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THE IMPACT OF THE STANDARDIZATION OF THE NPD PROCESS ON ITS EFFICIENCY

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Abstract. The purpose of this study is to examine the impact of the standardization of the new product development (NPD) process on its efficiency. A dilemma exists with regard to determining to what extent NPD processes should be standardized, in order to not hinder the operators during the performance of NPD process and consequently, weaken it.

The case analysis for this study was carried out at a company whose process development has been standardized for a decade and has undergone several degrees of standardization.

Quantitative and qualitative research methods were applied in the study. A regression method was used for quantitative research in order to study the effects of selected dependent and independent variables; using qualitative analysis, we supported the findings of the quantitative analysis.

The results of the analysis indicate that the standardization of the NPD process does have an impact on its efficiency. From the obtained results, it may also be concluded that a very high degree of standardization begins to reduce the efficiency of the NPD process.

Keywords: NPD, process, NPD process, standardization of NPD process, efficiency of the NPD process.

JEL Classification: O32.

Introduction

This case study was designed to study the impact of standardization on the efficiency of NPD processes.

The research question was as follows: How does the standardization of the development process (the NPD process) impact the efficiency of the development process in a company in the standard classification of 22.290?

Jang and Lee (1998) define standardization “as the degree to which work rules, policies, and operating procedures are formalized and followed”. Furthermore, the standardization of processes mostly implies that these processes are coordinated and followed by

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pre-determined rules and regulations (Münstermann & Weitzel, 2008). Moreover, the literature shows multiple possible benefits of business process standardization. Manrodt and Vitasek (2004), for example, conducted a case study to present the benefits of process standardization and proved that those positively affect not only the firm but also its customers.

However, standardization also has disadvantages in addition to the multiple advantages described above. Griffin (1997) stated that companies with successful NPD processes do not always use formal processes. It is further argued that formal processes might not be necessary in order to perform successful NPD, but instead only provide advantages for some specific kinds of projects.

Several empirical studies have indicated that the success of a company depends on the success of its NPD projects (Kerzner, 2000; Cooper, 2001). An important issue for many companies implementing large numbers of NPD projects is to determine how standardized and diversified groups of activities that are being executed for the purpose of designing and commercializing new products are being run (Rupani, 2011).

Successful NPD is of great importance to many firms, especially because products are becoming more complex (Johnsen, 2009). Additionally, process standardization is often described as significant in regards to process performance (Lee & Tang, 1997; Manrodt & Vitasek, 2004). Ramakumar and Cooper (2004) state that business process standardization can lead to higher profitability; Swaminathan (2001) describes standardization as beneficial for business processes. Therefore, the increasing complexity of processes and products and the involvement of independent parties within the specification, design, and implementation of products calls for more formal specifications and improved integration methods (Borchardt, 2015).

Buganza, Chiaroni, Colombo, and Frattini (2011) reveal that the adoption of a formal development process, formal project plan, and standard project organization for the NPD process is positively related to the firm's revenue growth.

In the literature, we have failed to find detailed research that would discuss the impact of standardization on the effectiveness of the NPD process. The field of standardization of NPD processes is poorly explored in the segment of small and medium-sized enterprises.

The objective of this research is to help understand the impact of standardization on the effectiveness of the NPD process, especially in the SME sector, as well as in the 22.290 industry classification, and thus contribute additional knowledge for formulating standards for the industry and small and medium-sized enterprises.

The purpose of this study is to examine the impact of the standardization of the new product development (NPD) process on its efficiency.

Quantitative and qualitative research methods were used in this research study. Quantitative analysis constituted the collection and classification of data and its statistical evaluation. Qualitative analysis constituted gauging a deeper understanding and analysis of the problem (Johnson & Cristansen, 2012).

The structure of this paper is organized as follows: Section 1 reviews the relevant theoretical background, Section 2 describes the research methodology, and Section 3 reports research results.

