:2016 standard requirements do not represent a totally new approach of quality improvement within the automotive industry. The change of the last, from 2009 year ISO/TS), the quality management standard is only an expected consequence of changes, which, in managerial systems, was brought by ISO Organization in 2012 (Annex SL). Implementation of the Total Productive Maintenance (TPM) requires several important steps. The article describes framework of TPM implementation on a basis of PDCA (P-plan; D-do; C-check; A-Act) cycle and evaluates influence of Occupational health and safety pillar (OHS) on the "stability" of TPM house.

Methodology/Approach: Individual steps of TPM implementation are analysed and added with suitable tools for making the effective integration of TPM and IATF (which is expansion of ISO 9001:2015).

Findings: Implementation of autonomous maintenance and other TPM pillars requires support from management. Although the 5S tool is understood as a basic TPM tool, knowledge from its implementation suggest the fact that 5S is also a significant tool of management integration within organisation.

Research Limitation/Implication: Research presented in this article is influenced of the maturity of organisation as well as its size and types of its activities.

Originality/Value of paper: Method of TPM implementation analysis in the conditions of integrated approach with an emphasis on 5S and its relation to OHS management is original approach.

Category: Conceptual paper

Keywords: maintenance management; risk; safety; TPM; 5S

1 INTRODUCTION

Maintenance management is constantly encountered with an effort to be identified as a less important aspect of a complex organisation management (Antosz, 2018; Willmott and McCarthy, 2001; Pacaiova, et al. 2012; Park, Kim and Won, 2017). It is possible to express the definition of maintenance management (if the definition of quality management is applied, STN ISO 9001, 2016) as follows: it represents a part of company management, the aim of which is optimisation of maintenance activities considering both material and human resources, support of manufacturing of the expected final product quality and safety of operation (if possible, defined by means of figure parameters) as well as support of prospective further growth and development of organisation – its goals.

Or: maintenance management is a discipline for ensuring of outputs, contributions and processes of maintenance, that are supplied with a purpose to fulfil the customers' requirements and parties in question.

In maintenance management (STN EN 13306, 2017), maintenance is defined as a combination of all technical, administrative and managerial actions during the life cycle of an item intended to retain it in, or restore it to, a state in which it can perform the required function.

Quality management mainly in automotive industry relies on two basic concepts:

- based on the standards ISO 9001, IATF 16949 etc. (Fonseca and Domingues, 2018; Zgodavova, Hudec and Palfy, 2017);
- based on other frames such as e.g. total quality or world quality management - TQM (Total Quality Management), WCM (World Class Manufacturing), (Storey and Harrison, 1999).

In automotive industry, quality is one of the most significant arguments for management. In order to maintain a long-term achievement of quality, it is necessary to retain the capability of machines (processes), their reliability and performance (Fonseca and Domingues, 2017, Pinto, H et al., 2016). By TQM implementation, involvement of all the employees into full-company effort to eliminate all defects (non-conformities) is emphasised. Similarly, TPM results from a principle of a zero loss achievement, whether a machine, human, outputs, energy or material is considered (Galar et al., 2012; Chlebus et al., 2015; Jain, Bhatti and Sign, 2014). The difference between TQM and TPM is often declared mistakenly. TQM is oriented on quality and TPM is oriented on machines and equipment (Sahoo, 2018). However, it is not true. Their objective is mutual – to eliminate all the losses that may have an impact on objectives of the organisation, or possibly, at least, to reduce them to the lowest possible level (Singh et al., 2013; Pacaiova, Sinay and Nagyova, 2017). Chronic problems in organisations are often understated; however, sporadic (assumed) problems are solved by means of preventive measures as well as by checking their efficiency.

TPM is integrated part of TQM, thus, of quality management, and it observes identical objectives. It must be based on thorough process analyses of their significance for the fulfilment of the requirements of customers and parties in question, analysis of effects on non-quality, searching of the most suitable tools of how to eliminate them by means of appropriate improvement. The difference is only in the fact that TQM creates frame, TPM strengthens it and provides further components or tools how to maintain or develop this frame.

WCM – world class manufacturing is a concept, which, at present, is trying to integrate all the processes of TPM, TQM, Lean Manufacturing, Six Sigma etc. into one integrated system, that is able to provide increase of profits through constant process improvement (Sukurma, 2014). This holistic approach is one of the possibilities of integration of requirements of managerial systems based on RBT.

2 METHODOLOGY

Applied research methodology was based on the analysis of theoretical approaches of TPM implementation and was compared with real conditions of its implementation and improvement in accordance with IATF requirements.

2.1 TPM Structure

Concept of TPM was first defined in Japan in the 70s of the last century (Japan Institute of Plant Maintenance JIPM), and it initially brought requirements on the quality process aimed at reliability, high profit, minimum costs and later on, requirements on minimisation of impact on environment and safety. The entire TPM philosophy is illustrated by means of the so-called "TPM house" (Chlebus et al., 2015; Kigsirisin, Pussawiro and Noohawn, 2016), where individual pillars of the house represent basic elements which enable achievement of the determined objectives in a form of elimination of all the non-conformities, i.e. zero number of human failure (defects), equipment failure, accident and waste, Fig. 1 (Nakajima, 1988; Kigsirisin, Pussawiro and Noohawn, 2016).

A lot of organizations, having experience with TPM, prefer naming total productive manufacturing (eng. Total Productive Manufacturing), due to emphasizing the relations among production and maintenance employees, as the notion total productive manufacturing tempts to limitation of the activity connected thereto and their transfer to maintenance department only. Especially in this effort, it is possible to see non-understanding of the relation between TPM and TQM (Pramod et al., 2006).

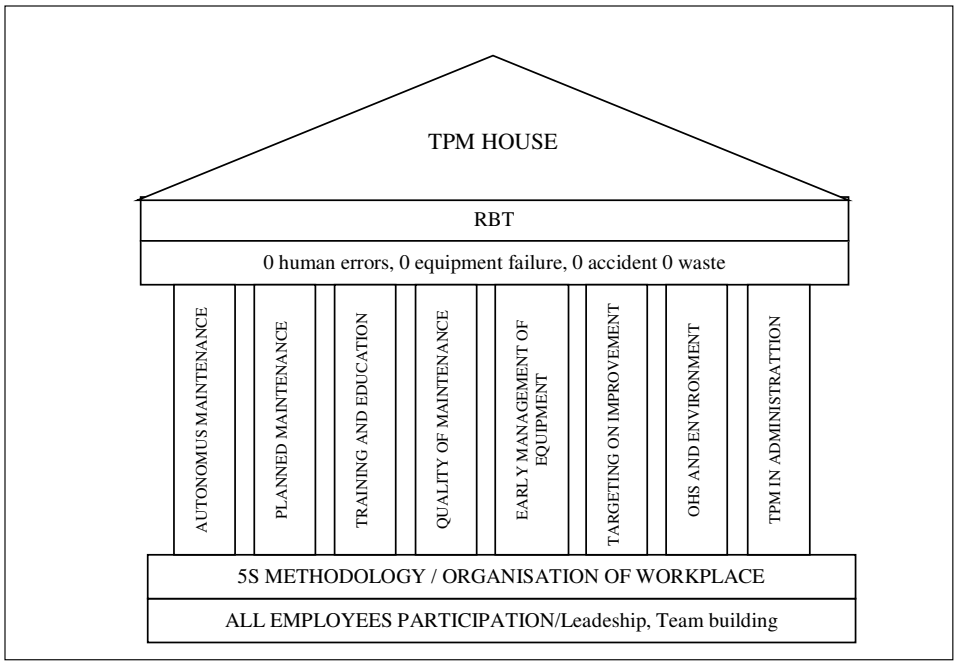

Figure 1 – TPM Structure – 8 Pillars

TPM is based on involvement of all the employees and activities on all organisation levels, targeting at reduction of losses, the so-called 6 main losses and increase of machine and equipment efficiency and the activites related to it (plus 10 losses in the field of human activities and materials). Losses such as unplanned (random failures) and planned stops; small stops and slow cycles; production rejects and startup rejects; in tree areas availability loss, performance loss and quality loss are considered.

The meaning of individual words of TPM notion (Jain, Bhatti and Sign, 2014) is explained in easy way by holistic approach in TPM management related to the expectations of the parties in question, see Tab. 1.

Effectiveness of TPM implementation depends on the level of mastering five basic principles:

- achievement of maximum equipment effectiveness (OEE – Overall Equipment Effectiveness);
- creation of complex system of preventive maintenance based on constant improvement;
- participation of all: constructors, technologists, operators and maintenance workers, safety technicians;
- involvement of each employee from the top (top-management) up to the lowest management level – complex activity support (management support);

- implementation of preventive maintenance for small groups – autonomous maintenance.

TPM combines all activities related to machines and equipment and the products manufactured by them, and which are important for the "core business" of organisation. Actual 8 pillars, illustrated on Fig. 1 and defining the TPM concept, was extended from 5 initial ones (Jain, Bhatti and Sign, 2014): Focused Improvement, Autonomous Maintenance, Quality Maintenance, Training & Education, Prevention Maintenance; similarly, as the identification Six Big (equipment) Losses was extended to 16 Global Losses. However, the Six Big Losses (6BL) became a basis for assessment of organisation performance by means of OEE indicator.

Table 1 – TPM Meaning and Its Expression

Meaning description	**Meaning explanation**	**Comment**
Total	Involvement of all the employees.	i.e. not only maintenance workers and operators
	Elimination of all non-conformities.	4 zeros strategy
Productive	Activities performed prior to problem origination.	Proactive approach using root cause analysis
	Manufacturing problems are minimised continuously.	Active attitude of all in improvement, e.g. Ishikawa diagram
Maintenance	Maintenance of equipment in good conditions	Preventive care of equipment and work environment
	Consistent performance of regular maintenance activities such as: repair, cleaning, greasing, checking etc.	Preventive, predictive and autonomous maintenance strategy

On one hand, the calculation of this figure helps to measure all the processes contributing to the achievement of maximum productivity of significant processes of the entire organisation, and to eliminate or minimise loss causes, but on the other hand, it requires observance of the most possible objective method of its measurement and assessment. (Hedman, Subramaniyan and Almstrom, 2016; Fonseca and Domingues, 2017). Fundamental relation for its calculation with regard to loss characteristics contributing to individual OEE parameters is as follows:

$$\begin{aligned} &OEE \\ &= Availability\ (function\ of\ Time\ Losses) \\ &* Performance\ efficiency\ (function\ of\ Speed\ Losses) \\ &* Quality\ rate\ (function\ of\ Srap\ Losses) \end{aligned} \tag{1}$$

Effort to overtake responsibility of operators for the condition of the equipment – autonomous maintenance (the one who knows it best), supported by maintenance department as a professional advisor and a "doctor" in case of need performing specialized preventive checkups is a prerequisite for finding the best solutions motivating all employees to improvement. These activities clearly cannot work without support of the others, e.g. technologists and constructors, safety technicians and of course, the management of organisation.

Fundamental tool for maintaining the "attention" in TPM is formed from Japanese words (Nakajima, 1988; Storey and Harrison, 1999; Singh et al., 2013; Devaraj, Patidar and Soni, 2015):

1. SEIRI – Organization, removal of unnecessary things away from workplace – "Throw everything unnecessary away!".
2. SEITON – Systematization, ordering of things in the workplace for easy availability.
3. SEISO – Cleaning, keeping the workplace neat.
4. SEIKETSU – Standardization, establishment of high level of cleanliness and order in the workplace and creation of graphical and written standards.
5. SHITSUKE – Self-discipline, to ensure that people cared for cleanliness and order by themselves and so that they observed the documented procedures.

By organization of the workplace (1S), losses of searching and running around shall be eliminated, obstacles shall be removed as well; systematization (2S) shall ease the selection of tools and availability of the workplace; cleanliness (3S) is a basis for both prevention as well as identification of pollution sources. Creation of the standard (4S) – what, where and how it should be solved, enables enhancement of reliability and safety of operation. Thus, the last 5S is only logical consequence such as 4 previous "S" targeted on controlled checking of the workplace to maintain systematically and in the long term (e.g. 5S audit).

2.2 Relation between IATF and TPM

By IATF standard, maintenance was clearly assigned the obligation to introduce a concept of maintenance management within organization, or a system, as it is defined in the section 8.1.5.8. It requires the organization to create and keep a documented TPM system, which must include:

- Identification of the equipment used in the manufacturing process inevitable for manufacturing of identical product in required volume, , *i.e. identification of the so-called critical equipment that may be important source of 6BL*;

- Availability of spare parts for critical equipment, the so-called *provision – (logistics) of critical spare parts*;
- Provision of sources for machine maintenance, equipment and their facilities – *maintenance support ability*;
- Packing and preservation of equipment, tools and measuring instruments - *maintenance support ability and logistics of spare parts*;
- Documented method of realization of customers' specific requirements – i.e. *documented information of the requirement identification, objective setting and maintenance planning*;
- Documented maintenance objectives (e.g. OEE, MTBF – Mean Time Between Failure, MTTR – Mean Time to Repair etc.), measurement and assessment of preventive maintenance, whereas, maintenance performance, considering its objectives, must be entry for the management system(s) investigation – thus *measurement and assessment of maintenance performance as integral component part of organisation performance evaluation*;
- Regular reviewing of plans and maintenance objectives and documented action plan for solution of corrective measures, where the objectives determined have not been reached – *reviewing by management and adoption of corrective measures*;
- Using of preventive maintenance methods (*maintenance realisation*);
- Using of predictive maintenance, if suitable (*maintenance realisation*);
- Periodic overhaul (*maintenance realisation*).

If we analysed the assumption what results from these requirements, it is obvious that the standard confirmed, that TPM is a system supporting quality management in automotive industry in a strict manner, i.e. as a part of ISO 9001:2015 requirements. Problem arises in the moment when there is a real obligation of suppliers for automotive industry to respect the IATF, if any range of their activities is related to this field. For automotive chain, many of these organisations represent by their activity only 10% or less, but they need to fulfill the requirements for 100% if they want to remain on the supplier position. The tools characterising TPM must be applied in full range (5S, audit 5S, team cooperation, visualisation, data collection and their analysis – FMEA, motivation system, OEE assessment etc.). Some of them work in advanced organisations as a part of management targeting on constant improvement, however, it often happens that their involvement is only a formal way applied for the purposes of obtaining the respective certificate, most frequently within the field of quality management.

For easier understanding of TPM structure and its integration into quality management system, the TPM concept based on PDCA cycle – see Tab. 2 was designed for supplier in automotive industry.

Table 2 – TPM Meaning and Its Expression

PDCA element	Characteristics	TPM 8 pillars	Function of pillar
Plan	Identify problem and develop plan for implementation	Safety Health and Environment	Hazards and sources of losses identification Risk assessment Stated KPI (OEE) structure
		Early Equipment Management	
Do	Implementation, realisation	Autonomous Maintenance	Maintenance Plan and Autonomous standards KPI (OEE) measurement
		Planned Maintenance	
Check	Assess plan and evaluate results	Quality Maintenance	KPI (OEE) evaluation
		Administration TPM	
Act	Improvement	Focused improvement	Systematic problem solving Decision making
		Training & Education	

2.3 Safety and TPM

By implementation of TPM, similarly as by TQM, it is necessary to apply the so-called hard – normative but also "soft" processes (Zgodavova, Hudec and Palfy, 2017). TPM cannot work without all the pillars being formally as well as functionally applied. Usually, the very first problem is to persuade operators about the importance of change of their approach to machines and equipment used for manufacturing. The other significant problem is implementation of 5S and securing its stability for 8 pillars. Why indeed is this tool a fundament of the TPM house? It is obvious that for creating of organisation culture mainly within the field of OHS management, quality and environment, it is important to identify hazards, source of defects (risk), and to select appropriate procedures how to check and maintain them on a long-term acceptable level. With regard to all the losses, it is possible to describe the influence of 5S as follows:

1. SEIRI – Organize the work area (layout) – prevents time losses when transporting the materials; identification of problems, malfunctions and errors; supports environment suitable for each employee – respects their ergonomics, thus has influence on health protection and safety.
2. SEITON – Systematization – saves time at solving problems, enhances performance and readiness, enables to identify near miss and prevent them effectively.

3. SEISO – Cleaning – prevents origination of malfunctions, enables quick identification of the possible sources, has an impact on hygiene and safety of workplace.
4. SEIKETSU – Standardization – is a result of previous three activities serving for the identification of unwanted events (potential losses), is a basis for analysis and risk assessment and creation of appropriate procedures, and implementation of efficient preventive measures for their reduction.
5. SHITSUKE – Self-discipline – helps to train and improve in the way so that each employee is provided with comfort in the workplace. Its result is active approach to increasing of reliability level, safety and health at work and its long-term maintaining.

Within the organisation, where OHS is managed on a high level and is integrated into all the managerial activities, 5S has already been implemented subconsciously. Elements of ergonomics, human behaviour (e.g. BBS – Behaviour Based Safety), both work and external environment are taken into consideration. However, it often happens that safety at work is a subject of external contractual relation, which brings difficult starting-point conditions, when trying TPM implementation, Fig. 2.

Figure 2 – Workplace with Implemented OHSMS Prior TPM Implementation according to IATF (Author's Elaboration)

Assessment of the readiness of organisation was performed by 3 suppliers for automotive end producer. Each of these suppliers has already had implemented OHS management system (OHSMS) in the past according to OHSAS 18001. Even two of them are (transmission producer; vehicle lighting system producer) currently working on implementation of ISO 45001 (STN ISO 45001, 2018) standard.

For the assessment of the 5S level, as of the TPM basis, criteria were formed as follows:

- Workplace organization must be obstacle-free, safety distances and ergonomic requirements according to regulation and standards must be observed.
- Systematization of workplace must take into consideration fluency of both production and need of operator for the achievement of maximum performance in a safe way (e.g. by using of BBS methodics). Tools, personnel equipment must be suitable for the respective purpose and certified (CE marking).
- Cleaning must be described in standards for all operators and maintenance personnel as a part of performed preventive activities. Requirements for cleanliness maintenance must be included in OHS (Occupational Health and Safety) as a risk prevention (dust, chemical substances, slippery floor etc.).
- Standardization is sufficiently visualised in a suitable way. It is a component part of regular checkings and consultations. Accidents, non-conformities, and mistakes are a part of OHS trainings and are regularly assessed. Information is verified in the workplace randomly by all employees.
- Discipline (or Self-Discipline) is managed with a target to secure constant improvement. Suitable motivation tools for observance of rules are adopted. Violation of regulations (also within the field of OHS) is primarily a subject of investigation of possible mistake in description of methodology or in procedures, and only then conclusions towards the violator of regulations are drawn.

The methodology assessed 5S requirements in integration with OHS requirements in the following way: they were assigned points from 0 (criteria are not fulfilled) up to 10 (all the criteria are fulfilled in terms of formal as well as realization aspect). Average values and standard deviations of the assigned number of points of 5S elements for individual producers are found in Tab. 3.

Table 3 – Evaluation of 5S Methodology based on OHS Factors

5S Methodology with OHS aspects	**producer of plastic products**	**transmission producer**	**vehicle lighting systems producer**	**Statistical parameters**	
	I.	*II.*	*III.*		
	OHSAS 18001	ISO 45001	ISO 45001	$\bar{x}$	s
1S Organisation	7	9	10	8.67	1.53
2S Systematization	6	8	8	7.33	1.15
3S Cleaning	2	8	9	6.33	3.79
4S Standardization	5	4	8	5.67	2.08
5S Discipline	9	10	10	9.67	0.58
$\bar{x}$	5.8	7.8	9		
s	2.59	2.28	1		

Statistically significant difference in assessment of the readiness of organization among 3 suppliers was assessed by means of one – way analysis of variance (ANOVA), Tab. 4.

The one-way ANOVA (Guzanova et al., 2017) is used to determine whether there are any significant differences between the means of three or more independent (unrelated) groups. The one-way ANOVA compares the means between the groups and determines whether any of those means are significantly different from each other. Specifically, it tests the null hypothesis:

$$H_0: \ \mu_1 = \mu_2 = \mu_3 = \cdots \mu_k$$

$$\textit{and then} \qquad (2)$$

$$H_1: \textit{non } H_0$$

Where μ - group mean and k - number of groups. If, however, the one-way ANOVA returns a significant result, we accept the alternative hypothesis (H_1), which is that there are at least 2 group means that are significantly different from each other.

Table 4 – One-Way ANOVA Application

Variable	**One-way ANOVA** Marked effects are significant at p < 0.050							
	SS Effect	df Effect	MS Effect	SS Error	df Error	MS Error	F	P
Producer	26.133	2	13.067	51.6	12	4.3	3.0388	0.0855

Notes: SS – sums of squares; df - degrees of freedom; MS - mean of squares; F - testing characteristics; p – value.

The result of test is *p-value*, p = 0.0855 > 0.05, is then the null-hypothesis accepted on significance level 0.05. The 5S methodology implementation based on OHS factors in tree producers for automotive companies is not a statistically significant difference. Since null-hypothesis accepted (H_0: $\mu_1 = \mu_2 = \mu_3$), that as, which is that there are not at least 2 group means that are significantly different from each other. For this reason, it is possible to claim that OHS plays a role of the same importance by implementation of 5S methodology (TPM) by all the producers.

In case there were several compared producers, there is assumption, that statistically significant differences might arise and subsequently, by means of multiple comparison (by means of post hoc analysis), those couples would be determined whose OHS management level has a significant impact on 5S.

3 CONCLUSION

Correctly managed safety and health at work requires correctly managed risks. If hazards and assessed risks are not identified properly, it is possible to manage them adequately. It often happens that the risk assessment process is only a formal matter. External services within OHS are limited by price offer, however, the result of which are problems pointing at inappropriate managerial practices. According to literature (Mohammadfam et al., 2017), it is possible to state, that until 2018, more than 100,000 companies in the world have been implementing management system of OHS according to OHSAS 18001 (currently, gradual transition to ISO 45001:2018 is expected). However, certificate should declare "quality" of OHS management. TPM implementation according to IATF standard represents integrated approach of quality and safety management (Devaraj et al., 2015; Teeravaraprug Kitiwanwong and SaeTong, 2011; Andodnou, 2017) that can be achieved only if these objectives have adequate management support.

This article describes integration of IATF and OHSMS requirements by using 5S methodology (TPM). The next research in this field requires a greater number of compared producers and also extension of criteria, e.g. with figures of performance assessment within maintenance, safety and quality and their mutual interaction.

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The Impact of Implementation of Standardized Quality Management Systems on Management of Liabilities in Group Purchasing Organizations

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ABSTRACT

Purpose: The main purpose of the paper was to determine the impact of an implementation of the quality management system according to ISO 9001 on the improvement of processes related to the management of liabilities to suppliers.

Methodology/Approach: The research covered 38 Polish small trading enterprises operating in two group purchasing organizations. The research period concerned the years 2014-2016. The surveyed enterprises were divided into those that implemented standardized quality management systems (10 organizations) and the ones that do not use such solutions (28 organizations). Next, the analyses were made and the results obtained by enterprises associated in particular groups were compared.

Findings: The obtained results confirm that more effective management of liabilities towards suppliers can be observed in enterprises applying appropriate system procedures. This group includes long-term liabilities and the turnover ratio of short-term liabilities in days achieves lower results than results for enterprises that did not introduce standardized quality management systems.

Research Limitation/implication: Due to a small research sample, the obtained results can only be considered as an introduction to further research and deliberations.

Originality/Value of paper: The considerations discussed in this article concern a relatively rarely discussed subject matter in the literature.

Category: Research paper

Keywords: QMS; commitment management; improvement

1 INTRODUCTION

In the subject literature it is emphasized that the optimal level for the debt ratio in enterprises should be at the level of 0.57 to 0.67 (Gabrusewicz, 2017; Nowak, 2017). Therefore, it is recommended to have an advantage of an equity over outside funds. From the point of view of the structure of liabilities, it is important that long-term liabilities and obligations to suppliers were included in it. It should be remembered that the trade credit granted by suppliers is the cheapest source of financing for the unit. Virtually without interest, it is worth supporting this form of financing individuals. On the other hand, too much support with foreign capital may result in the loss of financial liquidity. In the case of increasing liabilities, it is easy to make mistakes that may result in the loss of an additional discount for early payment of obligations to the supplier. In the case of group purchasing organizations such occasions often appear and should be used. Purchasing groups are based on the use of economies of scale, which allows the negotiation of the representative of the group with the producer to lower the price and negotiate an additional discount for the earlier payment of obligations. (Zimon, 2018a) This action leads to a reduction of operational costs. In general, the benefits that companies gain as a result of activities in the purchasing group include the reduction of direct and indirect costs of production, prices of purchased goods and an extended trade credit, as well as shortened delivery time. (Tella and Virolainen, 2005; Nollet and Bealulieu, 2005; Burns and Lee, 2008). Many authors also point out that acting together, creating shopping consortia allows reducing the costs of supplies (Nollet and Beaulieu, 2003; Bakker, Walker and Harland, 2006; Schotanus and Telgen, 2007). It can be concluded that the creation of trade policy in the area of purchasing slowly changes its function from tactical, short-term management to management of a strategic enterprise. (Johnsen, 2018). Especially in purchasing groups where managers often face a dilemma whether to use additional discounts for an early payment or to lengthen the repayment date. Very often it is a late decision, which may lead to errors in the department that makes payments.

Mistakes in the area of managing liabilities to suppliers happen and often lead to penal interest charges. Most often these are small amounts, but it is worth introducing a system that would improve the management process. These mistakes can be divided into two types: these that appear in the department of administration and in departments related to operating activities, e.g. on construction sites or warehouses, or these that appear in administration, and which may result from missing payment dates. The second group of mistakes occurs most often in small service enterprises where the material, the goods go to a given construction, an invoice is collected by the employee and the document never reaches the accounting. Lack of procedures often causes that the goods are picked up by employees who are not authorized for such activities. Quantitative and qualitative errors in the receipt of the delivery appear, the document is forfeited and then an interest note appears in the accounting and the search for the person responsible for the situation begins. According to the authors of this

publication, it is recommended to implement standardized quality management systems which put a lot of emphasis on developing an effective management system and developing effective forms of cooperation with suppliers. The implementation of the requirements of standardized quality management systems also leads to the organization of basic processes and significant minimization of signaled errors and mistakes (Zizka, Budaj and Madzík, 2016; Levine and Toffel, 2010). Enterprises are obliged to develop well-thought-out procedures, implement improvement actions and carry out regular system reviews (Fonseca and Domingues, 2018; Zgodavova, Kisela and Sutoova, 2016). The review of the quality management system should cover all activities carried out by the company and the effects of these activities (Kafel and Simon, 2017). These are both the activities described in the system procedures (audits, quality records, corrective and preventive actions, etc.) and operational procedures (production, logistics, sales, finances or marketing, etc.). In addition, the review should take into account all levels of management, starting from the simplest workstations on the board ending. The final result of the reviews should be a program of actions improving all areas of the organization's operation both in the short and long time horizon (Dellana and Kros, 2018). With this in mind, the following research hypothesis was adopted: it is assumed that an implementation of standardized quality management systems may affect the effectiveness and efficiency of commitment management strategies in organizations that co-create purchasing groups.

2 LIABILITY MANAGEMENT STRATEGIES IN GROUP PURCHASING ORGANIZATIONS

Managers decide what strategy for managing the sources of financing they will use and they have to choose between aggressive, moderate and conservative strategies.

The classic strategies should be modified because it is difficult on the basis of the presented guidelines to adapt the company to a given strategy. The new guidelines for commitment management strategies are as follows (Zimon, 2018b):

- Safe (conservative) strategy, characterized by high financial liquidity. In the structure of financing sources, the predominance of equity over foreign capital is clearly visible. Long-term bank loans must exist in the structure of liabilities and provisions for liabilities.
- Risky (aggressive) strategy whose characteristic feature is a low level of financial liquidity. The structure of financing sources is dominated by liabilities over equity. There are no long-term bank loans in the structure of liabilities and provisions for liabilities. This type of strategy should be characterized by a predominance of liabilities towards suppliers over

receivables from recipients. In the structure of short-term liabilities, liabilities to suppliers constitute a high share.

- Moderate (indirect) strategy based largely on the conservative strategy. The structure of financing sources is dominated by equity over foreign capital. Long-term bank loans appear in the structure of liabilities and provisions for liabilities. This type of strategy is characterized by a clear advantage of receivables from customers over liabilities to suppliers. Often this ratio achieves the results around 2 or above 2. Managers, in contrast to the conservative strategy, do not quickly collect debts. They also use a long period to pay off their debts. The receivables turnover ratio in days is at a similar level to the liabilities turnover ratio. Short-term liabilities in the structure of short-term liabilities are bank loans. In the article, enterprises were evaluated in terms of modified and presented new commitment management strategies.

In group purchasing organizations the central unit of the group negotiates prices with the producer, payment deadline and possible rebate for earlier payment. The cash flow is as follows.

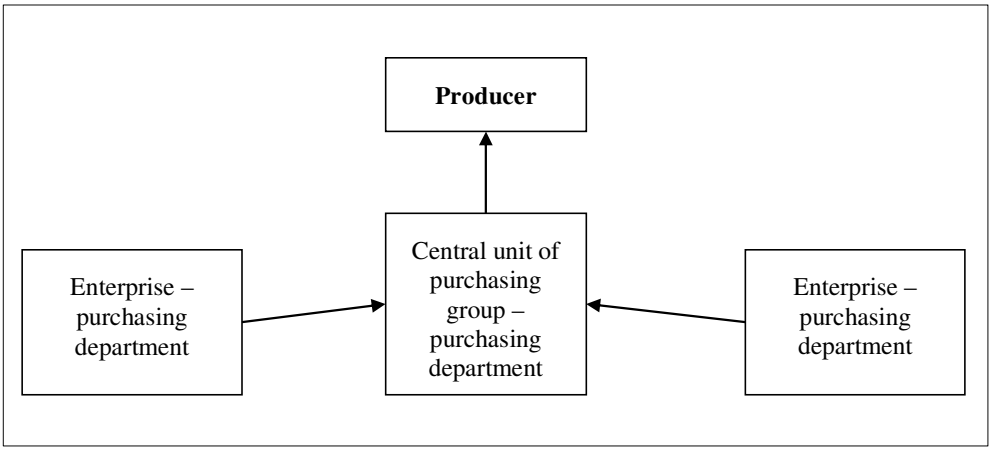

Figure 1 – Cash Flow in the Group Purchasing Organization

It is important to respect the deadlines as delays may result in the loss of benefits for individual participants of the purchasing group. It is, therefore, worth introducing standardized quality management systems that will allow developing appropriate procedures for managing liabilities. Personnel involved in the settlement of obligations needs to have a clearly separated range of duties. The managers of the given units have to in a timely manner present the value of future liabilities to be settled, broken down into interest and not interest. The budget commitments that needs to be paid must be clearly identified. Persons responsible for the process of settling liabilities must have at all times

information about available funds and on current liabilities. Therefore, the flow of information is very important, as there are no payment bottlenecks in the enterprise because a situation may arise that an element that cannot be bought is needed to complete the investment because the producer blocked the sale. At that time, the managers made a mistake and settled other liabilities instead of the key one. Such situations should be avoided. Therefore, the persons deciding on the payment queue should receive a lot of information on finance as well as investments, production and works that are carried out in the enterprise.

As already indicated in the introduction, quality management systems can significantly contribute to organizing processes in the organization, minimizing errors and introducing solutions that effectively prevent their formation (Bugdol and Jedynak, 2015). These systems are based on seven basic principles and one of them is an improvement (Domingues, Sampaio and Arezes, 2016). The term improvement should not be understood only as counteracting errors, but also as any actions leading to a gradual improvement of the efficiency of processes in the organization through the use of new technologies, techniques, methods, materials or better organization of work (Zimon, 2017). Improving the organization should be based on the following rules:

- improvement is a sequence of activities focused on solving and correcting detected and predicted problems,
- an improvement process should be monitored in order to improve its effectiveness,
- each organization, due to its specificity, should choose the most optimal pace of improvement activities,
- the guiding principle of improvement should be broadly understood customer good.

An implementation of the above-mentioned rules will allow a clear division of duties and responsibilities and a quick diagnosis of possible mistakes. Employees will therefore get tools that will allow them to make the right decisions and reduce the risk of mistakes (Psomas, Kafetzopoulos and Fotopoulos, 2012).

3 TEST METHOD

The purpose of the analysis was to determine the impact of the implementation of the requirements of standardized quality management systems on the improvement of processes related to the management of obligations to suppliers. The explanation of the generally discussed research problem prompted the author to formulate a research question whether an introduction of quality management systems can be considered as a tool that positively influences the process of managing liabilities towards suppliers? The main reasons for the interest in this research subject include a small number of studies on the impact of quality management systems on the process of managing liabilities.

The research covered 38 Polish small trading enterprises operating in two purchasing groups. The enterprises belong to branch purchasing groups operating in the construction industry. Enterprises operating in purchasing groups generate turnover in the range from PLN 10 million (USD 2 million) to PLN 120 million. (USD 30 million). The research period concerned the years 2014-2016. The surveyed enterprises were divided into those which implemented quality management systems according to ISO 9001 standard (10 organizations) and those that do not use such solutions (28 organizations). The analyzes were made and the results obtained by enterprises associated in particular groups were compared. The analysis of financial ratios and statistical methods were used as the basic research tools. The research period covered the years 2014-2017.

4 AN ANALYSIS OF THE IMPACT OF QUALITY MANAGEMENT SYSTEMS ON THE LEVEL OF LIABILITIES

The first stage of the research process was to conduct a preliminary financial analysis in the area of the structure of liabilities. The results for enterprises that do not apply quality management systems are presented in the Tab. 1.

Table 1 – Ratios of the Structure of Liabilities in Enterprises that Do Not Introduce Quality Management Systems in 2016 (Author's Own Study)

Enterprise	Share of debts in total liabilities (%)	Share of long-term liabilities to total liabilities (%)
1	30	0
2	34	12
3	80	0
4	71	4
5	24	0
6	78	58
7	23	0
8	73	9
9	49	0
10	54	37
11	62	0
12	53	0
13	54	0
14	5	0
15	17	0

Enterprise	Share of debts in total liabilities (%)	Share of long-term liabilities to total liabilities (%)
16	26	0
17	35	0
18	55	0
19	49	0
20	64	0
21	12	0
22	62	7
23	24	0
24	81	0
25	34	10
26	9	0
27	70	0
28	63	0

In the analyzed group, model results in the range of 0.57-0.67 for the debt ratio were recorded in 8 out of 28 enterprises. In 14 the results are below this range in turn in 6 above. It can be seen that the analyzed enterprises maintain the level of liabilities in the theoretically safe range, do not exceed the level of 0.67. One can only accuse these enterprises that they should use foreign capital to finance their property to a greater extent. The share of long-term liabilities in liabilities should be assessed negatively, it appears in only 7 enterprises. Long-term liabilities in the analyzed enterprises are long-term loans. In general, they are assessed as a safe source of financing for enterprises. Tab. 2 presents the indicators of the structure of liabilities in enterprises applying quality management systems.

Table 2 – Ratios of the Structure of Liabilities in Enterprises that Introduce Quality Management Systems in 2016 (Author's Own Study)

Enterprise	Share of debts in total liabilities (%)	Share of long-term liabilities to total liabilities (%)
1	36	0
2	84	0
3	80	26
4	57	5
5	14	0
6	53	4

Enterprise	Share of debts in total liabilities (%)	Share of long-term liabilities to total liabilities (%)
7	36	0
8	58	1
9	15	20
10	65	10

When assessing companies using quality management systems, up to 0.67 obtained 8 out of 10 enterprises. It is a safe policy of managing liabilities that does not have a negative impact on financial liquidity, but it is worth increasing the engagement of liabilities in the structure to make the model results more than 4 companies. The appearance of long-term liabilities should be positively assessed, occurring in 6 enterprises.

Tab.3 and Tab. 4 present detailed results of the turnover of short-term liabilities in days in 2014-2016. Tab. 3 presents the results for enterprises that do not apply quality management systems.

Table 3 – Liabilities Rotation Rates in Days in the Analyzed Enterprises that Did Not Apply Quality Management Systems in 2014-2016 (Author's Own Study based on the Financial Statements of Enterprises)

Enterprise	2016	2015	2014
1	79	63	66
2	22	17	21
3	96	101	109
4	38	40	46
5	43	45	35
6	127	114	113
7	22	27	156
8	72	60	85
9	71	67	56
10	37	25	22
11	20	10	14
12	60	57	64
13	21	27	20
14	63	59	79
15	31	26	20

Enterprise	2016	2015	2014
16	41	36	26
17	116	103	11
18	99	98	103
19	48	69	62
20	16	23	33
21	113	128	97
22	102	104	96
23	122	88	82
24	89	81	83
25	96	95	94
26	94	78	93
27	32	32	18
28	107	116	108

Tab. 4 presents the detailed results of receivables turnover rates in days for units using quality management systems.

Table 4 – Liabilities Rotation Rates in Days in the Analyzed Enterprises Applying Quality Management Systems in the Years 2014-2016 (Author's Own Study Based on the Financial Statements of Enterprises)

Enterprise	2014	2015	2016
1	48	33	36
2	78	45	43
3	62	47	55
4	36	32	39
5	49	64	57
6	83	83	67
7	81	51	63
8	64	40	51
9	37	18	33
10	41	43	47

Tab. 5 and Tab. 6 present the results of statistical surveys for the analyzed enterprises. Tab. 5 presents average ratios for the analyzed enterprises (the test probability value is marked as mark '*p*').

Table 5 – Average Results of Liabilities Turnover in the Days of the Analyzed Enterprises (Author's Own Study)

Liabilities turnover ratio in days	**Group**										***p***
	Enterprises that do not use quality management systems (*N* = 28)					**Enterprises that use quality management systems B (*N* = 10)**					
	$\bar{x}$	Me	*s*	min	max	$\bar{x}$	Me	*s*	min	max	
2014	64.7	65.0	38.5	11	156	49.1	49.0	11.5	33	67	0.3505
2015	63.9	61.5	34.6	10	128	45.5	43.5	18.0	18	83	0.2304
2016	67.0	67.0	36.0	16	127	57.5	55.5	18.4	36	83	0.5901

The conducted analysis showed the existence of differences for the average and median in the analyzed enterprises. Quite large differences in the level of averages for the ratio of liabilities turnover in days and financial liquidity are not statistically significant as they are relatively small in relation to the range of variability of this ratio in each group (standard deviations are large in relation to the difference between groups). However, it should be noted that the results for a group of companies using standardized quality management systems are lower. When analyzing the detailed results, one did not observe very high results reaching results above 90 days. In enterprises operating without a quality management system, they often achieve results within 90 days and over 100 days.

The level and strategy of managing short-term liabilities have a decisive influence on the results of the financial liquidity ratio. The table below presents average results for the current liquidity ratio in 2014-2016 in the analyzed enterprises.

Table 6 – Average Financial Liquidity Results in the Analyzed Enterprises (Author's Own Study)

Financial Liquidity	**Group**										***p***
	Enterprises that do not use quality management systems (N = 28)					**Enterprises that use quality management systems B (N = 10)**					
	$\bar{x}$	Me	*s*	min	max	$\bar{x}$	Me	*s*	min	max	
2014	3.62	1.85	3.21	0.13	12.0	2.78	2.80	0.88	1.30	4.1	0.5241
2015	3.65	1.90	3.29	1,20	15.0	3.10	3.30	0.87	1.20	4.2	0.5029
2016	3.55	1.90	2.89	1.20	11.0	3.02	2.40	1.65	1.20	7.0	0.5901

Fast turnover of short-term liabilities allows reducing the level of short-term liabilities. The median result for enterprises using quality management systems of the financial liquidity ratio indicates overliquidity as compared to enterprises not using quality management systems. Then, the correlation between the turnover ratio of short-term liabilities and the financial liquidity ratio was examined. The analysis was carried out for data from 2016, determining the Spearman rank correlation (R) coefficient matrix between pairs of ratios. The research shows that financial liquidity is very strongly connected with the level of short-term liabilities (R = -0.94), the negative sign of the coefficient results from the negative significance of the level of liabilities. In view of such a strong correlation, it can be concluded that the ranking of companies' financial standing in relation to liquidity is almost identical to the liabilities or the Quick Ratio - these measures can be used interchangeably with liquidity.

5 CONCLUSIONS

The conducted research is an introduction to further research related to the subject of the impact of quality management systems on the level of financial liquidity. The presented analysis showed that in the surveyed enterprises lower results of the short-term liabilities turnover ratio were recorded in enterprises applying quality management systems. In the group of these enterprises, long-term liabilities in the structure of liabilities appear more often. In the group applying quality management systems, the share of liabilities in asset financing more often achieves results below the model size range of 0.57-0.67. These results indicate that higher financial liquidity should be obtained by enterprises applying quality management systems, this is confirmed by statistical surveys and more precisely by the results of the median. The presented results confirm that more effective management of liabilities towards suppliers can be observed in enterprises applying appropriate system procedures. This group includes long-term liabilities and the ratio of short-term liabilities turnover in days achieves lower results than results for enterprises that did not introduce quality management systems. In addition, this efficiency translates into high financial liquidity, which is confirmed by a strong correlation between the ratio of short-term liabilities to financial liquidity (R = -0.94). And financial liquidity is currently one of the basic measures informing the environment of a strong competitive position of the company. Summing up, it can be stated that an effective and effective quality management system can effectively support the analyzed processes and be a starting point for consolidating positive relationships with suppliers.

Based on the above conclusions, it can be sum up that the research hypothesis raised by the authors has been confirmed.

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From Academic Publications and Patents to the Technological Development of the Economy: Short and Long Run Causalities

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ABSTRACT

Purpose: The paper examines the potential effects of academic publications on patenting and the share of high technology exports. We test the short-run and the long-run causalities among high technology exports, the number of academic publications and the number of patents in three separate models.

Methodology/Approach: Our sample consists of panel data for 61 countries and 20 years. The panel Granger causality and vector error correction model have been used in order to capture the short-run causalities. Furthermore, panel cointegration regressions have been applied to test for long-run causalities.

Findings: Our results strongly suggest that there is a positive long-run effect of academic publications on both patenting and the share of high technology exports. This suggests that the outcomes of basic science in the form publications strongly support technological development, and thus emphasises the importance of basic research. In addition the effect of patents on high technology exports is mostly insignificant when controlling for academic publications and GDP.

Research Limitation/implication: First, the variables used in the analysis are only proxies. The scope of the data has been significantly limited by the data availability. This leads also to limited the number of control variables.

Originality/Value of paper: There are still only a very limited number of studies testing the effect of academic outcomes on the technological development of the economy. Our research brings new empirical insights into this problem.

Category: Research paper

Keywords: academic research; academic publication; patent; technological development; high-technology exports

1 INTRODUCTION

The technological development of the economy is mostly seen as one of the most important or even the most important determinant of sustainable economic growth. Keys to this are technical change and innovation. Our perceptions of these processes have developed considerably since the early work of Solow (1957) a critical change has been the emergence of endogenous growth models. According to one version of the endogenous growth model, technological progress is generated in research and development (R&D). As reported by Anselin, Varga and Acs (1997) the accumulation of knowledge and its spillover into productive capacity through technological change is a central theme in the new theory of endogenous growth. They stated that universities play an important role in this process, in the role of producers of basic research, as well as by creating human capital. In our research we take into account the scientific outputs of all knowledge producers. However, we are predominantly applying our results on universities. In our research we take into account the data capturing the scientific outputs of all knowledge producers, but we are predominantly applying our findings to universities. However, universities are the main knowledge producers only in some countries. They are mostly the key knowledge producers with respect to outputs of basic science. Universities also play a central role in models such as the triple helix, which evolved out of earlier work done on National Innovation Systems (NIS) (Freeman, 1987; Lundvall, 1992, and Nelson, 1993). The NIS views innovation within nations as revolving around the interactions of companies, universities and research institutes. Their activities are governed by institutions, particularly public sector institutions and this is one way governments can stimulate interaction between learning and knowledge transfer, leading to successful innovation. It emphasises the role universities play in research, PhD and other training, and technology transfer (Mowery and Sampat, 2004). Such interaction between academia and industry is often done within the context of science parks (Minguillo and Thelwall, 2015). The Regional Innovation Systems (RIS) concept evolved from that of the NIS. To an extent this is similar to NIS, but on a smaller scale. However, with a regional focus it emphasises the importance of spatial proximity, which is particularly important with respect to tacit knowledge which requires face to face interactions (Asheim and Gertler, 2005).