1. Theoretical background

Previous research has shown that process standardization has many positive effects (improved efficiency, knowledge transfer, decision-making, and resource allocation) as well as negative effects (reduced creativity and innovation, learning and adaptation, employee satisfaction) (Rupani, 2011). Tatikonda and Rosenthal (2000) argue that process standardization does improve the efficiency of the NPD process, even when projects differ in their complexity. Performance evaluation is the process of evaluating the effectiveness, efficiency, and capability of actions and system to obtain given objectives (Al-Ashaab et al., 2015). Spear and Bowen (1999) explain that process standardization at Toyota accelerates learning and adaptation, with a view to continuous improvement, and provides a basis against which improvements can be measured and implemented.

Various researchers have conversely determined that standardization may also serve to lower the efficiency of the NPD process (Cooper & Edgett, 2008). Reduced NPD process efficiency is an essential issue for enterprises whose profitability is impacted by efficiency in the NPD process (Cooper & Kleinschmidt, 2007). In order to improve the management of NPD process efficiency, it seems necessary to understand the factors that could contribute to it. Several authors have examined the factors that contribute to NPD process efficiency (Lettice, Roth, & Forstenlechner, 2006; Cooper & Kleinschmidt, 2007) and have indicated that an understanding of critical factors that can be used in the standardization and restructuring of the NPD process benefits the industry (Holmes, 2011).

Equally as essential but even less clear is how NPD processes should be standardized within an organization to best support cost recovery and control. Eminent researcher Sid Winter, states that “There is a complex causal link that responds in different ways in different situations. This could mean that we should not summarize the generalized conclusions regarding the general question, but rather try to understand the links and unforeseen events.” (Rupani, 2011). In reviewing the relevant literature, no study examining the efficiency of the NPD process in relation to the standardization of the development process was found. There is, however, a study entitled “Improving the NPD Process by Applying Lean Principles: A Case Study” by Nepal, Yadav, and Solanki (2015), that examines the efficiency of the development process using the introduction of Lean Management Principles (Lean Leadership). In particular, the authors of the study identify the shortening of the development cycle as well as the importance of cost reduction as an enterprise’s strategic advantages. The introduction of Lean Principles may also be deemed one form of NPD process standardization. Similarly, Zhu and Lin (2017) also found that the implementation of Lean Management has a significant and positive effect on achieving the firm value for a long term. Abdi et al. (2018) also think that specifically, companies know that with a clear knowledge management strategy they can be more innovative, achieve better financial results, improve their processes and develop capabilities of human resources. The results of the study from Marasquini Stipp, Lopes Pimenta, and Jugend (2018) highlight that formal-temporary teams present a higher capacity to generate incremental innovation in products, whereas permanent-informal teams have a higher capacity to generate innovation in the internal processes and public answering contexts.

The definition of the New Product Development (NPD) process is that of a process conceived from the ideation to the marketing of new and updated products (Neely, Gregory, & Platts, 1995). For decades, the development of new products has encouraged researchers from diverse fields to study the NPD process (Song, Ming, & Wang, 2012). Market opportunities, available manufacturing technologies, and various types of functional integration enable rapid development cycles (Marion, Friar, & Simpson, 2012). Highly competitive enterprises, particularly high-tech enterprises, have a suitable NPD process strategy and collaborate and compete with suitable enterprises for survival (Lee, Chen, & Tong, 2008). As viewed in terms of competitiveness, the NPD process is one of the most critical business processes within an enterprise (Liker & Morgan, 2011). The NPD process must, therefore, be continuously evaluated and improved upon at given time intervals, based on the findings concluded from NPD process improvement projects (Costa, Rozenfeld, Amaral, Marcacinit, & Rezende, 2013). A significant number of good practices, tools, methods and systems have been developed for the purpose of improving NPD processes. Nevertheless, many enterprises have failed to develop their products promptly, in the framework of a set budget, according to customer expectations and with adequate quality assurance (Cooper, 2001; Rozenfeld et al., 2008).