In some cases, knowledge is transferred to the private sector via university industry collaboration in publishing (Lebeau et al., 2008). On occasion too, the knowledge transfer to the firm is direct as the academic turns entrepreneur. Thus it is not uncommon for academics, or at least their universities, to do the patenting (Czarnitzki, Glänzel and Hussinger, 2007). Despite this, the mechanism on exactly how the university-industry linkage facilitates innovation is only imperfectly understood and there has, e.g., been only relatively few studies which look at the dynamics of NIS and RIS (Perkmann et al., 2013). This is a gap which this paper is focused on at least partially filling. We are especially focused on the impact of basic research, and estimate the potential long-run effect of academic

outputs on the technological development of the economy. We thus use the number of academic publications in selected journals as the proxy for scientific output. This variable was specifically used as there seems to be some growing doubts about the impact of this kind of research outcome on the real economy (Castellacci and Natera, 2013). Moreover, we also take into account the number of patents. To some extent patents could be seen as another kind of scientific output, but in a more applied form. On the other hand, patents are often used as a proxy for inventions, as for example by Artz et al. (2010). They can then be seen as the first step towards innovation. We believe that academic publications can be seen more as the output of basic research and create an important basis for invention and innovation. On the other hand patents are one step further down the line towards innovation and technological development (Breschi, Lissoni and Montobbio, 2005).

The main aim of the paper is to test the potential causalities between academic publications, the number of patents and the share of high technology exports controlling for endogeneity. We proxy the technological level of the economy by the high technology exports share in total exports. The link between these two has previously been noted in the literature by, e.g., Montobbio and Rampa (2005). Castellacci and Natera (2013) are one of few authors who looks at the dynamics of NIS. There are still only a very limited number of studies testing the effect of academic outcomes on the technological development of the economy in the long-run. In our analysis, a macroeconomic perspective on this problem is applied, despite the fact that we are aware of the importance of certain processes which are more at the micro level, e.g. at the level of universities, research organizations and companies.

In the next section of our paper we review the most suitable literature sources which have been published in this field so far. In the third section we describe the data and methodology used in the analysis. The methodology part is followed by the presentation and discussion of the most important results and the paper ends with the conclusions.

2 LITERATURE REVIEW

As argued by Bercovitz and Feldmann (2006), universities are often viewed as engineers of economic growth as well as regional technological development and revitalization. However, the process of university-led development could take considerable time and energy that is often outside of the immediate interests of the political processes (Bercovitz and Feldman, 2006). Despite the indisputable role of universities as knowledge producers, there is still a growing pressure on universities to apply that knowledge in closely cooperating with industry and government in the development of innovation. This is in line with the triple helix model, where the relationships between universities, industry and government are the key factors for innovation and further technological development (Etzkowitz and Leydesdorff, 2000). However, in fact there are still relatively large

differences among sectors of the economy. As argued by Stankevice and Jucevicius (2013) collaboration with universities is much more important for high-technology companies than service companies, which are more reliant on other agents such as clients, suppliers and external consultants when developing innovation. The argument is that the high technology companies are more dependent upon intellectual property and the external sources that can generate it. Maglio et al. (2006) have also suggested that links between the service sector and academia are relatively weak. In addition high technology areas of the service sector are likely to co-operate with partners, although less so with universities, than high technology manufacturing (Tether, 2002).

Based on the concept of open innovation introduced by Chesbrough (2006), the universities are seen in the context of innovation as external sources of information. This kind of information tends to be more often used by companies compared to internal R&D. In order to facilitate the flow of information there is a need for more intensive scientific openness. McMilla, Mauri and Casey (2014) measured scientific openness by the number of academic publications. They found that academic publications are a good predictor of both positive technological changes at the level of firms and appear to have an effect also on the scientific outcomes of firms, measured by the number of times an individual firm's patents cite the scientific literature. The findings of Herrera, Muñoz-Doyague and Nieto (2010) confirm that scientific knowledge provided by public researchers has a significantly positive effect on both inputs and outputs of the firms' innovation process. The authors emphasized the importance of access of firms to additional knowledge which is complementary to that which they already hold, and often leads to practical application of this knowledge.

Thomas, Sharma and Jain (2011) stated that academic publications are one of the most common indicators that can be used as a proxy for academic productivity and excellence. Nguyen and Pham (2011) examined the effect of scientific articles on a knowledge based economy index. They analysed articles published in international peer reviewed journals between 1991 and 2010 in East Asian countries. They found that at the country level, the correlation between a knowledge based economy index and academic publications was 0.94. The authors concluded that the results suggested the existence of a strong relationship between academic research and the degree of "knowledgization" of the economy. Another indicator used in analysis is the number of patents. In general patents have been accepted as indicators of R&D processes and even though not all inventions are patented and not all patents are profitable, they have become the most common indicator of innovative output (Thomas, Sharma and Jain 2011). Zachariadis (2003) argues that R&D expenditure is mostly reflected in the number of patents, and patents have a positive effect on the development of technologies which raises economic growth. A similar effect of patents on growth is also shown by Hudson and Minnea (2013). The positive effect of university R&D on patents has been previously found, for example by Jaffe (1989). Moreover, Stephan et al. (2007), as well as Carayol and Matt (2004) both

found a positive correlation between academic outputs, as measured by publications, and the number of patents.

There are several ways in which patenting and academics are related together. On the one hand, firms with access to academic research have been shown to enhance their patent performance. This is particularly true for younger firms (Soh and Subramanian, 2014). On the other hand universities can apply for their own patents based on their research activities. Appling for a patent by universities could be an effective way to commercialize the results of their research to a certain extent. Veugelers et al. (2012) map the presence and impact of universities on development of technology. They analyse the number of patents applied for by universities and found that academically owned patents are more commonly used by firms in the US than in European countries. This may be related to the so-called European paradox, which describes the phenomenon that EU countries play a leading role in terms of top-level academic output, but still lag behind in the ability of converting these results into wealth-generating innovations in the business sector (Czarnitzki, Hussinger and Schneider, 2012).

Apart from the triple helix model, work on NIS and RIS also paved the way for the university engagement approach (Chatterton and Goddard, 2000). The concept of the engaged university explicitly emphasises a strong regional focus in their teaching and research activities. As suggested by the related concept of the 'entrepreneurial university', universities are to take a proactive role in this process and thus in regional development. Such universities are not only entrepreneurial in terms of technology development, but also respond to the needs of the region (Chatterton and Goddard, 2000). They play a 'developmental' role by building institutions and facilitating networks which facilitate the regions they are located within (Gunasekara, 2006). The mechanism by which the university industry linkage facilitates innovation is only imperfectly understood. Considerable work has been done on commercialisation (Perkmann et al, 2013). Castellacci and Natera (2013) in a panel cointegartion analysis of 98 countries over a 29 year period found that the dynamics of NIS are driven by the coevolution of technological output, academic output and innovative input on the one hand, and per capita income, infrastructures and international trade, on the other. Surprisingly they found a negative relationship between scientific and technological output. This is one of the relatively few studies which has looked at the dynamics of NIS. Thus overall a great deal of work has been written which assumes universities play a critical role in innovation. But there has been much less empirical work which supports this view.

3 DATA AND METHODOLOGY

In our analysis we are testing the assumed long-run and short-run causalities between science, patenting and high technology exports. We are focused on the output side, which means in the case of universities we take into account the number of publications, for patenting it is the number of patents. On one hand we assume that a higher intensity of academic activity could have a positive effect on patenting, which could be interpreted as innovation itself or could foster innovation (as reported for example by Zachariadis; 2003). On the other hand, academic publications could have also a positive influence on technological development by many other ways apart from the patenting path. The number of publications can also be seen as a proxy for scientific openness as applied for example by McMillan, Mauri and Casey (2014). Scientific openness is one of the key determinates of technological development. It is rational to assume that all these effects are likely to be significant in the long-run rather than in short-run. Hence, in order to verify these assumed causalities, we examine potential long-run as well as short-run relationships between the number of academic publications, the number of registered patents and the high-technology exports share.

The intensity of scientific activity of academia could be represented by several different indicators. However, we decided to apply the number of scientific articles as an appropriate proxy. We take into account only scientific articles covered by the Science Citation Index (SCI) and the Social Sciences Citation Index (SSCI), published in the following fields: physics, biology, chemistry, mathematics, clinical medicine, biomedical research, engineering and technology, and earth and space sciences. The number of scientific articles is calculated per 100,000 residents of the relevant country in each period. Similarly, the number of patents is calculated per 100,000 inhabitants. We consider only those patent applications for which the first-named applicant or assignee is a resident of the state concerned. As already discussed, the share of high-technology exports of manufactured exports was used as the proxy for the technological level of the economy. Based on an assessment of available data, this variable appears to be the most suitable for our purposes. All variables used in regression models are summarized and described in Tab. 1.

Table 1 – Variables Used in the Regression Models (World Bank database)

Variable (abbreviation)	Description
High-tech export (HTEshare)	*High technology exports (as % of manufactured exports)* High-technology exports are products with high R&D intensity, such as in aerospace, computers, pharmaceuticals, scientific instruments, and electrical machinery. The method for determining high-technology exports was developed by the Organisation for Economic Co-operation and Development in collaboration with Eurostat. It takes a "product approach" based on R&D intensity (expenditure divided by total sales) for certain groups of products.
Scientific articles per capita (SApc)	*Number of scientific articles per capita *100,000* The number of scientific and engineering articles published by authors from a certain country in the following fields: physics, biology, chemistry, mathematics, clinical medicine, biomedical research, engineering and technology, and earth and space sciences per capita (considering only articles from a set of journals covered by Science Citation Index and Social Sciences Citation Index)
Patents per capita (PATpc)	*Number of resident patents per capita *100,000* Resident patent applications are those for which the first-named applicant or assignee is a resident of the State concerned. Patent applications are worldwide patent applications filed through the Patent Cooperation Treaty procedure or with a national patent office.
GDP per capita (GDPpc)	*GDP per capita* (at price purchasing power parity – PPP) (in international dollars)

We also intended to apply foreign direct investment (FDI) inflows as a dependent variable, because we assume that there is some spill-over effect of FDI for the development of the country. FDI can be also seen as one of the carriers of knowledge from developed regions to less developed regions. However, based on the results of panel stationarity tests this variable is very likely stationary at its level, thus we should not use cointegration analysis in this case.

There are several significant outliers in the case of patents, scientific articles as well as GDP per capita. These variables have rather high variability and right skewed distribution. In order to partly eliminate all mentioned problems we used logarithm transformation of these variables in regression models. This also allows us to keep proportionality with the share of higher tech exports which is. Due to transformation we indicate proportional changes rather than unite changes, which is much better in our case due to significant differences between countries. The regression coefficients can be also interpreted as semi-elasticity or elasticity. It is likely that increase in research outputs can have stronger impact on technology development in countries with developed research infrastructure and previous success in basic and applied research.

We assume that the number of scientific articles could have a positive effect on the patenting and the high-technology export share of total exports. Hence the equations we will be estimating are:

$$HTEshare_{it} = f[log(SApc_{it}), (GDPpc_{it})], \quad (1)$$

$$PATpc_{it} = f[log(SApc_{it}), (GDPpc_{it})], \quad (2)$$

where *HTEshare* is the share of high technology exports, *SApc* is scientific articles per capita, *GDPpc* is GDP per capita and *PATpc* is the number of patents per capita.

We will then add to the right hand side variables, academic articles per capita and patents per capita. Wu used especially fully modified ordinary least square (FMOLS) and dynamic ordinary least square (DOLS) in order to estimate long-run causalities. In the case of short-run effects we applied vector error correction model (VECM). All estimation techniques are in more detail described in the text.

Our dataset consists of panel data, thus all variables include a cross-sectional (country) dimension as well as a time dimension. It includes the data for 61 countries in the period 1993-2012. The list of all countries can be seen in Tab. 2. Our aim is to include, as well as more developed countries, developing and poor countries in the sample if possible. Despite this, the data from these countries are often less available, thus most of the countries included in our dataset are developed countries. Due to several missing observations, we get a slightly unbalanced panel with a maximum of 1,220 observations. If there was only one missing observation for a certain country, it was substituted by the arithmetic average of the observations ahead and behind this observation (together 18 values have been obtained this way for all variables).

Table 2 - The List of Countries in the Dataset

EU Countries	Other Countries
Austria, Bulgaria, Croatia, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Latvia, Lithuania, Netherlands, Poland, Portugal, Romania, Slovak Republic, Slovenia, Spain, Sweden, United Kingdom	Algeria, Australia, Brazil, Canada, Chile, China, Colombia, Ecuador, Egypt, Guatemala, Iceland, India, Indonesia, Israel, Jamaica, Japan, Korea Rep., Macedonia, Madagascar, Malaysia, Mexico, Moldova, New Zealand, Norway, Pakistan, Peru, Philippines, Russian Federation, Saudi Arabia, Singapore, South Africa, Sri Lanka, Switzerland, Thailand, Turkey, Ukraine, , United States, Uruguay

Nevertheless, in the case of scientific publications, there were missing observations for all countries in the year 2012. Thus in all models, where this variable was used the period dimension was reduced to 19 years (1993-2011).

For every other model, the dataset with a 20 years' time frame was applied. The basic descriptive statistics for the three main variables used in our analysis are summarized in Tab. 3.

Table 3 – The Basic Descriptive Statistics of the Main Variables Used in the Models

	HTEshare	*SApc*	*PATpc*
Mean	13.60	29.42	18.20
Std. Dev.	13.56	33.61	43.18
Observations	1,204	1,152	1,210

In the first step of the analysis we test for weak stationary and the order of integration for all variables, which we want to use in the cointegration model. We used the Levin, Lin and Chu (2002), Im, Pesaran and Shin (2003) and Breitung (2000) tests as well as the Fisher ADF and PP tests defined by Choi (2001) and Maddala and Wu (1999). After we managed to satisfactorily demonstrate the same level of integration by unit root tests, we tested for the existence of cointegration by panel cointegration tests. Cointegration between the dependent and independent variables has been tested for using panel cointegration tests developed by Pedroni (2004) and Kao (1999), which are both widely used in the empirical literature. Both are testing the null hypothesis of no cointegration between selected variables. The Pedroni (2004) cointegration tests use seven different statistics. Four of them are panel cointegration statistics based on the within approach and three of them are group-mean panel cointegration statistics which are based on the between approach. Kao (1999) tests the null hypothesis that the residuals from the estimation are non-stationary.

Obviously, the panel cointegration tests allow us to identify the presence of cointegration, but cannot by itself estimate any long-run coefficients. For this purpose we use panel cointegrated regression models. The long run parameters are estimated by the fully modified OLS (FMOLS) and the dynamic OLS (DOLS) panel cointegration estimators. Both types of estimators have been used in their two forms referred to as a pooled estimator and group-mean estimator. While pooled estimators are based on the "within dimension" of the panel, the group-mean estimators are based on the "between dimension of the panel". The pooled FMOLS estimator is proposed in Phillips and Moon (1999) and the group-mean FMOLS estimator is developed by Pedroni (2000). The pooled DOLS estimator is introduced by Kao and Chiang (2000) and the concept of the group-mean estimator is extended from FMOLS to DOLS by Pedroni (2001). We now briefly describe the essence of the FMOLS and DOLS estimators.

Both FMOLS and DOLS are based on standard OLS considering the simple fixed-effects panel regression model that can be written as:

$$Y_{it} = \alpha_i + \beta_i X_{it} + u_{it}, i = 1, \ldots., N, t = 1, \ldots, T, \quad (3)$$

where Y_{it} is a vector of dependent variable and β is a vector of coefficients. α_i is an individual fixed effect and u_{it} are stationary disturbance terms. It is assumed that X_{it} are integrated processes of order one for all i. The FMOLS estimator then is written as follows:

$$\hat{\beta}_{FMOLS} = \left[\sum_{i=1}^{N}\sum_{t=1}^{T}(x_{it} - \bar{x}_i)'\right]^{-1}\left[\sum_{i=1}^{N}\left(\sum_{t=1}^{T}(x_{it} - \bar{x}_i)\,\hat{y}_{it}^{+} + T\hat{\Delta}_{\epsilon\mu}^{+}\right)\right], \quad (4)$$

where $\hat{\Delta}_{\epsilon\mu}^{+}$ is a serial correlation term that gives the covariance matrix of the residuals corrected for autocorrelation and $\hat{y}_{it}^{+}$ is the transformation of the dependent variable y_{it} in order to achieve the endogeneity correction.

The DOLS estimator is obtained from the following equation:

$$y_{it} = \alpha_i + \beta x_{it} + \sum_{j=q_1}^{q_2} c_{ij}\Delta x_{i,t+j} + u_{it}, \quad (5)$$

where c_{ij} is the coefficient relating to the leads and lags of the first differenced independent variables. We can estimate β, the long run coefficient, by the following equation:

$$\hat{\beta}_{DOLS} = \sum_{i=1}^{N}\left[\sum_{t=1}^{T} z_{it} z_{it}'\right]^{-1}\left[\sum_{t=1}^{T} z_{it}\,\hat{y}_{it}^{+}\right], \quad (6)$$

where $z_{it} = (x_{it} - \bar{x}_i, \Delta x_{it-q}, \ldots., \Delta x_{it+q})$ is a $2(q+1)\times 1$ vector of regressors.

Both estimators are robust with respect to the potential problems of serial-correlation and endogeneity, which are potential problems with common ordinary least squares panel data estimators. The FMOLS estimator solves this by nonparametric corrections, while the DOLS estimator uses parametric correction, in effect adding leads and lags of differenced regressors into the regression.

In the final step of the analysis we estimate a panel vector error correction model (VECM) using the residuals from the FMOLS cointegration equation as an error correction term (ECT). While cointegration coefficients reflect the long run balanced relationship, the VECM model is also able to capture the correcting mechanism of short term deviations from long run equilibrium. Thus, this approach is suitable to identify the sort-run effects, while taking into account the long-run relationship between variables. The speed of adjustment to long-run equilibrium can also be estimated by the error correction term coefficient. We

used the lagged residuals derived from the FMOLS cointegrated regression as error correction terms.

4 RESULTS

First of all we apply the panel stationary test as stated in the methodology part. The results of these stationarity tests are summarized in the Appendix at the end of the paper. Based on the majority of the results we can say that all variables except FDI inflows seem to be non-stationary at their level and stationary at their first differences. Thus they are all integrated of the same order, I(1). Hence, we can apply cointegration tests on them. However, we have to exclude the FDI inflows variable from our analysis in this point. In order to test the potential short-run causalities we perform panel Granger causality tests. The results are shown in Tab. 4.

As can be seen there are some indications that the short run effect runs from the number of scientific articles per capita to the number of patents per capita. However, when taking into account the optimum number of lags based on the Schwarz criterion (SBC), which is four in this case, the effect becomes insignificant. Furthermore, there is no evidence for Granger causality between patents and high tech exports. Thus, this kind of effect is not significant at least in the short-run according to our results. On the other hand, the results indicate a statistically highly significant effect of scientific articles on high technology exports share, when considering four lags, which is again the optimum according to Schwarz criterion. This could be interpreted as short-run causality in the Granger sense.

Table 4 – Results of Pairwise Panel Granger Causality Tests

Number of Lags	**Lag =1**	**Lag =2**	**Lag =3**	**Lag =4**
H0: ΔSApc does not Granger cause ΔPATpc	3.19*	3.73**	2.40*	1.61
H0: ΔPATpc does not Granger cause ΔSApc	1.15	0.40	2.35*	0.79
Observations	1018	956	894	832
H0: ΔPATpc does not Granger cause ΔHTEshare	2.57	1.90	1.28	0.91
H0: ΔHTEshare does not Granger cause ΔPATpc	0.63	1.20	1.27	1.95
Observations	1063	1000	937	874
H0: ΔSApc does not Granger cause ΔHTEshare	1.08	0.65	2.35*	3.11**
H0: ΔPATpc does not Granger cause ΔHTEshare	0.19	1.17	0.83	1.71
Observations	1,011	950	889	828

Notes: */**/*** means significance at the 10%/ 5%/ 1% levels.

In the next part of the analysis we focus our attention on the long-run causalities. We test for the existence of cointegration among selected variables using the panel cointegration tests described in the methodology part. The results of these tests are summarized in Tab. 5 and Tab. 6. As can be seen in the upper half of the Tab. 5, based on most of the tests we can reject the null hypothesis of no cointegration between high technology exports, academic publications per capita and GDP per capita. Thus, the results are in line with the outcomes of the stationarity tests performed earlier. Similar results can be seen in the lower half of Tab. 5, where we test the null hypothesis of no-cointegration between the number of patents per capita, scientific articles per capita and GDP per capita. Again the results imply the rejection of this null hypothesis, so we can conclude that these variables are cointegrated.

Table 5 – The Results of Cointegration tests

Cointegration: HTEshare; SApc; GDPpc (intercept)			
Null Hypothesis: no cointegration		**Statistic**	**Weighted Statistic**
Pedroni test (Engle-Granger based) tests – individual intercept, lag length selection based on SBC	Panel v-Statistic (within dimension)	0.07	-0.38
	Panel rho-Statistic (within dimension)	1.38	-0.31
	Panel PP-Statistic (within dimension)	-1.59*	-5.12***
	Panel ADF-Statistic (within dimension)	-5.72***	-8.10***
	Group rho-Statistic (between dimension)	3.04	
	Group PP-Statistic (between dimension)	-3.83***	
	Group ADF-Statistic (between dimension)	-7.27***	
Kao coint. test	ADF-Statistic	-4.11***	
Cointegration: HTEshare; SApc; GDPp (intercept & trend)			
Null Hypothesis: no cointegration		**Statistic**	**Weighted Statistic**
Pedroni tests (Engle-Granger based) – individual intercept & trend, lag length selection based on SBC	Panel v-Statistic (within dimension)	-0.36	-3.79
	Panel rho-Statistic (within dimension)	1.23	1.73
	Panel PP-Statistic (within dimension)	5.20***	-7.24***
	Panel ADF-Statistic (within dimension)	-8.08***	-10.67***
	Group rho-Statistic (between dimension)	4.56	
	Group PP-Statistic (between dimension)	-6.25***	
	Group ADF-Statistic (between dimension)	-8.75***	

Cointegration:PATpc; SApc; GDPpc (intercept)			
Null Hypothesis: no cointegration		**Statistic**	**Weighted Statistic**
Pedroni tests (Engle-Granger based), lag length selection based on SBC	Panel v-Statistic (within dimension)	6.86***	0.20
	Panel rho-Statistic (within dimension)	-3.98***	-3.54***
	Panel PP-Statistic (within dimension)	-10.70***	-9.55***
	Panel ADF-Statistic (within dimension)	-11.12***	-10.88***
	Group rho-Statistic (between dimension)	-0.14	
	Group PP-Statistic (between dimension)	-9.50***	
	Group ADF-Statistic (between dimension)	-11.52***	
Kao test	ADF-Statistic	-4.63***	
Cointegration: PATpc; SApc; GDPpc (intercept & trend)			
Null Hypothesis: no cointegration		**Statistic**	**Weighted Statistic**
Pedroni tests (Engle-Granger based), lag length selection based on SBC	Panel v-Statistic (within dimension)	1.11	-4.70
	Panel rho-Statistic (within dimension)	0.74	0.06
	Panel PP-Statistic (within dimension)	-7.91***	-9.42***
	Panel ADF-Statistic (within dimension)	-15.59***	-11.58***
	Group rho-Statistic (between dimension)	3.26	
	Group PP-Statistic (between dimension)	-10.66***	
	Group ADF-Statistic (between dimension)	-12.41***	

Notes: */**/*** means significance at the 10%/ 5%/ 1% levels.

Analogous tests have been applied for all four variables together (high tech exports, scientific articles per capita, patents per capita and GDP per capita), which can be seen in Tab. 6. As with the other cases, we can once again conclude that the majority of the tests reject the null hypothesis. Thus it is likely that the tested group of variables are cointegrated, which basically means that we are capable of performing cointegrated regressions on these variables to examine potential long-run causalities.

Table 6 – The Results of Cointegration Tests for All Variables Used in Regressions

Cointegration: HTEshare; SApc; PATpc; GDPpc (intercept)			
Null Hypothesis: no cointegration		**Statistic**	**Weighted Statistic**
Pedroni test (Engle-Granger based) tests – individual intercept, automatic lag length selection based on SIC	Panel v-Statistic (within dimension)	1.52*	1.83**
	Panel rho-Statistic (within dimension)	1.72	0.67
	Panel PP-Statistic (within dimension)	-1.40*	-4.30***
	Panel ADF-Statistic (within dimension)	-4.75***	-6.73***
	Group rho-Statistic (between dimension)	3.72	
	Group PP-Statistic (between dimension)	-3.99***	
	Group ADF-Statistic (between dim.)	-8.77***	
Kao cointegration test	ADF-Statistic	-5.169***	
Cointegration:HTEshare; SApc; PATpc; GDPpc (intercept & linear trend)			
Null Hypothesis: no cointegration		**Statistic**	**Weighted Statistic**
Pedroni tests (Engle-Granger based) tests – individual intercept & trend, automatic lag length selection based on SIC	Panel v-Statistic (within dimension)	1.71**	-0.06
	Panel rho-Statistic (within dimension)	1.83	2.32
	Panel PP-Statistic (within dimension)	-7.46***	-6.46***
	Panel ADF-Statistic (within dimension)	-9.90***	-8.26***
	Group rho-Statistic (between dimension)	4.56	
	Group PP-Statistic (between dimension)	-6.25***	
	Group ADF-Statistic (between dim.)	-8.75***	

Notes: */**/*** means significance at the 10%/ 5%/ 1% levels.

In accordance with our main aim we tested the long-run causalities using the FMOLS and DOLS regression described in the methodology. The FMOLS models have been slightly preferred in our analysis, due to several more suitable characteristics, such as the alternative of using heterogeneous first stage long-run coefficients.

First of all, we analyse the long-run effect of academic publications on patents, which could be also seen as an initial step towards the actual technological development of the economy. We assume that more intensive research at universities and other research institutions leads to a higher number academic publications, which could subsequently have a positive effect on patenting. This theoretical assumption was strongly supported by the empirical results from the cointegrated regressions as can be seen in Tab. 7. We applied different types of cointegration models. The models with an individual constant only, as well as

with a constant and linear trend have been used. The leads and lags in the DOLS models have been fixed or chosen according to the Schwarz criterion. The long-run effect of academic publications on patenting is positive and statistically significant at the 5% level of significance in nine models. The results are very similar for both the FOMLS and DOLS models. GDP per capita was used as a control variable in all models.

Table 7 – Cointegrated Regression Models with Number of Patents Per Capita as Dependent Variable

Dependent variable: log(PATpc); Pooled estimator (within dimension)						
	(1) A	**(2) B**	**(3) C**	**(4) D**	**(5) E**	**(6) F**
Log(SApc)	0.75*** (9.73)	0.75*** (9.73)	0.63*** (6.23)	0.76*** (10.86)	0.66*** (17.95)	0.62*** (6.23)
Log(GDPpc)	0.05 (0.72)	0.05 (0.92)	0.04 (0.54)	0.05 (0.81)	0.11*** (3.15)	0.04 (0.54)
R2	0.97	0.97	0.98	0.97	0.97	0.98
Adj. R2	0.97	0.97	0.98	0.97	0.97	0.98
Long-run variance	0.27	0.27	0.16	0.27	0.07	0.16
Observations	1,075	1,075	1,024	1,075	1,075	1,024
Dependent variable: log(PATpc); Group-mean estimator (between dimension)						
	(7) G	**(8) H**	**(9) I**	**(10) J**	**(11) K**	**(12) L**
Log(SApc)	0.18** (2.00)	0.32** (2.55)	0.30* (1.67)	0.16* (1.89)	0.31**** (2.55)	0.14 (0.54)
Log(GDPpc)	0.31*** (3.13)	0.35*** (2.80)	0.53 (3.30)	0.35*** (3.89)	0.35*** (2.79)	0.73 (1.54)
Long-run variance	0.05	0.04	0.03	0.04	0.04	0.02
Observations	1,075	1,024	952	1,019	1,024	952

Notes: */**/*** means significance at the 10%/ 5%/ 1% levels; (.) denotes t-statistics; long-run variances calculated based on Bartlett kernel and Newey-West bandwidth have been used for coefficient covariances; A - FMOLS (pooled estimator), constant included, coefficient covariance matrix with homogenous variances; B - FMOLS (pooled estimator), constant included, coefficient covariance matrix with heterogeneous variances; C – DOLS (pooled estimator), constant included, lags and leads based on the SIC; homogenous variances; D - FMOLS (pooled estimator), constant & linear trend, coefficient covariance matrix with homogenous variances; E - FMOLS (pooled estimator), constant & linear trend, coefficient covariance matrix with heterogeneous variances; first-stage residuals use heterogeneous long-run coefficients; F- DOLS (pooled estimator), constant, lags and leads based on the SIC; heterogenous variances; G - FMOLS (group-mean estimator), constant included; H - DOLS (group-mean estimator), constant included, lags and leads included based on the SIC; I - DOLS (group-mean estimator), constant included, 1 lead and 1 lag (fixed leads and lags specification); J - FMOLS (group-mean estimator), constant & linear trend included; K - DOLS (group-mean estimator), linear trend, lags and leads included based on the SIC; L - DOLS (group-mean estimator), linear trend, 1 lead and 1 lag (fixed leads and lags).

In the next models we focused our analysis on the long-run causalities between scientific articles and high technology exports. In this case we again found rather strong empirical support for our assumption that scientific articles as an indicator of academic activities intensity have a positive effect on the high technology exports in the long run. In order to check for the robustness of our results we apply different estimation approaches with different assumptions. The assumed positive effect is statistically significant at the 5% level in most of the cointegrated regression models, which can be seen in Tab. 8. In particular, this effect is significant in all models which are based on a group mean estimator.

It is important to note that we have not controlled for the potential effect of patenting in the previous regressions. Despite academic publications seeming to have a positive effect on patenting, patenting itself could also be another important factor affecting the share of high technology exports. This effect has been taken into account in the next set of regression models which include high technology exports as the dependent variable and scientific articles per capita, GDP per capita and patents per capita as independent variables. A wide variety of long-run causal estimators has been used in this case in order to check the robustness of the results. The results from the pooled estimators are summarized in Tab. 9. According to these, the effect of scientific articles is statistically significant at least at the 10% level in all FMOLS models (upper part of Tab. 9). On the other hand we get somewhat mixed results for the DOLS estimator. Half of the DOLS models support our assumption about the positive effect of scientific articles on high technology exports at least at the 5% level of significance. In addition the effect of patents appears to be insignificant in most of the DOLS and FMOLS models when controlling for academic publications and GDP per capita.

Table 8 – FMOLS and DOLS Regressions with Share of High Technology Exports as Dependent Variable

Dependent variable: HTEshare; Pooled estimator (within dimension)						
	(1) A	**(2) B**	**(3) C**	**(4) D**	**(5) E**	**(6) F**
Log(SApc)	1.70* (1.94)	1.70*** (2.43)	2.07** (2.10)	1.73 (1.09)	1.40* (1.65)	4.47* (1.91)
Log(GDPpc)	0.18 (0.20)	0.18 (0.18.)	0.88 (0.96)	-1.88 (-0.63)	-2.77 (-1.55)	-6.53* (-1.78)
R2	0.91	0.91	0.95	0.94	0.94	0.96
Adj. R2	0.91	0.91	0.93	0.94	0.93	0.94
Long-run variance	35.23	35.23	18.51	23.39	11.03	11.89
Observations	1,072	1,072	993	1,072	1,072	1,001

Dependent variable: HTEshare; Group mean estimator (between dimension)						
	(7) G	**(8) H**	**(9) I**	**(10) J**	**(11) K**	**(12) L**
Log(SApc)	6.24*** (3.34)	7.68** (2.21)	6.00*** (2.90)	5.82*** (3.26)	16.47*** (3.03)	14.15** (2.53)
Log(GDPpc)	-3.53*** (-3.03)	-6.65*** (-3.10)	-5.44*** (-4.21)	-10.84*** (-4.15)	-20.02*** (-3.06)	-19.54*** (-2.57)
Long-run variance	14.99	9.07	15.79	9.23	8.55	8.91
Observations	1,072	993	1,020	1,016	1,001	1,016

Notes: */**/*** means significance at the 10%/ 5%/ 1% levels; (.) denotes t-statistics; long-run variances calculated based on Bartlett kernel and Newey-West bandwidth have been used for coefficient covariances; A - FMOLS (pooled estimator), constant included, coefficient covariance matrix with homogenous variances; B - FMOLS (pooled estimator), constant included, coefficient covariance matrix with heterogeneous variances; C - DOLS (pooled estimator), constant included, lags and leads included based on the AIC; D - FMOLS (pooled estimator), linear trend, coefficient covariance matrix with homogenous variances; E - FMOLS (pooled estimator), constant & linear trend, coefficient covariance matrix with heterogeneous variances, first-stage residuals use heterogeneous long-run coefficients; F-DOLS (pooled estimator), linear trend; lags and leads based on the AIC; coefficient covariance matrix with heterogeneous variances; G - FMOLS (group-mean estimator), constant included; H - DOLS (group-mean estimator), constant included, lags and leads included based on the AIC; I - DOLS (group-mean estimator), constant included, lags and leads included based on the SIC, individual HAC (Newey-West) standard errors & covariances; J - FMOLS (group-mean estimator), constant & linear trend included; K - DOLS (group-mean estimator), linear trend, lags and leads included based on the AIC; L - DOLS (group-mean estimator), linear trend, lags and leads included based on the SIC; individual; HAC (Newey-West) standard errors & covariances.

Table 9 – The Results of Models with Pooled Estimator – Within Dimension

Dependent variable: HTEshare; FMOLS: (dependent variable: HTEshare)						
	(1) A	**(2) B**	**(3) C**	**(4) D**	**(5) E**	**(6) F**
Log(SApc)	1.26** (2.33)	1.26*** (3.09)	1.27* (1.92)	1.46* (1.70)	1.46** (2.29)	1.33*** (83.01)
Log(PATpc)	0.41 (1.37)	0.41* (1.76)	0.55 (1.44)	-0.38 (-1.05)	-0.38 (-1.23)	3.56*** (11.85)
Log(GDPpc)	0.26 (0.53)	0.26 (0.63)	0.15 (0.24)	-1.89 (-1.19)	-1.89 (-1.50)	-6.61*** (-264.5)
R2	0.91	0.91	0.91	0.94	0.94	0.93
Adj. R2	0.91	0.91	0.91	0.93	0.93	0.92
Long-run variance	11.15	11.15	10.83	6.52	6.52	5.09
Observations	1,059	1,059	1,059	1,059	1,059	1,059

Dependent variable: HTEshare; DOLS: (dependent variable: HTEshare)						
	(7) G	**(8) H**	**(9) I**	**(10) J**	**(11) K**	**(12) L**
Log(SApc)	2.72** (2.05)	1.34 (1.36)	0.068*** (3.32)	2.32 (1.35)	2.32 (1.49)	1.10*** (3.42)
Log(PATpc)	0.07 (0.06)	0.04 (0.06)	0.32** (2.13)	-0.70 (-0.85)	-0.70 (-0.79)	-0.28 (-1.56)
Log (GDPpc)	0.46 (0.43)	0.22 (0.24)	0.56** (2.38)	-5.78* (-1.90)	-5.78** (-2.07)	-2.05** (-2.33)
R^2	0.97	0.96	0.96	0.95	0.95	0.95
Adj. R^2	0.93	0.93	0.93	0.94	0.94	0.94
Long-run variance	10.13	14.58	14.58	16.62	16.62	16.62
Observations	935	985	985	1,057	1,057	1,057

Notes: */**/*** means significance at the 10%/ 5%/ 1% levels; (.) denotes t-statistics; long-run variances calculated based on Bartlett kernel and Newey-West bandwidth have been used for coefficient covariances; A - FMOLS pooled estimator; constant included, coefficient covariance matrix with homogenous variances, first-stage residuals use heterogeneous long-run coefficients; B - FMOLS pooled estimator; constant included, coefficient covariance matrix with heterogeneous variances, first-stage residuals use heterogeneous long-run coefficients; C - FMOLS pooled estimator; constant included, coefficient covariance matrix with heterogeneous variances; D - FMOLS pooled estimator; linear trend included, coeff. cov. matrix with homogenous variances; E - FMOLS pooled estimator; constant & linear trend included, coeff. cov. matrix with heterogeneous variances; F - FMOLS pooled weighted estimator; constant& linear trend included; coefficient covariance matrix with homogenous variances, first-stage residuals use heterogeneous long-run coefficients; G - DOLS pooled estimator; constant included, fixed leads and lags (leads=1, lags=1), coefficient covariance matrix with heterogeneous variances; H - DOLS pooled estimator; constant included, leads and lags based on SIC, long-run variance, coefficient covariance matrix with homogenous variances; I - DOLS pooled weighted estimator; constant included, leads and lags based on SIC, long-run variance, coefficient covariance matrix with homogenous variances; J - DOLS pooled estimator; constant & linear trend included, leads and lags based on SIC, coefficient covariance matrix with homogenous variances; K - DOLS pooled estimator; linear trend included, leads and lags based on SIC, coefficient covariance matrix with heterogeneous variances; L - DOLS pooled weighted estimator; linear trend included, leads and lags based on SIC, coefficient covariance matrix with heterogeneous variances.

The results from the grouped-mean estimators are summarized in Tab. 10. As can be seen, the results achieved by DOLS and FMOLS group-mean estimators are mostly similar. Scientific articles have a positive and statistically significant effect on high technology exports in all regressions. As stated before, scientific articles have a significant effect on both patents and high technology exports. The effect of patents is, however, positive and significant only when excluding the scientific articles variable from the models. Our results thus strongly suggest that the outputs of basic science could be seen as an actual source of technological development of the economy. This effect seems to be even more significant and intensive when using the group-mean estimator considering the "between dimension" of panel data.

Table 10 – The Results of Models with Group-Mean Estimator (between Dimension)

FMOLS: (dependent variable: HTEshare)					
	(1) A	**(2) B**	**(3) C**	**(4) D**	**(5) E**
Log(SApc)	2.93** (1.90)		3.78*** (3.06)	5.94*** (3.37)	
Log(PATpc)	0.47 (0.68)	2.66*** (2.73)	0.92 (1.37)		1.68** (2.01)
Log (GDPpc)	-1.20 (-1.09)	0.19 (0.21)	-5.91*** (-2.60)	-10.46*** (-4.20)	-3.18 (-1.28)
Long-run variance	9.17	15.18	5.04	8.88	8.48
Observations	1,059	1,124	1,059	1,072	1,124
DOLS: (dependent variable: HTEshare)					
	(6) F	(7) G	(8) H	(9) I	(10) J
Log(SApc)	12.95** (2.30)	14.54*** (3.63)	24.73*** (3.27)	4.39** (1.99)	
Log(PATpc)	-5.10** (-2.45)	-4.58*** (-3.26)	-1.19 (-0.38)	-0.20 (-0.16)	2.38 (1.44)
Log (GDPpc)	-2.41 (-0.88)	-1.60 (-0.73)	14.31 (1.23)	-7.39** (-2.08)	-3.76 (-1.06)
Long-run variance	3.04	5.48	2.29	8.46	8.91
Observations	935	985	935	1,057	1,060

Notes: */**/*** means significance at the 10%/ 5%/ 1% levels; (.) denotes t-statistics; long-run variances calculated based on Bartlett kernel and Newey-West bandwidth have been used for coefficient covariances; coefficient covariance matrix with homogenous variances; A - FMOLS group-mean estimator; constant included; B - FMOLS group-mean estimator; constant included; C - FMOLS group-mean estimator; constant & linear trend included; D - FMOLS group-mean estimator; constant & linear trend included; E - FMOLS group-mean estimator; constant & linear trend included; F - DOLS group-mean estimator; constant included; fixed leads and lags (leads=1, lags=1); G - DOLS group-mean estimator; constant included; leads and lags based on SIC; H - DOLS group-mean estimator; constant & linear trend included; fixed leads and lags (1,1); I - DOLS group-mean estimator; constant & linear trend included; leads and lags based on SIC; individual HAC, (Newey-West) covariance matrix estimator; J - DOLS group-mean estimator, constant & linear trend included; leads and lags based on SIC.

In the next and final step of our analysis, we use the panel vector error correction model (VECM) to capture potential short-run causalities. The results of the analysis can be seen in the Tab. 11. Using this kind of model we can also revaluate the significance of the long-run relationship using the error correction term and also calculate the speed of the expected return to long-run equilibrium. The number of lags included in the models was selected using the Schwarz criterion. This resulted in two lags for both models.

Table 11 – The Results of the VECM Models

Coef.	*Dependent variable: ΔHTEshare*			
C(1)	ΔHTEshare(-1)	-0.02 (1.22)	ΔHTEshare(-1)	0.02 (0.76)
C(2)	ΔHTEshare(-2)	0.02 (0.75)	ΔHTEshare(-2)	0.02 (0.78)
C(3)	Δlog(SApc(-1))	0.93 (1.02)	Δ(log(SApc(-1)))	0.91 (1.05)
C(4)	Δlog(SApc(-2))	0.92 (1.05)	Δ(log(SApc(-2)))	0.89 (1.05)
C(5)	Δlog(PATpc(-1))	-0.04 (-1.62)	Δ(log(GDPpc(-1)))	-3.94* (-1.86)
C(6)	Δlog(PATpc(-2))	0.02 (0.64)	Δ(log(GDPpc(-1)))	1.92 (0.94)
C(7)	Δ(log(GDPpc(-1)))	-3.84* (-1.77)		
C(8)	Δ(log(GDPpc(-2)))	1.65 (0.79)		
C(9)	ECT(-1)	-0.015*** (-4.2)	ECT(-1)	-0.01*** (-4.04)
	Constant	0.09 (0.63)	Constant	0.08 (0.56)
	Wald test: C(3)=C(4)=0	1.98	Wald test: C(3)=C(4)=0	2.04
	Wald test: C(5)=C(6)=0	2.64	Wald test: C(5)=C(6)=0	3.64
	R^2	0.03	R^2	0.02
	Number of observations	988	Number of observations	1,001

Notes: */**/*** means significance at the 10%/ 5%/ 1% levels. (-1) / (-2) means the variable is lagged by one/two years.

Based on the results of Wald test, both variables capturing scientific articles and patenting are not significant. Regression coefficients by both lagged variables are jointly not statistically significant. Hence, we can say that there is no evident short-run effect of the independent variables on the dependent variable. Most of the variables are insignificant and the coefficient of determination is very low. However, the coefficients of the error correction term are significantly negative, which is fully in line with the assumptions of a long-run stable relationship between variables. The speed of adjustment to the long run equilibrium between each pair of variables is slow but identical in both models.

5 CONCLUSION

The outputs of basic and applied research could have a positive effect on the development of new technologies with further impacts on the economy, particularly in the long run. Several studies confirm that research at universities is an essential part of the innovation process within a country (such as for example Jaffe, 1989). This is true in the linear model of innovation as well as in the triple helix model. Similarly, Herrera, Muñoz-Doyague and Nieto (2010) argue that scientific knowledge provided by public researchers supports both inputs and outputs of the firms' innovation process. However, there is only very little empirical research done on estimating any long-run effects, particularly in a multi-country context.

Our analysis has focused on supplementing our understanding in this area, by primarily focusing on testing the long-run as well as short-run effects arising from academic publications and patents on the share of high technology exports. The results mostly suggest that there are virtually no or only very little short-run effects between these three variables. Despite this, it seems likely that there could be some sort of causality in the Granger sense between scientific articles and high-technology exports. However, the results suggest that there are several significant long-run causalities between the selected variables. The number of patents in the country is positively affected by scientific articles in the long run. This could be interpreted as the demonstration of the long-run relationship between basic research and applied research or innovation. Even more interesting is the potential effect of scientific articles on the technological development of the economy. Taking into account more recent views on innovation rather than the pure linear innovation process, we test not only the effect of scientific articles on patenting but also on high-technology exports. Our results strongly suggest that there is a long-run positive effect of academic scientific activities on technological development. This evidence is somewhat stronger when using group-mean DOLS and FMOLS estimators. These results are in some respect supplement the findings of Nguyen and Pham (2011) and McMillan, Mauri and Casey (2014). Based on our results it seems likely that the positive effect of scientific articles on technological development is robust even when controlling for the number of patents. On the other hand, the similar effect of patenting is considerably less significant and less intensive, especially when controlling for scientific articles.