Several types of standardization are familiar to us. One such example is the process for the development of specifications, such as ISO standards, which is based on a consensus approach with input from relevant enterprises and stakeholders (Saltzman, Chatterjee, & Raman, 2008). There is also an emergence of standards that are designed for companies, which can influence the entire product and process development cycle and that extend all the way from the conception of product or process development ideas (Wright, Sturdy, & Wylie, 2012). Standards can also be used to facilitate coordination between an organization's internal departments and with its external partners (Perera, Nagarur, & Tabucanon, 1999; Baud-Lavigne, Agard, & Penz, 2012). Standardization can thus benefit manufacturers by simplifying production, reducing inventory volumes and easing the complexity of production (Fredriksson & Gadde, 2005). Standardization stimulates similarity, unity, continuity of behavior and use of documentation, which are factors that some researchers argue also serve to hinder the development of new and innovative ideas (David & Rothwell, 1996; Thompson, 1965).

Standardization can also be based on the process of developing and establishing a given set of solutions for actual or potential problems that are geared towards benefitting the user in order to balance the user's needs and expectations that similar such solutions will be repeated or will be used over a given period by a significant number of the clients for whom they are intended (Blind & Hipp, 2003).

Naveh (2005) argues that most research projects are based on an assessment of efficiency and innovation (creativity) of the NPD process. Ciarapica, Bevilacqua, and Mazzuto (2016) point out that the NPD process is a dynamic process in which all activities are not predictable, cannot be planned and cannot be standardized.

According to Toney and Powers (1997), a standardized process (with its approaches and procedures) is a factor of success. Standardized management of NPD projects comprises the tools, methods and skills that are necessary for project management, which are factors that Sobek and colleagues claim are also critical to the success of Toyota (1998).

Standardization is also closely linked to research and development activities. In the broadest sense, participation in standardized processes is a particular type of open cooperation between companies, users, consumers and other stakeholders (Blind, 2006). According to Hansson and Smith (2018) there are several benefits of standardizing the project management process for NPD: improved collaboration; enhanced the lessons learned process by learning from each other; provide a holistic perspective for employees as to improve departmental responsibilities.

Blind (2002) has determined that an organization's intensity of research and development, as well as patent and export activities, are the main drivers in its adoption of standards for the development of standardization at the sectoral level. Other researchers have, however, argued that standardization allows organizations to develop a common working method and means of communication. This enables the management of knowledge and expertise, the development of products and processes and the adoption of new technologies that lead to the improvement of the enterprise's creativity or innovation (Wang, Zhang, Sun, & Zhu, 2016; Funk & Luo, 2015; Wright et al., 2012).

Standardization as a concept associated with product development was first used in the 1980s as the "Stage Gate Model" (Pahl & Beitz, 1988). The expression "Gates" is used to break down a development process into separate phases. Each phase requires appropriate documentation that must be processed prior to the project passing onto the next phase. Activities are thus standardized into a process. The purpose of the standardized NPD process is to assure product quality, to prepare relevant documentation and to reduce the time required to market entry (Cooper, 1995).

Product development is more difficult to conceptualize than calculating the volume of inventories or rating the efficiency of production processes are, because it is quite difficult to determine what actually constitutes loss within a development process and thus how to evaluate whether the process is efficient or not (Gudem, Steinert, & Welo, 2014). Enterprises must focus on improving efficiency in the NPD process. They must enhance learning, and they must also learn from failure (Lawson, 2002). Most researchers have identified "time" as being the most important factor related to the efficiency of the NPD process, taking into account that the efficiency of the NPD process involves a number of aspects other than time (Tyagi, Choudhary, Cai, & Yang, 2015; Millson, Wilemon, & Kim, 2011; Davila & Wouters, 2004).

According to Ciarapica et al. (2016), the method of combining and structuring customer needs as well as the time required to market entry can also be improved upon using some standard methods and tools, such as the mapping processes used in the Lean Production method. This allows companies to analyse current conditions and to develop a basis for defining a standardized working method, thereby increasing the overall NPD process efficiency. A review of the literature has revealed that the efficiency of the NPD process, that is the achievement of project goals such as manageable costs, timely performance and quality, also depends on the characteristics that are inherent to a particular project. These include complexity and novelty among other characteristics (Shenhar, 2001; Krubasik, 1988).