Thus our results indicate the importance of university research. In this they are consistent with both the NIS and the RIS approach and thus support a policy framework based on these approaches. Furthermore, several policy implications follow from our results. Firstly, there is strong evidence that R&D intensity at universities and other research organisations is a fundamental factor supporting the technological development of the economy in the long-run. Hence, support of basic science even in the less applied form seems to be a good way to enhance the development of new technologies and increase the share of exports with higher added value in the long-run. Secondly despite recent undergoing debates,

the number of good-quality papers appears to capture the impact of basic research on R&D technological impact in the long-run. The positive effect of basic research could in part be distributed into the economy through the patenting path. However, according to our results, it seems likely that there are other ways (such as positive spillovers) as to how basic research facilitates the technological development of an economy. Knowledge from basic research can be transferred to private sector firms through informal contacts, networks and consultancies. In addition it is reasonable to assume that good quality research publications reflect the quality of the academics. In this case their significance may reflect the transfer of knowledge, often tacit knowledge, though face to face interactions (Asheim and Gertler, 2005) and consultancies. It may also reflect the quality of PhD training and the impact that has on private sector performance (Mowery and Sampat, 2004). In this case it is right for RIS and NIS to encourage basic research, as with much public sector research funding in the countries of the EU, and formal attempts to evaluate and reward research as in the REF in the UK.

It is important to note that despite our considerable effort to achieve the most relevant results, our analysis has certain limitations. First, the variables used in the analysis are only proxies for the intensity of science and technological development of the economy. Secondly, we assumed that the effect of R&D intensity is largely localised in the same country. Hence, we do not take into account potential direct effects and spillovers crossing borders. Moreover, the scope of the data has been significantly limited by the data availability. This also limited the number of control variables. Despite the fact that the problem of endogenity has been to a large extent solved by using panel DOLS and FMOLS estimators, more control variables might improve the robustness of our results even more in this respect. Our approach does not allow us to capture differences between countries. Moreover, we are also not able to distinguish between the different research areas or different knowledge producers. The effects of scientific activities in diverse research areas should be of course significantly different. Potential further research can be focused on the examination of differences between research areas and different knowledge producers. Furthermore, there is also space for further research focused on examining the knowledge transfer from academia to business in more detail. More research needs to be done to allow us greater insight into the mechanisms by which university based research impacts on the economy.

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APPENDIX

The results of panel unit root tests

	Null Hypothesis: non-stationarity				
	LLC test	**Breitung**	**IPS test**	**ADF test**	**PP test**
SciArticles_on_pop - intercept	2.9		5.52	106.2	145.5
SciArticles_on_pop - intercept & trend	-1.6	6.1	0.4	159.1**	170.9***
ΔSciArticles_on_pop - intercept	-18.4***	-18.9***	-17.7***	602.1***	800.4***
ΔSciArticles_on_pop - intercept & trend	-18.3***	-4.3***	-16.8***	501.9***	743.2***
HighTech export - intercept & trend	-5.1***	4.8	-1.4	157.1**	108.12
ΔHighTech export - intercept & trend	-17.9***	-11.4***	-15.4***	438.2***	616.2***
Patents_on_pop - intercept	-2.9		-0.1***	237.7*	338.81*
Patents_on_pop - intercept & trend	0.5	6.03	-3.6***	226.4***	252.8***
ΔPatents_on_pop - intercept	-20.9***		-21.3***	786.0***	1863.2***
ΔPatents_on_pop - intercept & trend	-35.2***	-4.7***	-21.9***	517.4***	767.0***
GDP per capita - intercept & trend	-0.3	6.0	1.9	109.9	70.6
ΔGDP per capita - intercept & trend	-13.7***	3.9***	-10.3***	338.4***	391.3***
FDI net inflow - intercept	-8.5***		-11.3***	351.9***	335.8***
FDI net inflow - intercept & trend	-8.5***	7.1***	-8.7***	277.9***	298.0***

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University-Industry Links in Slovakia: What are the Factors Underlying the Number of Interactions with Industry?

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ABSTRACT

Purpose: The main aim of the paper is to investigate the determinants of university-industry links, considering the number of contracts with industry as an output variable. Also, the spatial dimension of contracts is examined, explaining to what extent U-I cooperation is anchored regionally or nationally.

Methodology/Approach: The paper uses a unique dataset comprising 1,158 contracts with industry at the 25 faculties belonging to five technical universities in Slovakia. Negative binomial regression analysis is used to evaluate the determinants for academic engagement in contract research.

Findings: Empirical findings reveal the impact of the factors such as age, personnel structure, the intensity of supervising and experience in research projects financed by public authorities, mattering more than patenting or teaching intensity in the propensity of researchers to engage with industry.

Research Limitation/implication: The outcomes only concern technical universities in Slovakia, and there is still room for analysis of other faculties comprising other subject areas. Since there is no longer time series data, the 2014-2016 timeframe did not permit to explore additional contexts in the model.

Originality/Value of paper: Foremost, this is the first attempt to investigate the relationship between different factors and the level of contract research in Slovakia, making several contributions to the existing literature.

Category: Research paper

Keywords: university's third mission; contract research; technology transfer; university-industry links

1 INTRODUCTION

Universities have traditionally been perceived as elite institutions, places of teaching and learning rooted in quality research. In the early 19th century, the Humboldtian model of higher education emerged and was introduced in Europe, combining and integrating research and education and developing knowledge of general nature and ideas of cultural knowledge. Over the years, the new tendencies in terms of focus on knowledge for the sake of solving the compelling problems of society appeared (Audretsch, 2014), and universities have widened their activities beyond teaching and academic research. Thus, many universities have taken action by developing a third mission (entrepreneurship and technology transfer) in order to initiate the process of shifting from the ivory tower atmosphere towards the philosophy of academic capitalism (Novotny, 2008). The roots of entrepreneurial university concept trace back to the late 19th century when the lack of a formal research funding system in the U.S. placed a premium on individual and collective initiatives for obtaining resources to support original research (Etzkowitz and Leyedesdorff, 2000). The cut-off resources from the government together with increasing competition for research funds and skilled students have put universities under pressure to reconsider the way they function and activities portfolio (Hudec, 2017). Universities have extended their role as core actors within regional innovation ecosystems and have established new and diverse opportunities for effective knowledge transfer. Predominantly the pull model has slowly replaced a closed system characterised by the presence of push model of innovation and universities have started to foster links with industry to facilitate technology transfers (Perkmann et al., 2013). Within triple helix system (University-Industry-Government), universities act as a generator of knowledge and also a conduit between government and industry (D'Este and Patel, 2007). More recently user-driven innovation models have emerged adding a fourth stakeholder group to the triple helix model, namely end-users. Universities have recognised the need to strengthen their collaboration and cooperation between quadruple helix stakeholders (Carayannis et al., 1998). Accordingly, specialised infrastructure consisting of technology transfer offices (TTOs), science parks and incubators have been established at universities to serve as an interface between the diverse stakeholders as well as to accomplish a third entrepreneurial mission (Ramaciotti and Rizzo, 2014).

Undoubtedly, there is potential at universities to generate innovations, provide expertise to industrial companies, develop new technologies and products and deliver them to the business sector (Capaldo et al., 2016; Hunady, Orviska and Pisar, 2018). Various channels exist through which academic knowledge and technology are transferred to industry. Recently, there has been burgeoning empirical literature dealing with the more easily measurable university-industry (U-I) interactions such as patenting, licensing and generation of spin-off companies (Shane, 2004; Phan and Siegel, 2006; Rothaermel, Agung and Jiang, 2007). Besides the one-way commercialisation of academic research, there are

other knowledge exchange channels. This paper focuses on one of the channels, namely contract research, which is defined as a paid-for service performed by university researchers for external clients (Perkmann and Walsh, 2007). In comparison to licensing, which does not necessarily require close relationships between university researchers and industry users, links based on contract research require greater relational involvement. Research contracts are also highlighted as a mean for co-creational knowledge transfer between universities, industry, government and end-users within open innovation quadruple helix ecosystem (McAdam et al., 2012). Despite its evident importance, only a few studies about industrial contract research are available (Spithoven, 2016). Contract research has largely been unobserved (D'Este and Patel, 2007) as much of the literature on U-I links have paid more attention to patenting and spin-off activities. However, a number of authors have confirmed contract research more relevant channel than licensing (Cohen, Nelson and Walsh, 2002; Roessner, 1993; Schartinger et al., 2002). Therefore, the purpose of this paper is to address these gaps by exploring the drivers of this type of U-I link, utilising a unique dataset comprising more than 1,158 research contracts in the 25 faculties belonging to the 5 different technical universities in Slovakia.

In this study, the five technical universities in Slovakia were chosen as an empirical case as they do more applied research what is also reflected in the higher amounts of research contracts. For instance, biotechnology academic knowledge generally seems to be transferred to industry through university spin-offs. However, contract research is more frequent in engineering disciplines (Meyer-Krahmer and Schmoch, 1998; Schartinger et al., 2002). Technical universities were used to have close links with local firms, and there have always been researchers involved in U-I contract research, as a one-shot or a repeating activity (Perkman et al., 2013). Additionally, Slovakia is a compelling case of a post-communist Central and Eastern European countries (CEE) where higher education institutions have experienced decades of central planning and political control, emphasis on technology fields and isolation from Western countries. Due to massive industrialisation, high centrally given student quota rates in engineering studies were applied to match the centrally planned requests of state-owned enterprises. Moreover, the primary focus of universities in Central Europe, especially in the 1990s, has been on the teaching mission (Kwiek, 2012), to some extent based on Humboldt's style (Audretsch, 2014). The HEIs, however, were allowed to perform contract research, which was called secondary economic activity. Privatisation and economic decline affected the volume of contract research negatively, but its older forms have survived to some extent. Today, the position of U-I contract research is largely influenced by to the adoption of new roles in science and research - in particular, the budget for public universities has become more dependent on the academic research performance. Also, less emphasis on contract research might be related to third university role, i.e. promoting commercialization of own research rather than responding to business sector requirements. At last, a new factor affecting contract research after entering the European Union appeared, namely

accessibility of public and European funds. The efforts to promote entrepreneurial attitudes at universities in Europe are at odds with the institutional history of central planning and control (Franzoni and Lissoni, 2009). Hence, it would be interesting to find out to what extent university's direction from education towards its new roles and a more innovative orientation has changed. In our study, the determinants of creating U-I partnerships are investigated in terms of the number of contracts and the income they generate at faculties. In addition, the spatial dimension of contracts is examined, explaining to what extent U-I cooperation is anchored regionally or nationally.

This paper is organised as follows. In Section 1, we review the literature on university-industry knowledge transfer channels as well as on the factors affecting the formation of contract research with industry. Section 2 introduces the data and methodology used in this paper. Section 3 and 4 present the main empirical results. In the last Section 5 the main findings are interpreted and discussed and recommendations for future research are proposed.

2 UNIVERSITY-INDUSTRY COLLABORATION

U-I collaborations and their impact on innovation processes have been a long-standing object of analysis in numerous studies (Cohen, Nelson and Walsh, 2002; Schartinger et al., 2002; Perkmann and Walsh, 2007). Generally, knowledge interactions can be studied from both sides; from the view of the firm and the view of the university. The knowledge flow from universities to industry has traditional forms such as the hiring of recent graduates, conferences, publications and services; personal training, information exchange, consultancy, temporary exchange of staff (Dutrénit and Arza, 2010). The commercial channel transfers of intellectual property include patenting, licensing and commercialisation, and university spin-outs (Cohen, Nelson and Walsh, 2002). In comparison, the bi-directional academic engagement model is defined as a knowledge-related collaboration of academic researchers with non-academic companies, where universities, industries are co-creators of research (Sengupta and Ray, 2017). Bi-directional U-I relationships comprise activities such as collaborative research, contract research, knowledge networks and scientific-technological parks, etc. (Capaldo et al., 2016). From a private-sector perspective, the benefits of collaborating with academia have been found to be unambiguously positive (Hottenrott and Thorwarth, 2011). Industry can benefit from the access to new knowledge, complementary know-how and cutting-edge technology, access to research facilities, risk reduction or sharing, or shortening the product life cycle (Ankrah and Al-Tabbaa, 2015). Equally, universities may benefit from the complementary funding to already existing public financing, initiation of new ideas, hiring additional researchers, investment in lab equipment, employment of new knowledge into the learning process, commercialisation of their intellectual property as well as internships and placement opportunities for students (Lee, 2000). The interaction between any segment of the higher education system and

industry targets knowledge and technology exchange in many channels - joint research, contract research, informal contacts, mobility or training (Meyer-Krahmer and Schmoch, 1998; Schartinger et al., 2002). The bilateral approach to U-I co-operation has since been broadened as "multi-way" to accentuate the role of actors such as governmental agencies (Meyer-Krahmer and Schmoch, 1998). This has a close connection to innovation networks and the theories of innovative systems (Furman, Porter and Stern, 2002; Schiuma and Lerro, 2008). Institutional factors, potential capabilities of a spatial system to convert knowledge into innovation can be expressed in the framework of national (NIS) or regional (RIS) innovation system theory (Hudec, 2015; Prokop, Stejskal and Kuvíková, 2017). In the centrally planned economy, there was a national science and technology system in operation instead. Transition to a market economy should gradually lead to the decentralisation and strengthening of regional innovation systems considered to be more effective for innovation performance due to the exchange of tacit knowledge. That is why, in the example of contract research, we are looking at the degree of regional cooperation. Collaborative or joint research refers to formal collaboration arrangements among organisations aimed at co-operating on R&D activities. In Europe, these projects are often subsidised by public funding. e.g. the framework programmes of the European Commission (Capaldo et al., 2016). By contrast, also unlike in collaborative research, contract research is more one-way in the sense that company unilaterally specifies requirements, type of expertise or service and the researchers carry out the assignment against payment. This type of research has low entry costs and requires low levels of absorption capacity.

1.1 Factors Influencing the Formation of Contract Research

Despite the increasing attention devoted to the determinants of U-I linkages, there is still little consensus as to what explains the formation of such linkages (Giuliani et al., 2010). U-I creation has been emphasized as a multi-level phenomenon, determined by both the characteristics of individuals as well as the organisational and institutional context in which they work (Perkmann et al., 2013). This study is aimed at the faculties and the importance of two groups of factors on the propensity of their engagement in contract research with industry – *organisational* (academic quality, reputation, teaching intensity) and *institutional* (the environment in which the research is undertaken).

Organisational Context

The most salient organisational determinant for academic engagement is the academic quality. Based on the assumption that the older the faculty, the higher its prestige and the higher its impact on the number of contracts with industry (Sengupta and Ray, 2017), we control for the faculty *age* (F_AGE). As the size of the faculty may strongly affect the volume of industry interactions (D'Este and Patel, 2007), each independent variable is divided by the *number of academic staff* (professors, associate professors, and assistants who have full-time tenured or tenure-track appointments) (STAFF). A high share of senior researchers (the

personnel structure, measured as researchers with the title of Professor) indicates more experienced researcher capacity and a higher probability of engaging with industry (D'Este and Patel, 2007; Schartinger, Schibany and Gassler, 2001). Firms are likely to feel more confident about advice obtained from tenured *professors* (Giuliani et al., 2010). The independent variable (PROF/NON_PROF) is measured as the ratio of the number of professors to the number of other researchers (associate professors and assistants). *Faculty reputation* is related to the quantity and quality of its publications. There may be a trade-off between publications and U-I linkages. Researchers receiving more funding from industry and occupied with reports have less time capacity to academic research (Jensen and Thursby, 2001). Faculties with a high publication record exhibit a strong commitment in terms of time and orientation at the expense of knowledge transfer outwith the academic community. On the other hand, high output of publications is a sign of expertise and firms may prefer to interact with academics with established scientific reputations rather than with researchers who are less well known scientifically. The independent variable (SWC/STAFF) is measured as the number of journal articles indexed in the databases Scopus, Current Contents and Thomson Routers to the number of faculty staff. *The reputation of the faculty* can also be measured by the rating (D'Este and Patel, 2007). The rating scores of Slovak university faculties can be gathered from The Academic Ranking and Rating Agency (ARRA), and the ranking is based on publicly available and verifiable data about scientific activities, faculty, student numbers, student application numbers, grants and doctoral studies. As the last rank was available for the year 2014 we used the data from this year (ARRA, 2014). Perhaps results can be intriguing, but several authors confirmed the correlation between lower rating and the corresponding higher probability of researcher's involvement in a wider variety of interactions (D'Este and Patel, 2007). If firms need to interact with researchers willing to focus on their immediate problems by helping them to apply new knowledge, less prestigious faculties may have a comparative advantage (Mansfield and Lee, 1996). Experience in *externally funded* research projects shows expertise in the competitive acquisition of external funds (Schartinger, Schibany and Gassler, 2001). The number of research projects financed by public authorities (PUBLIC/STAFF) or financed by the EU or another foreign grant scheme per faculty's staff (FOREIGN/STAFF) might be related to the interactions of a faculty to the business sector. The *high intensity of teaching* students and supervising PhD students can detract resources from the other activities including contract research. We assume a negative relationship between a faculty teaching intensity (BM/STAFF) and establishing interactions with private firms. The independent variable (PHD/PROF) is measured as the number of PhD students to professors and the independent variable (BM/STAFF) is measured as the number of Bachelor and Master students to academic staff.

Institutional Context

The institutional approach attempts to explain the formation of linkages through the context in which they are embedded – the culture and environment in which the research is undertaken (Owen-Smith et al., 2002). Academic systems faced with budgetary difficulties will be more open to commercial collaborations with companies. Universities/faculties can be expected to interact differently with industry depending on their mission (Etzkowitz and Leyedesdorff, 2000). In the study, we control for the *regional context* by including the gross domestic expenditure on R&D (GERD PER CAPITA). Districts with a lower gross domestic expenditure on R&D may have fewer high-tech companies willing to finance contract research. Thus, we can expect a negative relationship between the GERD and the amount of contract research. Another aspect of the institutional context is the affiliation to a scientific discipline. *Disciplinary affiliation* is an important variable explaining engagement with industry (Martinelli, Meyer and Von Tunzelmann, 2008). Typically, less industrial interaction is among social disciplines, and U-I collaboration prevails in natural and technical sciences (Schartinger et al., 2002). The independent categorical variable (TYPE_FAC) indicates the type of faculty and takes the value 0 for an agricultural faculty, 1 if it is an economic faculty, and 2 for a technical faculty.

3 DATA AND METHODOLOGY

The study is based on a unique dataset that has been created from different data sources. The core data has been gathered from the database "The domestic and foreign grant allocation to universities" provided by the Ministry of Education, Science, Research and Sport of the Slovak Republic. The database includes basic information about the different types of research activities: domestic and foreign contract research (private entities), research grants financed by foreign grant schemes (e.g. European Commission, HORIZON 2020, Visegrad Fund etc.) and research grants financed by public grant schemes (APVV, VEGA). The data lacked information about the addresses of the firms involved in contract research, so a manual search through the public Business Register of the Slovak Republic (orsr.sk) was needed to complete missing data. The additional information regarding the number of publications and patents comes from the Central Registry of Publications Activity (crepc.sk) and information on the number of academic staff comes from the statistical yearbook provided by the Slovak Centre of Scientific and Technical Information (cvtisr.sk). Due to changes in the reporting rules, comparable information is available for the years 2014-2016. The analysis is limited to five public technical universities in Slovakia (Technical University in Košice – TUKE, Slovak Technical University in Bratislava – STUBA, Technical University in Zvolen – TUZVO, University of Žilina – UNIZA, Slovak Agriculture University in Nitra – SPU) and their faculties. The final sample includes 23 faculties and comprising more than 1,158 research contracts in total. The empirical analysis is based on an econometric

model where the dependent variable is the average number of contracts with industry generated by each faculty between the years 2014 and 2016.

As the dependent variable (measured as the average number of contracts with industry generated by each faculty between the years 2014 and 2016) is overdispersed and contains non-zero numbers, negative binomial regression is preferred to zero-inflated Poisson regression. The estimator based on this approach can also be used for non-integer data (Santos Silva and Tenreyro, 2006). The Voung test confirms the choice. In order to address the issue of heteroscedasticity, the Huber/White estimator method was used to produce robust standard errors (White, 1982). Finally, we also tested model for multicollinearity by calculating the variance inflation factors (VIFs) for the exogenous variables. The mean VIF in the model does not exceed 10 which indicates that multicollinearity is not a concern (O'Brien, 2007).

4 PERFORMANCE AND SPATIAL DISTRIBUTION OF CONTRACT RESEARCH

Tab. 1 depicts the development of the different sources of funding for the selected universities in the period 2014-2016. Compared to the year 2014 (61%), the universities' share of income from public grants has decreased in 2016 (58%), while the total share of income generated from industry grants has increased in 2016 (24%) compared to the year 2014 (20%). There is no surprising volatility in the percentage of income from industry grants; a long time series is unfortunately not available. However, UNIZA's unique position in the volume of U-I industry links is strong. UNIZA and SPU have been able to increase their total income from industry from 2014 to 2016. Performance in contract research should be positively affected by launching science parks at several universities, financed from the European funds in Slovakia. AgroBioTech Research Centre focusing on applied research in the field of agrobiology, biotechnology and technology in agriculture was opened in Nitra (SPU) in 2015. University of Žilina also established Science and Technology Park in 2015. The other universities were still only preparing to open their science parks. It appears that the opening of science parks may have a positive influence on promoting the cooperation of universities and industry in R&D activities (Ramaciotti and Rizzo, 2014). Another factor explaining the performance of UNIZA is the external environment, a highly developed regional innovation system, a dense network of R&D organizations that play a central role in diffusing knowledge to a large number of firms (Čorej, 2006; Hudec and Procházková, 2018). Moreover, the Žilina region has recorded the second highest average R&D expenditure per capita (132 EUR) between the years 2014 and 2016 (compared to 96.5 EUR in the Košice region and 86.8 EUR in the Nitra region).

Table 1 – An Overview of Different Sources of Funding at Universities (Authors' Calculation on Data Provided by the Ministry of Education, Science, Research and Sport of the Slovak Republic)

University	The share of public grants in the total university income in % *(Absolute value in thousand in EUR)*			The share of foreign grants in the total university income in % *(Absolute value in thousand in EUR)*			The share of industry grants in the total university income in % *(Absolute value in thousand in EUR)*		
	2014	2015	2016	2014	2015	2016	2014	2015	2016
SPU	82.0 *(500)*	86.7	32.9 *(500)*	11.3 *(64)*	13.3	0.8 *(11)*	6.8 *(38)*	NA	66.3 *(900)*
STUBA	70.5 *(5,000)*	79.8	65.4 *(4,800)*	12.7 *(900)*	9.6	20 *(1,400)*	16.8 *(1,200)*	10.6	14.6 *(1,000)*
TUZVO	88.7 *(500)*	87.8	86.9 *(600)*	9.7 *(58)*	6.9	12.2 *(89)*	1.5 *(9)*	5.4	1.0 *(6)*
TUKE	49.9 *(1,700)*	55.9	61.8 *(2,000)*	23.1 *(800)*	25.2	22.5 *(700)*	27 *(900)*	18.8	15.7 *(500)*
UNIZA	44.2 *(1,400)*	49.1	45.9 *(1,700)*	29.4 *(900)*	9.5	15.0 *(600)*	26.4 *(800)*	41.3	39.1 *(1,500)*
TOTAL	61 *(9,100)*	70.0	58 *(9,700)*	18 *(2,700)*	13.0	17.0 *(2,900)*	20 *(3,000)*	17.0	24.0 *(4,000)*

Notes: Slovak Agriculture University in Nitra (SPU); Slovak Technical University in Bratislava (STUBA); Technical University in Zvolen (TUZVO); Technical University in Košice (TUKE); University of Žilina (UNIZA).

Not surprisingly, universities have most of the linkages at the intra- and inter-regional level (Tab. 2). Moreover, the highest share of contract research income is not in the region of their seat, confirming still undeveloped regional innovations systems. Again, UNIZA might be a role model for other universities, having the highest share of income from the international industry (48%). Together with STUBA, they show a right balance between an inward and outward orientation towards cooperation. It seems that the universities do not pay attention towards a capacity building partnerships with regional firms and vice versa. However, further investigation would be needed to shed light on this matter.

Table 2 – An Overview of Different Universities' Sources from Industry (Authors' Calculation on Data Provided by the Ministry of Education, Science, Research and Sport of the Slovak Republic)

University	The share of inter-regional industry income in the total university income from industry in % *(Absolute value in thousand in EUR)*			The share of intra-regional industry income in the total university income from industry in % *(Absolute value in thousand in EUR)*			The share of international industry income in the total university income from industry in % *(Absolute value in thousand in EUR)*		
	2014	2015	2016	2014	2015	2016	2014	2015	2016
SPU	21.1 *(8)*	NA	99.3 *(900)*	40.3 *(15)*	NA	0.8 *(7)*	38.6 *(14)*	NA	NA
STUBA	41.2 *(5,000)*	51.5	41.9 *(500)*	43.2 *(500)*	39.5	20 *(400)*	15.6 *(200)*	9.0	17.2 *(200)*
TUZVO	70.1 *(500)*	99.6	100 *(7)*	29.9 *(2)*	0.4	NA	NA	NA	NA
TUKE	26.6 *(1,700)*	23.9	51.1 *(300)*	73.3 *(700)*	70.5	22.5 *(700)*	0.1 *(1)*	5.7	21.9 *(100)*
UNIZA	56.9 *(1,400)*	51.1	40.9 *(600)*	3.6 *(29)*	18.3	15.0 *(600)*	39.5 *(300)*	30.6	48.5 *(700)*
TOTAL	41.0 *(1,300)*	46.0	56 *(2,300)*	41.0 *(1,200)*	36.0	19.0 *(700)*	17.9 *(500)*	17.8	25.0 *(1,000)*

5 ECONOMETRIC ANALYSIS AND RESULTS

Tab. 3 reports the model results described in Section 2. The findings support hypothesis that the age of the faculty is a determinant of the number of contracts with industry. Brand recognition and the long-term experience gives employees the specific knowledge to carry out industry tasks more efficiently and thus leading to a higher number of contracts with industry.

Table 3 – The Estimation of the Determinants of Contract Research

Organisational Context	
F_AGE	0.059*** (0.009)
PROF/NON_PROF	3.594** (1.497)
SWC/STAFF	1.310** (1.911)
PUBLIC/STAFF	0.168*** (0.032)
FOREIGN/STAFF	-0.0002 (0.0001)
BM/STAFF	-1.707* (0.087)
PHD/PROF	0.204** (0.038)
ARRA	-0.064** (0.021)
PAT/STAFF	-0.021 (1.534)
Institutional Context	
GERD PER CAPITA	0.205** (0.053)
TYPE_FAC_ECONOM	-0.597 (0.969)
TYPE_FAC_TECHNIC	1.565* (0.789)
Pseudo R^2	0.6274

*Notes: Robust standard errors in parenthesis. Coefficients marked with ***, ** and * are significant at 0.001, 0.01 and 0.05 level respectively. Agricultural is the reference category.*

Public spending on research is positively and significantly related to the amount of contracts with industry. Both public and private expenditure on research are comparably lower in Slovakia than the EU average. An increase in public research expenditure aimed at promoting partnerships between universities and industry could have a positive impact on the formation of further research collaboration with industry and generating positive spatial spillovers. Besides, *a faculty's experience* in international research projects financed by the EU or similar foreign grant schemes is not shown significant. Despite it, the relationship appears to be negative. The ability of a department to gain research grants from the EU is based on a fiercely peer-reviewed competitive basis. Successful faculties are taken as having high research capabilities and thus external funding substitutes public funding and private funding from industry including contract research. Alternatively, due to the high concentration on global research, necessary human capacity for contract research is not at disposal. But higher publication performance is shown to impact the propensity of forming a contract with industry, faculties conducting a high quality of research are attractive to private firms. Research universities, their knowledge and technological problem-solving capacities are trusted by industry. An interesting point is a negative relationship of the faculty *reputation* measured by the multidimensional rating score ARRA and the engagement with industry. Less prestigious faculties appear

to be more open to satisfying firms' demands and more willing to solve specific problems. There is no significant effect of the patenting intensity. In engineering science, *patenting* is less attractive due to the lower monetary pay-offs. Therefore, academics are primarily pursued to develop relationships with firms or exploit other research-related opportunities. However, the relationship of patenting and contract research might be different in some other disciplines, patents have higher monetary value e.g. in life sciences. Further, the results confirm that a high *intensity of teaching* is negatively related to the propensity to establish research contracts with industry (Schartinger et al., 2002). On the contrary, a positive relationship was confirmed between a high overall number of PhD students to professors and the number of contracts with industry. This confirms that if there is a predominance of learning in the portfolio of academic activities, there is a lack of human and time capabilities, but also sufficient experience for contract research. This shows also the great importance of PhD. students in exchange of knowledge between the academy and firms. Faculty personnel structure also exhibits a positive relationship with the number of contracts with industry. The result is consistent with the career life cycle argument that individuals who are well-established in their academic careers will be more likely to capitalise on their reputation to increase their engagement in U-I activities (D'Este and Patel, 2007).

6 CONCLUSION

The principal focus of this paper is to identify the determinants influencing the amount of contracts with industry, filling the gap in the literature on the factors of U-I links. There is a growth from 20% to 24% in the Slovak universities' share of income from industry partners in 2016 compared to the year 2014. However, in 2015 the share has declined to 17%. Still, the dominant position of income from public grants persists. The regional knowledge-producing systems are still not fully developed and open in Slovakia; faculties have a higher share of contracts with firms at the inter-regional level compared to the intra-regional level. There are only two universities, namely STUBA and UNIZA, overcoming national closure having a higher share of income generated from foreign industry partners. International collaboration enables universities to acquire complementary and diversified knowledge and thus, to support their knowledge productivity. Future research could examine origins of these bilateral linkages and formation of international networks. The results of the econometric model explain the amount of contracts with industry partners. U-I contract research performance is positively associated with a scientific productivity as expressed by the number of publications, acquired public research funding and the number of PhD students. Academic research forwardness together with the age factor contribute to a higher reputation and attractiveness for industry. Interestingly, the faculties that have public research grants interact with industry to a higher degree than those more funded form international funds. This is related to the capacity limit of university resources. Universities and their faculties take the strategic

decisions on the acquisition of different types of resources (research, education, domestic grants, international grants, commercialisation of research, industry contracts, etc.) which should be reflected in the definition of their mission and portfolio of their activities. Public funding to universities thus substitutes a potential funding from industry contracts, representing a more stable and easier obtainable resource. Moreover, in Slovakia the government has not shifted the direction of budgetary funding towards more applied research exploitable by industry, still rather financing fundamental research and evaluating academic publications. Thus, universities have not been directly stimulated to set in their entrepreneurship mission and also the contract research is outside the scope of the government. Policies encouraging knowledge transfer activities should take a better account to integrate the third university's mission with the priorities of teaching, research and producing publications. However, government policies still consider third mission as complementary in nature. Due to the lack of longitudinal data, we could not control for reverse causality between the publishing intensity and the number of contracts. It is questionable whether faculty scientific productivity is enhanced by its engagement with industry or vice versa, industry engagement is impacted by high research performance. The limitations in terms of inferring causal relationships between variables could be solved by using panel data on academic patents and publications to take into account the time dimension.

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Evolution of University Third Mission Activities in Slovakia: What Role for a Public Policy?

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ABSTRACT

Purpose: Universities are an important component of regional innovation systems. There have been a number of studies during recent years in developed countries which analysed activities of universities aiming to increase their contribution in regional innovation. The aim of this article is to explore the evolution of third mission activities of universities in Slovakia and explore the role of public policy in this process.

Methodology/Approach: We used a document analysis of annual reports of all public universities in Slovakia to see which third mission activities universities claim to perform and how the situation has changed over the years. We also compared universities according to their focus and location. Several personal and telephone interviews were conducted to verify or supplement the information.

Findings: We found that among all third mission activities, the greatest change was observed in research and cooperation activities with businesses. This mainly resulted from a change in government policy but mostly due to very strong support from EU structural funds.

Research Limitation/implication: The study is based on annual reports of universities which do not necessarily cover all activities that universities actually perform.

Originality/Value of paper: The paper provides the first complete overview of the third mission activities performed by universities in Slovakia with a focus on their development over time. Also, it identifies the role which governmental policy plays in these processes.

Category: Research paper

Keywords: universities; research; innovations; Slovak Republic; third mission of universities

1 INTRODUCTION

The increasing dependence of advanced economies on the use of new knowledge and new technologies has changed the requirements for higher education. As a result, universities introduced a set of new activities which supplement traditional educational and research missions of universities with more active participation in socio-economic development (Molas-Gallart et al., 2002; Boucher, Conway and Van der Meer, 2003; Laredo, 2007; Caniëls and Van den Bosch, 2011; Trippl, Sinozic and Lawton Smith, 2015; Kroll, Dornbusch and Schnabl, 2016). This movement is generally known as the third mission of universities.

In this paper, we focus mainly on the third mission activities aiming to increase regional innovation capabilities. While there is relatively extensive research on the third mission activities in developed countries, research in post-socialist countries is rather limited. Experience from post-socialist countries offer a great opportunity to study the role of framework conditions for university third mission activities. Rather dynamic changes in countries' economies in a relatively short time accompanied with dramatic institutional changes resulted in paradigmatic transformation of the mission of universities in these countries. This allows to investigate the evolution of such activities and the role of public policy in this process.

Slovakia belongs to a group of countries with a high level of economic growth but low innovation performance. After joining the EU under the influence of cohesion policy, Slovakia has put a greater emphasis on investing in education and research infrastructure and in building mechanisms to increase efficiency of knowledge transfer from universities. The aim of this article is to explore the development of the third mission activities of universities in Slovakia in the context of changing public policies. The authors assume that the changing economic and institutional environment in Slovakia has resulted in more targeted, formalized and institutionalized activities of universities.

The authors would like to answer two questions: Which universities' activities have begun to be implemented as their third mission research activities? How did the higher education policy affect implementation of such universities' activities? Current research in post-socialist countries has focused mainly on the analysis of the framework conditions in the field of higher education and less on the activities of universities themselves. Compared to similar studies that have the nature of cross-sectional studies, this article also looks at the time dimension of this process. This allowed the authors to evaluate the extent to which universities have begun to implement their activities, and to evaluate the influence of policy measures on these activities.

2 THE ROLE OF UNIVERSITIES IN REGIONAL DEVELOPMENT AND CLASSIFICATION OF THEIR ACTIVITIES

Trippl, Sinozic and Lawton Smith (2015) identify four theoretical concepts which provide a framework for analysing the third mission activities and their contribution to economic and social development, namely the Entrepreneurial University model (Etzkowiz et al., 2000), the Regional Innovation Systems (RIS) model (Braczyk, Cooke and Heidenreich, 1998), the Mode 2 model and the Engaged University model (Uyarra, 2010; Breznic and Feldman, 2012). What these concepts have in common is that they emphasize the importance of active and targeted diffusion of the knowledge of universities among other actors. Several authors attempted to identify and classify these activities (Molas-Gallart et al., 2002; Boucher, Conway and Van der Meer, 2003; Laredo, 2007; European Commission, 2011; Caniël and Van den Bosch, 2011; Kroll, Dornbusch and Schnabl, 2016). Authors divide them into three broad areas - education, research and community development (e.g. Caniëls and Van den Bosch, 2011). A substantial part of empirical research is mainly concerned with activities related to university research as these are expected to have a major impact on long-run economic development (Gunasekara, 2006; Vallance et al., 2017). These activities aim at increasing research collaboration between universities and firms (e.g. contract research, innovation vouchers), activities that support innovative entrepreneurship (e.g. technology incubators, spin-off and start-up support) and finally, commercialisation of intellectual property and equipment (e.g. licensing office).

The most comprehensive study of universities in 14 regions across seven EU countries by Boucher, Conway and Van der Meer (2003) found that the activities of universities might vary depending on the type of the host region (economic structure, location) and the university type (focus, size, age). Most active universities tend to be single and relatively large scale universities located in peripheral regions (Boucher, Conway and Van der Meer, 2003). In these regions, universities are unique partners for local actors, so their engagement level is higher. However, Gunasekara (2006) pointed out that their ability to respond to external needs is overestimated. On the other hand, traditional universities in metropolitan regions have significant engagement mostly at an international level. Kroll, Dornbusch and Schnabl (2016) noticed that university activities in developed regions are mainly driven by regional opportunities, while in the lagging regions rather by political order.

Engagement of universities is significantly determined by individual decisions of academics. Research in Germany on a sample of 1,500 academics (Kroll, Dornbusch and Schnabl, 2016) confirmed that choices to engage are strongly contingent on intrinsic motivations. Goldstein, Bergman and Maier (2013) compared the attitudes of academics in the US and the EU and also confirmed that individual factors explain the greatest differences in attitudes towards university activities in the field of research commercialisation and regional

development. Both studies, however, also pointed out that framework conditions play a significant role.

Differences in university activities between individual countries but also between regions within countries are influenced by the overall institutional context (Trippl, Sinozic and Lawton Smith, 2015). In their paper, (Trippl, Sinozic and Lawton Smith, 2015) call for more scholarly work in order to understand the effect of a larger set of policies (research policy, education policy, industrial policy etc.) on university activities. Regional involvement rate can be also positively influenced by a higher degree of decentralization of competencies in higher education at the regional level (Boucher, Conway and Van der Meer, 2003). The change in the funding of universities towards multi-source funding as well as the regionalization of policies, result in even greater interconnection with local and regional interests (Chatterton and Goddard, 2000).

Post-socialist countries offer a great opportunity to study the evolution of third mission activities under changing institutional contexts. The process of commercialization of intellectual property may be different and more complicated than in developed countries (Etzkowitz et al., 2000). Universities in post-socialist countries have a different position in innovation systems compared to universities in Western European countries (Rehák and Sokol, 2007; Gál and Páger, 2017). Innovation systems in Central and Eastern Europe have been characterized by higher degree of fragmentation, low levels of cooperation and a lack of intermediary organizations (Rehák and Sokol, 2007; Radosevic, 2002; Serbanica, Constantin and Dragan, 2015; Kwiek, 2012). Empirical research in Czechia (Krčmářová, 2011) showed that the first university activities were mainly focused on establishing offices for communication and knowledge transfer. However, majority of such offices only passively distributed information on research expertise. Research in Hungary (Gál and Páger, 2017), Poland (Kwiek, 2012), Romania (Serbanica, Constantin and Dragan, 2015) and Czechia (Krčmářová, 2011; Žížalová and Čadil, 2012) showed that a lack of incentives for cooperation and missing systemic support are still a typical issue in Central and Eastern Europe. European research and innovation policies played a major role in enhancing research activities and intermediary infrastructure (Ptáček and Sczyrba, 2017); and establishing systematic linkages in the regional innovation system (Vallance et al., 2017).

3 HIGHER EDUCATION SYSTEM IN THE SLOVAK REPUBLIC AND ITS CHANGES

Transformation of higher education in the Slovak Republic started in the early 1990s by granting academic freedoms and autonomy in decision-making. After 2000, public universities have been transformed from state budget organizations to independent public institutions. They acquired their own assets and a multi-source funding system has been introduced (Matlovič and Matlovičová, 2017). Public funding has been gradually transformed from being based primarily on the

number of students to a system taking into account also other activities of universities. For instance, the state provides 50% of university funding based on their research activities. (Pisár and Šipikal, 2017). There has also been expansion of higher education in the regions of the Slovak Republic. This brought a more even distribution of universities across the country and moderated the dominance of the Bratislava region. At the beginning of the 1990s, about a half of university students studied in the Bratislava region. This number dropped to 38% in 2016. As of 2016, there were 35 universities with 129 faculties operating in Slovakia. Of the 35 universities, 20 institutions were public (105 faculties), 12 were private (18 faculties) and 3 were state universities (6 faculties).

In 2015, the share of universities in total Slovak research and development (R&D) expenditure reached 44%, while in 2002 this share was less than 10% (see Fig. 1 for annual development). The massive increase in the share of research and development universities' expenditure was mainly related to Slovakia's entry into the EU in 2004 and the use of cohesion funding. Accession to the EU has brought greater opportunities for universities to raise funds from the EU structural funds in order to improve their technological equipment, renovate buildings and fund research activities, particularly outside of the Bratislava region. The total volume of resources contracted to support research from the EU structural funds in the programming period 2007-2013 for universities was over 860 million EUR, which in some years accounted for more than 20% of the total resources of universities (Pisár and Varga, 2018).

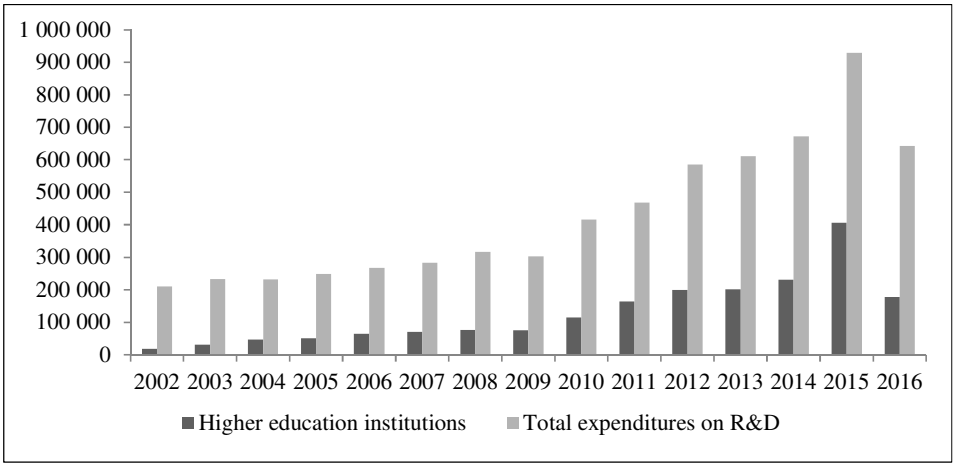

Figure 1 – Expenditure on Research and Development in Slovakia during 2002-2016 (in Thousand EUR in Current Prices)(Own Compilation based on Data from the Statistical Office of the Slovak Republic, DataCube)

In the area of education, the overall amount was much lower at about 92 million EUR (Šipikal, Pisár and Varga, 2015). The main areas of support are summarized in Tab. 1. The new programming period is even more focused on research activities. However, the first activities of universities funded from the

programming period 2014-2020 have only begun to be implemented in 2017, so the annual reports that we evaluate do not capture them.

Table 1 – Overview of Support Measures for Universities from the Structural Funds in the Programming Period 2007-2013 for Research and Development (www.nsrr.sk, all activities were Supported from Operational Programme Research and Development)

Measure	Total funds 2007-2013 in EUR for universities	Specific objective
1.1.	41,006,432.33	Modernisation and improvement of quality of technical infrastructure for research and development in 2007-2013 with a view to increase the ability of research and development institutions to efficiently cooperate with renowned research institutions in the EU and other countries, as well as with entities of the social and economic practice through the transfer of knowledge and technologies.
2.1.	108,385,148.80	Increase the quality of research organisations and support to excellent research activities with emphasis placed on areas of strategic importance for the further development of the economy and the society.
2.2.	291,377,531.90	Increase the level of cooperation of R&D institutions with the society and economy through the transfer of knowledge and technology, thereby facilitating economic growth of the regions and of whole Slovakia.
4.1.	33,756,888.20	Increase the quality of research organisations and support of excellent research activities in the Bratislava region with an emphasis placed on areas of strategic importance for the further development of the economy and the society.
5.1.	97,370,104.63	Improving the quality of education at universities by investing in material infrastructure. The purpose of the measure is investment activities aimed at the reconstruction and expansion of college buildings and/or the modernization of their interior facilities in order to improve the conditions in which the education process takes place in universities, with the priority being to modernize the internal equipment of the universities.

4 METHODOLOGY AND DATA

Universities in the Slovak Republic are of three types: public, state and private. Research of this paper focuses only on 20 public universities. In order to explore the third mission of universities, the authors focused primarily on public universities because they accommodate 90% of all university students and have the obligation to publish annual reports that were the main source of information for this research.

The period for exploring the third mission of universities in Slovakia was 2008-2016. We chose this period for three reasons. Firstly, universities had an opportunity to use EU structural funds for the first time in the programming period 2007-2013, which was subsequently extended to 2015. The first funds started to be used in 2008 (Šipikal and Némethová, 2017b). Secondly, there were substantial changes made in universities' funding, which took place primarily during 2009-2012 and which had a significant effect on their behaviour (Pisár and Šipikal, 2017). Thirdly, the idea of the third mission concept started to be more intensively discussed in the Slovak Republic after 2008 (Hanová et al., 2016).

The aim of our research was to identify how the Slovak universities third mission research activities have changed over time and to analyse what role public policy has played in this process. We also looked at whether different types of universities responded to these policies differently. We consider a third mission research activity as a concrete and implemented activity mentioned in an annual report of a university that concerned the relevant area under review.

The paper compared universities according to their focus (technical and non-technical) and location (universities in the Bratislava region and other Slovak regions). Based on the literature review, in case of technical universities, we assumed that there would be a stronger commitment to research and entrepreneurial activities than in non-technical universities in the field of education and community development. We also assumed that universities located outside of the Bratislava region would have a greater connection to the region's activities. The overview of universities and their structure is shown in Tab. 2.

Table 2 – List and Characteristics of Universities (Own Compilation)

University	**Type**	**Region**	**Number of students (2016)**	**Research grants in EUR (2016)**
Comenius University in Bratislava	Non - technical	Bratislava	23,305	9,885,297
Slovak University of Technology in Bratislava	Technical	Bratislava	11,496	10,171,108
University of Economics in Bratislava	Non - technical	Bratislava	7,453	2.430,188
Academy of Performing Arts in Bratislava	Non - technical	Bratislava	1,016	401,626
Academy of Fine Arts in Bratislava	Non - technical	Bratislava	620	402,693

University	Type	Region	Number of students (2016)	Research grants in EUR (2016)
University of Trnava in Trnava	Non - technical	Trnava	122	1,039,565
University of Constantinus the Philosopher in Nitra	Non - technical	Trnava	8,994	1,742,432
Selye János University in Komárno	Non - technical	Trnava	1,732	805,849
Slovak University of Agriculture in Nitra	Technical	Nitra	8,248	3,697.190
University of St. Cyril and Methodius of Trnava	Non - technical	Nitra	6,174	639,445
Alexander Dubček University of Trenčín in Trenčín	Non - technical	Trenčín	2,700	686,736
Matej Bel University in Banská Bystrica	Non - technical	Banská Bystrica	9,042	1,720,535
Technical University in Zvolen	Technical	Banská Bystrica	3,481	1,572,802
Academy of Arts in Banská Bystrica	Non - technical	Banská Bystrica	545	179,839
University of Žilina in Žilina	Technical	Žilina	8,792	6,289,258
Catholic University in Ružomberok	Non - technical	Žilina	4,107	545,609
University of Prešov in Prešov	Non - technical	Prešov	9,216	1,501,666
Technical University of Košice	Technical	Košice	9,713	4,427,017
Pavol Jozef Šafárik University in Košice	Non - technical	Košice	7,480	3,474,562
University of Veterinary Medicine in Košice	Non - technical	Košice	2,130	847,540

We primarily used document analysis, in particular annual reports of universities. The advantage of this method over others (e.g. interviews) is that the documents were created at a given time and are unchangeable, reflecting the priorities of the institution at the time. In interviews, participants can tailor responses to the current requirements of their activities (Bowen, 2009). The annual reports of individual universities for years 2008 and 2016 which are available on their

websites form the basis of data collection. In three cases, there were no annual reports available for year 2008. Thus, we worked with the documents from 2009. It is the case of Pavol Jozef Šafárik University in Košice, Selye János University in Komárno and University of Constantinus the Philosopher in Nitra. We also conducted several personal and telephone interviews to verify or supplement the information from the annual reports. Stating these activities in annual reports highlighted their strategic importance and their institutional acceptance. Hence, it is possible to distinguish between an important or systematic activity and an activity implemented on a random or personal basis.

The literature review of the paper has already identified that the third mission activities of universities could be analysed in three main dimensions - education, research and community development. The authors focused on research activities, which have changed most dramatically (see Tab. 3). In the field of research, the paper focused mainly on the three key areas of "third mission" defined by Hanová et al. (2016) in their report for the Ministry of Education.

Table 3 – Number of Universities with Third Mission Activities in the Specific Area (Own compilation)

	2008	**2016**
Education domain		
Matching the needs of the regional labour market	11	12
Increasing participation of local inhabitants in education	17	19
Retaining graduates in the region	0	0
Supporting entrepreneurial activity in the region	3	6
Research domain		
Increasing the cooperation between universities and regional companies	10	15
Promoting innovative enterprises in the region	3	7
Commercialization of intellectual property and equipment	0	4
Community development domain		
Increasing civil participation in the region	3	8
Improving facilities for cultural and sports infrastructure in the region	20	20
Demonstration activities	0	2

5 RESULTS

Research activities related to the third mission of universities have not been at the forefront of interest of Slovak universities for a long time. The government policy attempted to change it by an increase of its weight in the system of financing of universities in the Slovak Republic (Šipikal and Némethová, 2017a). The second important moment was the entry of Slovakia into the EU, which gave universities the opportunity to use EU structural funds for these activities. As part of this research, we were first interested in how the activities of universities in this area have changed; and second, what role the government policies have played in these changes.

Cooperation of universities and companies in research existed at the beginning of the observed period, especially in the case of technically oriented universities and universities in the Bratislava region. However, during the observed period, it was not only the increase of research activities that was important, but some improvement has been made also in the creation of systems for the continuous and systematic activities of universities. Based on data collected from interviews, most of collaboration had been based on personal contacts until the EU structural funds were available. Later on, these funds were mainly used to gradually create specialized departments or centres that led to greater interconnection of research with practice. Many of these activities were supported through structural funds, particularly through special measures 2.1 and 4.2 of the OP Research and Development - Transfer of knowledge and technology acquired through research and development into practice with more than 386 million EUR allocated. Within these measures, technical universities obtained more than 60% of all funds (for the entire period 2007-2013) and universities from Bratislava more than 47% of all funds. These results suggest strong abilities to use this measure in these two categories of universities.

Several centres of excellence, science centres or science parks were created at universities with the support of the EU structural funds. There was a specific measure in the Operational Programme Research and Development to support such activities with more than 280 million EUR allocated. For example, Slovak University of Technology in Bratislava "STU Scientific" is responsible for commercialization of research and founding of joint ventures. Other examples can be found at the university science park of the Technical University of Košice – "Technikon"; a joint project of two Košice's universities "Medipark"; the science park of the University of Žilina; the establishment of the Comenius University "Science Park" and many others. Almost all these systematized forms of support have arisen at technically oriented universities or faculties. In the field of social and human sciences, this cooperation was still based primarily on personal contacts of individual researchers. Hence, cooperation is substantially less developed than in technically oriented universities. Also, there was no other similar activity implemented without the EU support.

Table 4 – Number of Universities with Third Mission Activities in Research (Thematic and Regional Perspective) (Own Compilation)

	All universities (20)		Non – technical (15)		Technical (5)		Bratislava (5)		Rest of Slovakia (15)	
	2008	2016	2008	2016	2008	2016	2008	2016	2008	2016
Increasing the cooperation between universities and regional companies										
Joint research projects with regional companies	8	14	5	9	3	5	2	4	6	10
Contracted research	1	3	0	1	1	2	0	0	1	3
Consultancy services	3	3	2	2	1	1	0	1	3	2
Mobility of workers between firms and universities	0	0	0	0	0	0	0	0	0	0
Promoting innovative enterprises in the region										
Support for academic spin off companies	1	6	0	3	1	3	1	2	0	4
Technological incubators	1	3	0	1	1	2	1	2	0	1
Science and technology parks	1	7	1	4	0	3	0	2	1	5
Commercialization of intellectual property and equipment										
Intellectual property licensing	0	0	0	0	0	0	0	2	0	2
Commercial use of facilities	0	2	0	1	0	1	0	1	0	1
Non-academic dissemination	0	1	0	1	0	0	0	1	0	0

Cooperation has also grown due to EU projects. For example, in 2016, a call for joint research projects of enterprises and universities was launched. It attracted 200 applicants with 62 projects supported in a total value of 300 million EUR. This strong demand also points at progressively more active engagement with

business and also shows that there is still room and capacity of universities for more active engagement in this area.

Although research cooperation is much more intense than in the past, the commercial nature of this collaboration, which would have a greater impact on the university and the region, is still largely missing. Most of the cooperation so far has been based on joint projects, mostly supported by EU structural funds. Direct contracted research as an expression of direct business interest in the skills and knowledge of universities is still very scarce and with comparable lower budget. There are also no systems for the commercialization of research. These work only partially in some technically oriented universities. However, only little attention is being paid to them in the annual reports. In 2008, there was no mention of commercialization activities in any annual report of the universities. Intellectual property licensing basically does not exist and probably because of the very low patent activity of universities. However, the situation has also moved forward in this area. Under a project supported by the EU structural funds, a national technology transfer centre has been established, which has signed contracts with seven of the most active universities. They have established university technology transfer centres which are gradually organizing activities in the field of commercialization of research. For example, at the University of Žilina, the Center in 2016 prepared internal guidelines that regulate mechanisms for the management of intellectual property, creating the first premise for systematic work on commercialization of research. The centre also addresses implementation of technology transfer (intellectual property protection and commercialization). Its aim is to create and achieve a long-term self-financing and sustainable system of technology transfer support through the establishment and operation of the Joint Patent Fund. Similar centres were created at the Slovak University of Agriculture in Nitra and at Slovak University of Technology in Bratislava which are both technically oriented universities.

Technical equipment of the universities has also partially improved with the support of the EU structural funds. This resulted in higher demand from private companies in the commercial use of university assets. For example, Comenius University in Bratislava declares that the science park has contracts with 160 researchers who are involved in the research activities of the park or use the park infrastructure for their research. However, it is not clear how many of them are external subjects and other researchers of the university.

In the area of support of entrepreneurship, only few of the most important universities are active – most of them technology oriented. Only three universities have their own operating incubators and some of them offer courses in business skills. The oldest one is the Slovak University of Technology Technological Incubator, which has supported more than 50 incubated companies through the InQb program. Technical University of Košice had 5 companies in its incubator in 2016. Support of entrepreneurship is aimed at supporting own students rather than developing the region in which they operate. The aforementioned incubators are also more likely to encourage creation of

start-ups capable to compete on a national or international level rather than to support the establishment of businesses that would meet regional needs. This was the only activity where universities were more active even in the absence of EU support funding.

6 DISCUSSION AND CONCLUSION

The movement of universities towards fulfilling their third mission is a typical feature not only in Western countries, but this paper confirmed such a trend also in Slovakia. Comparison of different activities of Slovak public universities in three domains, namely education, research and community development, showed interesting results. The majority of universities are engaged in three main types of activities – activities aimed at increasing participation of local inhabitants in education; increasing cooperation between universities and companies; and improving facilities for sports and culture. While in the education and community domain only minor changes can be observed during 2008 and 2016, activities of universities in the research domain increased substantially.

The most significant change can be observed in joint activities with businesses such as joint research projects, contracted research and in activities which aim to promote innovative entrepreneurship. The main reason for this is a change in government policy in this area. Government has significantly strengthened the position of research, obtained grants and research activities directly connected to practise. A specific factor for improving the activities within the third mission of universities was support from the EU structural funds. The volume of these funds was extremely high when looking at the total funding of universities, the value of individual projects often reached almost the annual budget of the respective university. Demand of the universities for these resources has exceeded the possibilities of public support. Thus, this indicates there is still room for an increase in the volume of activities in this area. In addition, the need for project sustainability in combination with a large volume of resources have often led to the development of system solutions through which specialized institutions have been established with clearly defined long-term tasks.

However, the real effects of these activities may be observed only over a longer period. Some studies point to the possible effect of building a “cathedral in the desert” (Huňady, Orviská and Šarkanová, 2014). While the universities have significantly intensified cooperation with the private sector, no major increase in the number of patents or licenses was recorded. This may indicate low efficiency of these activities. High demand for public resources is usually accompanied with the problem of rent-seeking. Especially as the amount of co-financing from universities was only at 5% level. There are also areas where universities are not systematically involved, such as promoting worker mobility or non-academic dissemination of results. Again, this could be caused by a lack of government support in these areas.

Generally, we can contend that government policy has significantly influenced the behaviour of universities. Many other studies (Abramo, Cicero and D'Angelo 2011; Pisár and Šipikal, 2017) confirmed that universities to a large extent adapt their actions to the conditions set for funding by the government. Since public universities are financed mainly from public sources and the private sector has a very small share in higher education, universities are more likely to respond to government activities than to the needs of companies. This is especially the case of activities that are associated with high fixed costs in the initial phase (e.g. technology parks). It seems that in countries with low innovation performance, such as Slovakia, government support can be a key factor in the launch of new research activities or networks.

Different focus on the third mission activities can also be seen among different types of universities. The results show a significantly higher orientation of technical universities for research and cooperation with companies. This may be caused by the country's high industrial orientation and stronger demand of this sector for these activities. The activities that universities carried out with EU support would have probably been implemented only to a very limited extent or not at all, without public financial support. Diversity of activities differs with the size of universities. Largest universities have the widest range of activities. On the other side, unlike some other studies (Boucher, Conway and Van der Meer, 2003) pointed out, there is no significant difference between universities in developed and less-developed regions. However, this may be the result of strong EU support for less developed regions. Compared to developed countries, we have not seen a more prominent role of local and regional governments, which is probably due to concentration of competences in the field of Slovak higher education at a national level.

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University and Practice – Cooperation in Research and Science: Case study of the Slovak University of Agriculture in Nitra

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ABSTRACT

Purpose: Besides their educational and research functions, universities are currently essential for dissemination of knowledge in innovation processes, thus affecting the economic and social development of their environments. The formalized cooperation of the Slovak University of Agriculture (SUA) in Nitra and its partners in research and science was examined in this context.

Methodology/Approach: Formal cooperation of the university with working life partners in terms of their sectoral and geographic affiliation was analyzed in the paper. The Central Register of Contracts and the SUA Internal Register of Contracts were used as principal sources of data. Based on interviews and selected studies conducted in the Slovak Republic we further focused on identification of barriers to the transfer of the results of research into practice.

Findings: The paper confirmed cognitive and spatial proximity between SUA and its partners. The sectoral focus of the partners is closely related to the profile of the university. From the spatial point of view, more significant concentration of SUA partners in the region of Western Slovakia was confirmed. We identified several barriers to the transfer of the results of scientific research activities from the university environment into practical life.

Research Limitation/implication: We conducted research on the example of one university, thus it is not possible to generalize the results.

Originality/Value of paper: The paper analyzes the collaboration of the University in science and research with partners in practical life and identifies weaknesses and barriers to this cooperation.

Category: Case study

Keywords: cooperation; university; practice; research; innovative ecosystem

1 INTRODUCTION

In addition to the role of education and research, a university plays an important role in knowledge dissemination within the innovation process and thus influences the economic and social development of the territory.

The concept of an innovation ecosystem has emerged in works of authors exploring the innovative environment at both macroeconomic and microeconomic level (Oh et al., 2016). Jackson (2011) defines an innovation ecosystem as a network of complex relationships formed between actors or institutions to enable innovation development.

Various types of innovation ecosystems can be identified: the regional innovation ecosystem (Hudec, 2007; Žitek, Klimova and Kralova, 2016) urban innovation ecosystem (Cohen, Almirall and Chesbrough, 2016), the university innovation ecosystem (Graham, 2013) etc.

Following the institutional approach to regional development, the university innovation ecosystem can be decomposed into the following elements: internal formal rules, internal human resources (students, researchers, transfer centre staff, academic entrepreneurs), external actors, relations between system actors and material resources of the system.

The assumption that innovations arise from cooperation between universities, businesses and government (Etzkowitz and Leydesdorff, 2000), represented by actors at different territorial levels, is a basis of so called Triple helix concept (model). The model presents the roles that individual actors play in the innovation process: government's role is policy making and innovation support, funding and advice; universities carry out research and development, establish and support incubators and spin-off firms. Businesses apply innovations in practice – develop products and services. Several scientific papers stress the need to complement the Triple helix model with a group of civil society actors (Lindberg, Lindgren and Packendorff, 2014) who perform the role of intermediaries (Brannback et al, 2008; Cornett, 2009). The model is referred to as the Quadruple helix.

Universities play a key role in the Quadruple helix cooperation. Importance of collaboration between a university and working life partners in innovation is emphasized (Drejer and Østergaard, 2014). The main reason of universities' involvement in such cooperation is the possibility to participate in solutions of real life challenges (Ramos-Vielba, Sánchez-Barrioluengo and Woolley, 2016). Networking with the quadruple helix partners helps in developing a community that provides learning environment for students (Hakkarainen et al., 2004) using combination of science-based knowledge and experience-based learning (Jensen et al., 2007) and brings an opportunity to obtain means for further research and education activities. Firms with strong relationships with universities have more patents and lower costs for internal research and development than businesses with no such relationships (George, Zahra and Wood, 2002), gains in

productivity and innovation with greater novelty (Hanel and St-Pierre, 2006; Damvad, 2012) and higher revenues from new or improved products (Lööf and Broström, 2008; Mura and Rózsa, 2013; Yu and Lee, 2016). The intention of the governance and decision-making policy authorities is to operate looking for consensus and the best solutions. This can be effectively conducted only in cooperation with the other segments of quadruple helix.

The natural purpose of a university innovation ecosystem should not only be the creation of new knowledge but also its transfer. Technology transfer includes direct or indirect transmission of scientific knowledge to real life (Brennenraedts, Bekkers and Verspagen, 2006). However, a linear model of technology transfer is no longer sufficient to account for the nuances and complexities of the process. Shortcomings of the traditional linear model of technology transfer include strict linearity and oversimplification, a one-size-fits-all approach, overemphasis on patents etc. (Bradley, Hayter and Link, 2013). It is necessary to include informal mechanisms of technology transfer, for example building entrepreneurial (Hayter, Lubynsky and Maroulis, 2017) and organizational culture (Boh, De-Haan and Strom, 2016), university reward system, developing cognitive and social proximity with work-life partners etc. A model of the transfer can have sectoral specific nuances (Genet, Errabi and Gauthier, 2012). Several studies identified barriers related to the transfer of scientific and research activities into practice (Davey, Rossano and Van der Sijde, 2016).

Different dimensions (geographic, institutional, organisation, cognitive, social) of proximity to partners play different roles in the cooperation. Economic geographers put emphasis on economic advantages of being co-located (Boh, De-Haan and Strom, 2016; Balland, Boschma and Frenken, 2015). Geographic proximity to public knowledge institutions is generally important for firms' likelihood for innovation collaboration (Broström, 2010; Laursen, Reichstein and Salter, 2011). However, the proximity is sectoral specific. In some sectors it is less than 10 kilometers, in other sectors it is more or the co-location does not play a role (Abramovsky and Simpson, 2011). Actors of cooperation need also cognitive proximity in terms of a knowledge base in order to communicate, understand, absorb and process new information successfully (Noteboom, 2000). The innovation process requires coordinated effective mechanisms to transfer complementary pieces of knowledge between agents. Organizational, social, institutional and geographical proximity may, each in its own way, but most likely in combination, provide solutions to this problem of coordination (Boshma, 2005; Boh, De-Haan and Strom, 2016).

Davey, Rossano and Van der Sijde (2016) identified several barriers related to the transfer of scientific and research activities into practice as: lack of information on a suitable partner, lack of finance (Yencken and Ralston, 2005). The third barrier is cultural, social and economic differences in academic and business environment (Bruneel, D'Este and Salter, 2010). The differences reflect different time and market orientation. Universities strive to make progress in their own interests and use their own methods of validation and rewarding, while

entrepreneurs are more focused on practical aspects, profits and commercial results (Bruneel, D'Este and Salter, 2010; Lopez-Martinez et al., 1994), which leads to different expectations. Bureaucracy is considered the gravest problem of academic environment. The fourth barrier is the application of scientific and research results. Universities are aimed at dissemination of results and publishing, while business want to be owners and sometimes even hold some results secret as a part of the competitiveness strategy. The issue of intellectual property is also debated. Universities consider intellectual property as something more than a source of income; it is rather a progress in knowledge. They want to publish results before they are protected and do not want to guarantee exclusivity of results. On the other hand, businesses are limited by their absorption capacity (Bekkers and Bodas-Freitas, 2010) and the scale of knowledge. Small and medium enterprises face high transaction costs (Reinhard and Schmalholz 1996).

2 METHODOLOGY

The objective of the paper is to examine the level and character of cooperation between the Slovak University of Agriculture in Nitra (hereinafter referred to as SUA) and partners from the praxis and to identify the barriers limiting a closer cooperation between the university and partners in the field of research and technology transfer.

Based on published information as well as personal experience, we assume that the SUA cooperates in the field of science and research with the external environment. In order to get more detailed information on the level, the focus of this cooperation and in order to identify the cooperating partners, we ask the following questions in the article: Who are the SUA partners in science and research cooperation (in terms of their geographical and sectoral relevance)? Does the SUA mainly cooperate with partners who are close to its sectoral focus (cognitive proximity)? Does the SUA work more closely with partners closer to the site? What is the purpose of this cooperation specifically? Are there any obstacles to cooperation between SUA and their working life partners? If so, what kind of obstacles?

The paper is focused on the formal cooperation of the university and its faculties, objectively published by the Central register of contracts of the Slovak Republic (available at https://www.crz.gov.sk/) and internal records on contractual agreements of SUA. The contracts were evaluated in the period of six years (2011 to 2016) and were focused on the cooperation in the field of applied research, participation in research activities, networking and partnership building, transfer of finance in favor of science and research, common education for PhD students and providing opportunities for practical training for students.

The paper classifies the goals of cooperation as follows. Applied research is understood as creating conditions for the future and current research at SUA, establishment of common facilities for applied research in cooperation with

partners using research results in praxis. Transfer of resources means the transfer of finance to support research and scientific activities of SUA (non-repayable funds financing infrastructure important for research and science, financial support for research projects from agencies, donations from businesses etc.).Provision of services represents a wide scale of services in favor of partners, though it needs to be added that such relations are bilateral, i.e. a university is a service provider (e.g. consultancy, counselling, experiments, tests, measurements, analyses etc.) as well as a customer (expert services provided by specialized data acquisition for research etc.).

Co-investigation of a research means a cooperation of two or more partners in investigating a common research. It is usually agreed in cooperation contracts. Practical training for students is carried out based on a contract between a university and a partner on practical training of students and represents an immediate confrontation of knowledge from a university with practice. The type of cooperation also covers networking of partners (predominantly universities and businesses) aimed at connecting theory and practice. Networking and building partnerships includes activities building preconditions for a future cooperation in the field of research, development, innovation or technology transfer. PhD education means providing a PhD study in cooperation with a partner organisation based on a written contract.

Based on the selected contracts (590) we identified partners (319) cooperating with SUA in referred activities in the monitored period. Prevailing types of cooperation were identified based on number of contractual relations with partner categories. The paper analyses sectoral and geographical relevancy of the partners. It is assumed that cognitive proximity and geographical proximity support each other (Fáziková and Melichová, 2014). In the final part of the paper are examined the barriers limiting the transfer of scientific and research results of SUA into praxis. The identification of barriers was performed according to selected studies (Davey, Rossano and Van der Sijde, 2016; Yencken and Ralston 2005; Bruneel, D'Este and Salter, 2010; Lopez-Martinez et al., 1994; Plewa and Quester, 2006; Jones-Evans, 1998; Bekkers and Bodas-Freitas, 2010; Reinhard and Schmalholz, 1996; Plaisier, 2010; Hanel and St-Pierre, 2006; Lööf and Broström, 2008), the study "Strengthening the Roles of Universities in Regions" (Hanová et al., 2016), processed, based on a questionnaire survey, conducted at 16 Slovak universities (67% of all the universities in Slovakia), and 18 interviews with the SUA management and employees carried out in 2017.

3 RESULTS

The Slovak University of Agriculture was founded in 1952 (formerly called University of Agriculture in Nitra until 1996). Currently, it is composed of six faculties: Faculty of Agrobiology and Food Resources (FAFR), Faculty of Biotechnology and Food Sciences (FBFS), Faculty of Engineering (FE), Horticulture and Landscape Engineering Faculty (HLEF), Faculty of Economics

and Management (FEM), and Faculty of European Studies and Regional Development (FESRD).

Within the scope of its scientific and research activities, SUA traditionally covers the agri-food sector functions from the perspective of production sustainability, food quality, ecology and environment and also social status of society (Report on scientific and research results of SUA in 2016). Currently, the research at SUA is focused on the following 5 fundamental themes (Chreneková et al., 2017):

1. Sustainable agriculture and climatic changes (production and breeding systems, agro technologies, food production chains and biodiversity).
2. Biotechnologies and food technologies (high-tech and genetically modified production, quality and safety of food).
3. Horticulture, landscape architecture and changes in land use (knowledge-based horticulture, landscape architecture, water management, landscape planning etc.).
4. Industrial and bioindustrial technologies (technical and technological use of renewable resources and development of new technologies for industry and agriculture in production and processing).
5. Society and economy (behavior towards legislation, development and recovery of regions, commercial chains, social entrepreneurship in agri-food industry).

Research directions of SUA facilities are interdisciplinary, covering biological, ecological, production, socio-economic, technological and technical aspects of natural resources use and addressing the current issues of agricultural production, landscape and agri-food industry.

3.1 Forms of SUA Scientific and Research Cooperation

Cooperation of the university in research and science is conducted on formal as well as informal bases. Formal cooperation means cooperation based on a contract, a registered form of cooperation. Informal cooperation (non-contractual cooperation) is usually based on personal contacts between partner organizations and represents a “silent” transfer of knowledge acquired by university research (Grimpe and Hussinger, 2008). Results of informal cooperation are often unexpected (Link, Siegel and Bozeman, 2007). Although informal cooperation in research and science is important e.g. as a basis for starting a formal cooperation, it is hardly explorable and definable in an exact form. Therefore, the paper is focused on examining formal cooperation of the university in research and science, particularly in the field of knowledge transfer within applied research.

Throughout the monitored period, SUA has concluded 89 of such framework contracts, the most important being the Agreement on association of scientific and technological universities in Slovakia (2013) with Comenius University in

Bratislava, the Agreement on cooperation with Constantine the Philosopher University in Nitra and the Institute on Plant Genetics and Biotechnology (2013) starting the common research centre "AgroBioTech", and the Association Contract (2015), establishing the National Technology Transfer Centre. The Technology Transfer Centre members are the Slovak Centre of Scientific and Technical Information (CSTI), Slovak Academy of Sciences and seven Slovak universities, (SUA, Slovak University of Technology in Bratislava, Technical University of Košice, Technical University of Zvolen, Comenius University in Bratislava, Pavol Jozef Šafárik University in Košice and University of Žilina). The knowledge transfer from universities to praxis has been extensively implemented via cooperation with private sector. It is represented mainly by applied research, in some cases co-financed by businesses, mutual provision of services, and offering practical training and internships for students. Applied research is conducted based on cooperation contracts, agreements on co-investigation and co-financing of research projects, or contracts on future contracts with specific partners aimed at application of research project results. As for applied research, the projects financed by the Slovak Research and Development Agency (SRDA) are of crucial importance. The university provides its partner especially the following services:

- preparation of studies, strategic documents for public or private partners, handbooks, opinions,
- evaluation and monitoring of projects,
- access to databases, data, information systems and devices,
- trials, measurements, testing and assessment, development and laboratory activities,
- analyses and supervision, consultancy,
- publishing of research activities.

Many businesses support research activities of the university by direct donations. Though the average financial donation to research activities reached 803 EUR, it is not negligible. The overall sum of such donations throughout the monitored period reached over 90,000 EUR.

The knowledge transfer from universities to praxis is also executed through practical training for students, field trips and internships. These are mainly based on contracts.

3.2 Objectives of contractual cooperations

Goals of SUA cooperation in research and science depend on contractual partners, e.g. in case of applied research, university facilities cooperate with other universities, research institutions, units of regional and local self-government, business and also NGOs. A similarly wide scope of partners is applied when a

university provides services. When providing services, the relations are mutual; i.e. a university provides services to partners and vice versa (e.g. testing, measurements, lending equipment etc.). The preconditions for further development of research and scientific activities are built mainly through networking and partnerships with universities, research institutions and businesses, and also by providing education for new generations of researchers and offering possibilities for practical training in favor of students and graduates. Tab. 1 provides information on objectives of contractual cooperation between SUA and various types of contractual partners in 2011-2016. The data express intensity of cooperation with the particular type of entities.

Table 1 – Objectives of SUA Contractual Cooperations in Science and Research in 2011-2016 (%) (Own Contribution Based on Internal Records of Contractual Agreements of SUA)

	University/ universities	*Research institution*	*Public administration*	*Self-government*	*Businesses*	*NGOs*
Applied research	0.5	2.2	7.6	0.7	16.1	2.0
Transfer of resources			0.3	0.3	20.2	0.5
Provision of services	1.2	1.9	3.1	5.6	11.0	1.2
Co-Investigation of research projects	1.2	2.4	0.3			
Practical training		0.8	1.0		5.9	
Networking and partnerships	0.8	5.8	0.2	0.3	4.2	1.4
PhD education		1.0				

3.3 SUA partners

Motivation for cooperation in research and knowledge transfer to private sector depends on the type of a partner (Belderbos, Carree and Lokshin, 2004).

Within its scientific and research activities, SUA cooperates with subjects from private, public and NGO sectors. Public subjects are represented predominantly by universities, research institutions, specialized agencies to support science and research (CSTI, SRDA), ministries and self-government (regional and local) and their cooperation with SUA is extensive. As for the intensity of cooperation, a special position belongs to the SUA University Farm owned by the university. Its main goal is to create conditions and provide services related to practical

training, research, development and internship of students. Private subjects are domestic as well as foreign businesses active in the territory of Slovakia, cooperating on contractual bases. Non-profit sector is represented by associations, interest groups of legal persons, foundations and professional associations. The structure of contractual partners is dominated by private sector partners (67%), followed by public sector partners (25%) and NGOs (8%).

3.4 Sectoral Classification of Partners

As for sectoral classification, SUA cooperates in research and science predominantly with subjects active in the sector of agriculture and fishing (A category, 20%), followed by those classified to professional, scientific and technical activities (M category, 15%), manufacturing (C category, 15%), wholesale and retail trade, repair of motor vehicles and motocycles (G category, 13%), and public administration and defence; compulsory social security (O category, 10%). Intensity of cooperation and sectoral classification of partners depend on the focus of educational and research activities of the faculties and other university facilities, and also on their amount.

Based on registered contractual relations (science and research) it can be stated that by faculties, most contracts were concluded by FAFR (22%) and FE (16.30%). However, calculating the number of contracts per employee, small faculties (FESRD, HLEF, FE) are more active.

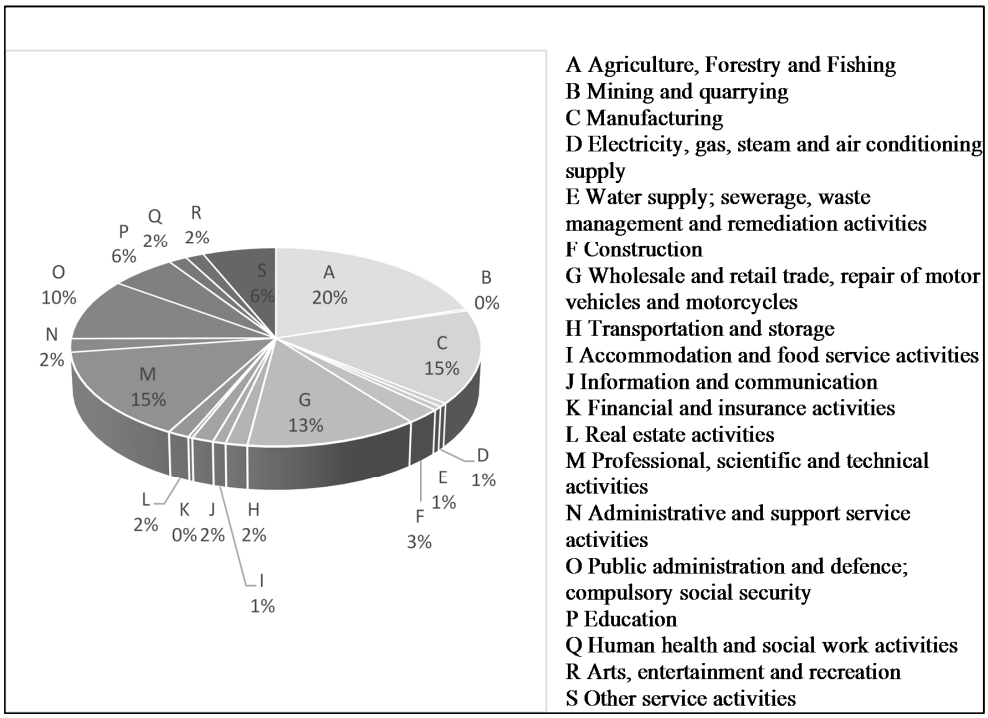

Figure 1 – Sectoral Structure of SUA Partners (2011-2016) (Own Contribution)

While contractual partners of FAFR belong mainly to the sector of professional, scientific and technical activities (M) and agriculture (A), FE has concluded contracts predominantly with partners belonging to the sectors of manufacturing (C) and wholesale and retail trade, repair of motor vehicles and motocycles (G). The partners of HLEF, FESRD, FBFS and FEM are significantly represented by those belonging to public administration (O). The analysis confirms that all faculties cooperate with scientific and research institutions (M) and businesses and associations active in the field of agriculture (A). The sectoral structure of partners is strongly dependent on the focus of scientific activities of the faculties and their facilities.

3.5 Spatial Aspects of Cooperation

Spatial distribution of subjects having concluded contractual cooperation with SUA in research and science is illustrated in Fig. 2. Based on the distribution and spatial concentration it can be claimed that the university cooperates mainly with local and regional external environment (Chreneková et al., 2017). Most of the partners come from Nitra district (68.3%). Western Slovakia partners represent 84%, Central Slovakia 8.3% and Eastern Slovakia 7.5% of all cooperating entities. A relatively high number of subjects cooperating with the university on the basis of contractual relations is concentrated in Bratislava and Trnava, the two closest agglomerations. There are localized mainly academic partners, other specialized scientific and research institutions and in case of Bratislava also public sector subjects. Nevertheless, in the case of local and regional external environment, there are mainly partners – business subjects of diverse focus and public sector representatives at local and regional level, mainly municipalities and their budgetary or subsidized organizations, located not only in district centres of the Nitra County but also in municipalities situated close to Nitra, the seat of the university. Based on the findings, it is presumed that the innovative ecosystem of the university affects local and regional development, and geographical proximity is significant when considering the transfer of research and science results and knowledge spill-overs from the university to society as a whole.

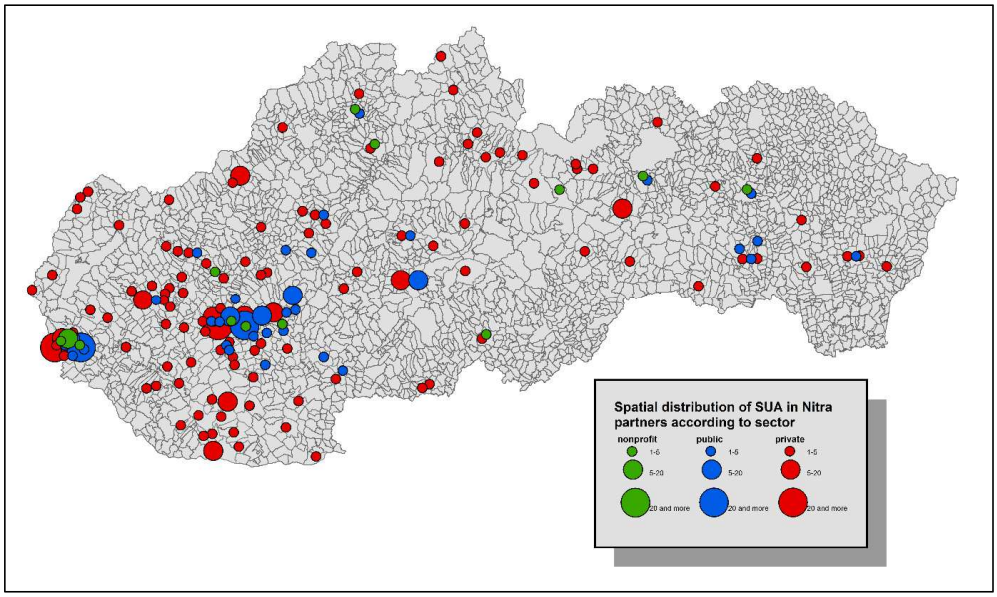

Figure 2 – Spatial Distribution of SUA Partners according to Sectoral Classification (Own Contribution)

As it is clear from controlled interviews with innovative ecosystem agents, research activities aimed at practice are to a great extent still conducted informally, based on personal contacts. The majority of subjects cooperating with the university in research is located in the counties of the Western Slovakia. The subjects located at a greater distance to the university (Northern and Eastern Slovakia) are mostly agricultural enterprises; it is presumed that their relations with the university are based on cognitive and social proximity.

3.6 Barriers Limiting Cooperation of Slovak Universities with Business Subjects and Other Agents of Regional Development

Identification of barriers to cooperation relations of Slovak universities with working life partners was performed. Generally, the barriers were recognized according to 11 selected studies (listed in the Methodology). In barriers identified in 16 Slovak universities resulted study "Strengthening the Roles of Universities in Regions" of Hanová et al. (2016).

In the context of the identified barriers limiting cooperation between universities and business subjects and especially the transfer of scientific and research results from academic to business environment it can be stated that situation in Slovakia is quite similar in many aspects. The study "Strengthening the roles of universities in regions" (Hanová et al., 2016) summarized the main barriers and opportunities of cooperation between universities and businesses as well as other agents of regional development in Slovakia (quoted parts of the following text correspond with results of the study). The study results confirmed that Slovak

universities also face the information and communication barrier – "when cooperating with practitioners, universities lack sufficient information, using ad-hoc systems"; "the academic environment is specific, conservative, complicated and intransparent from the perspective of business and public administration subjects, which causes communication problems and limits more effective cooperation"; "the common platform for the discussion on research projects and needs of regions and practitioners does not exists". The lack of resources and not only financial ones is another barrier of cooperation. "Universities are dependent primarily on public subventions, as no other financial mechanisms are customary in Slovakia"; "insufficient capacities (lack of finance, administrative and bureaucratic burdens, subsequent lack of time) of universities to carry out activities focused on fulfilling their missions". The above mentioned differences in academic and business environments limit the mutual cooperation. This results into university employees cooperating with external environment on individual bases.

3.7 Barriers Limiting Cooperation between SUA and Businesses and Other Practitioners

Cooperation barriers specific for SUA were analyzed and proven within 18 interviews with the SUA management and employees of research related units. Positions of interviewees are as follows: vice-rector for development, vice-rector for research, deans of faculties, director of the AgroBioTech research centre, head of the university Transfer Centre, head of the Expert Institute (of SUA), 3 seniors – members of former university management, representatives of 3 cooperating firms (quoted parts of the following text are statements of them).

Barriers limiting cooperation between SUA and businesses and other practitioners were identified based on controlled interviews with managers of SUA at the university level as well as at faculty levels. The interviews showed that practitioners often "cannot define a research or development issue or they have specific demands which they cannot put into context". On the other hand, "the university is often not familiar with demands of practitioners and does not seek them actively". Many businesses interested in cooperation with universities "do not appreciate results springing up in academic environment", and they have a mistaken belief that "as universities are financed from public resources, their know-how should be distributed free of charge". The interviews proved that the university is well-equipped from the perspective of human resources and material resources, but the disinterest of businesses in cooperation is a crucial barrier for the transfer of scientific and research activities into practice. "Cooperation in our sectors is often endangered by existential problems the businesses have to deal with." In their struggle to "survive", the businesses minimize their research and development costs. Moreover, the state does not create a legislation motivating agricultural businesses to increase quality of their products for instance. Such legislation would encourage the cooperation of agricultural enterprises and the university. Another problem is "lack of enterprises' confidence in research

results. The enterprises often adhere to their traditional procedures and they are not willing to adopt new ones".

The interviews also disclosed that even though the university has been making individual steps towards the support for knowledge transfer of research and science results into practice (e.g. adopting the Directive no. 4/2017 on Protection and Administration of Intellectual Property Rights at SUA), there is no complex internal system supporting the transfer of knowledge into practice.

Formal cooperation in research and science at the university often results from informal, personal relations between SUA employees and practitioners. Therefore, it is desirable that employees are encouraged towards both formal and informal cooperation with practice. The interviews also reflected criticism regarding the conditions for supporting entrepreneurial activities at the university. "The conditions are not motivational". Some faculties have their own support systems for cooperation with practitioners, motivating their employees to building more intensive and formalized relations with practitioners. One of the possible solutions is a reward scheme.

SUA employees (as well as employees of other Slovak universities) find also problematic that "results for practice are undervalued compared to publication and project results". Although they are equally demanding (from the perspective of time, qualification, material and technological requirements) as publications or projects, in light of accreditation criteria they are irrelevant. Due to the stated reasons, academicians are primarily focused on publications in scientific journals accepted by scientists (scientific journals with impact factors, scientific monographs etc. published in English in particular), which are not available to ordinary practical users or their highly professional language is hardly understandable to the public.

The use of university facilities' potential in favor of the university itself is an interesting idea mentioned in the interviews. Some research and scientific results are applicable directly in the university environment. The university uses the potential for transfer of knowledge acquired through its scientific and research activities within its environment to a limited extent only (direct awards, application of theses results in the university environment, accepting new ideas of employees etc.). "Why the university itself wouldn't be the lab?"

4 CONCLUSION

The role of universities in innovation processes is unsubstitutable. University is one of the key elements of the Triple helix model. In the model, a university executes research activities in the first place, and supports businesses that enable the transfer of new knowledge from academic environment to praxis (incubators, start ups) or valorize the results of research activities (spin-off). To fulfil these tasks, a university shall cooperate with partners of similar areas of interest (cognitive proximity). This was confirmed in orientation of SUA partners. The

university covers several areas of research, particularly biological, ecological, productive, socio-economic, technological and technical aspects of natural resources use and current issues of agricultural production, landscape and agri-food industry. Its research partners are primarily from the fields of agriculture, professional and scientific activities (research institutions) and manufacturing; these represent 50% of SUA contractual cooperations. The focus of contractual cooperation differs according to faculties and their research activities. The faculties focused on social sciences (FEM, FESRD) also cooperate with public administration bodies. The faculties focused on natural sciences (FAFR, FBFS) cooperate mainly with agricultural subjects and related research institutions, and the technical faculty (FE) concludes cooperation contracts with subjects focused on manufacturing and follow-up activities. There is a significant share of private sector on overall contracts of SUA (67%). The objects of cooperation in research and science are applied research, provision of services by the university, networking, building partnerships, mutual education of young scientists and students in cooperation with research institutions, and organization of practical trainings for students in cooperation with business subjects. From the spatial perspective, the university cooperates predominantly with subjects from the local and regional external environment. SUA partners are concentrated in the Western Slovakia (84% of all cooperating entities). In other regions of Slovakia, SUA cooperates mainly with agricultural enterprises. Even though authors agree on the statements "the scientific potential of universities is large" and "the cooperation between academic environment and business practitioners is inevitable", the transfer of scientific results from academic environment to businesses comes across many barriers. The conducted research stresses information barriers (communication problems), financial problems and motivations to transfer knowledge to practice, and barriers issuing from the differences between the two environments, including the different approaches to utilization of research results. Hanová et al. (2016) claim the level of cooperation between academic and business environments depends on economic levels of countries. We agree with the idea that "the cooperation in advanced countries with knowledge economy applied functions usually on the pull principle, with businesses extensively looking for new results of scientific and research activities of universities. However, in Slovakia (and also in other EU countries), this approach is replaced by the push effect, with universities and research institutions striving to enforce and apply their research results in praxis". The interviews imply that it is crucial to intensify the communication with practitioners (inform them on possibilities of the university, search for common research issues), encourage businesses to cooperate with the university, set up conditions for the support of knowledge transfer at the university in a motivational, rewarding way, and appreciate the published results devoted to practitioners in evaluation criteria of the university and its employees.

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