Roblek and Kern (2017) have determined that company growth also leads to substantial changes in a company's organization and information support. These result in a greater need for formalization or a predetermined degree of detailing a particular process. There also arises

a need for typification: classifying processes into different categories that require diversified management and information support. The degree of standardization is increased; there is a greater need to implement processes according to predetermined methods that should be optimal regarding very different factors. For example, the efficient use of human resources, physical resources, information technology and quality assurance of the process output (product).

In order to adequately take into account the impact that NPD process standardization has upon its efficiency, it is imperative to break down the NPD process into individual “characteristics”. This is important for standardization because different process characteristics will have a very different impact on NPD process efficiency.

2. Research methodology

Having established a research idea, the first step in implementing this study was to review relevant literature related to the NPD process. This was followed by a literature review in the field of NPD process standardization and finally, a review of the literature documenting the impact that standardization has on the efficiency of the NPD process. The essential findings of the literature review have been outlined in the previous section. On the basis of the research idea and literature review, a search for the gap in existing research followed. It was thus determined that little is known or has been documented on the question of how standardization impacts on the efficiency of the NPD process itself.

This determination was followed by the formulation of a research question, which is presented in Figure 1 below. Based on existing academic literature, parameters were determined for each description/category on the basis of which results were monitored. These are project characteristics, standardized processes, and efficiency.

Quantitative and qualitative research methods were used in this research study.

The quantitative analysis evaluated the data of already completed projects that were carried out as per the standardization steps of 2009 and 2016. In addition to the statistical processing of these results, projects were also assessed from the perspective of familiarization with and observation of standardization, taking their similarities and differences into account. In addition, the documentation of the company in which the research study was conducted was also reviewed.

The subjects of this quantitative research were completed projects that had been carried out on the basis of a set of rules, agreements, and regulations: in short, projects that were completed according to two standardized procedures developed in 2009 and 2016. The reason for the selection of these two procedures is as follows: in 2009, the company implemented the advanced product quality planning (APQP) method, which was improved and upgraded in 2016, in this period, there were no significant changes in connection with the NPD process.

The data for carrying out the analysis were collected with the Navisione information system, the Top Solutions module. In this business information system, the company concerned manages project records and the whole project implementation process. In addition to standard activities of the project, the information system also encompasses the management of all resources and the monitoring of their utilization.

All the data from successfully completed projects in the two observed years was used for the analysis. The SPSS program was applied in this respect.

With the qualitative analysis applied, we carried out a subjective evaluation of the impact of standardization on the NPD process efficiency, the importance of the NPD process standardization, and looked for the reason for the impact of standardization degrees among applicants of the method.

Qualitative research: This research can be described as a case study that is based on the conduct of in-depth interviews with project managers. Case studies enable the researcher to collect more in-depth information about one specific topic, as well as providing more capability for in-depth explanations (Gable, 1994). Qualitative research is provided based on interviews with project managers on their experiences with the NPD processes in 2009 and 2016. We posed questions in connection with typical project characteristics, the subjective evaluation of the standardization degree, and the NPD process efficiency. Qualitative analysis was used to support the evaluation and the understanding of quantitative research.

Because we have failed to determine how to define the standardization of the NPD process in literature we set out the criteria for the state of standardization ourselves. We analyzed standard implementation instructions for the two observed years. From the Top Solutions system, we obtained data on the number of defined activities according to which the project is to be managed. We determined that five activities were added in 2016, which means that the process is at a higher degree of standardization. Different methods are used in project implementation, e.g. Failure Mode and Effects Analysis (FMEA), Product Part Approval Process (PPAP), Measurement Systems Analysis (MSA), Statistical Process Control (SPC), and others. Furthermore, a number of documents, information, measurements, reports were used to assess the degree of standardization.

Finally, we evaluated additional information support for project management; in 2009, only Navision information system, the Top Solutions application, was used; in 2016, this was upgraded with the integrated documentation system.

Standardized procedure means that the rules and tools/equipment were documented and prescribed (laid out in advance). In addition to the prescribed method of implementation, the order of carrying out activities was also prescribed (determined in advance). In comparison with the 2016 standardized process, the 2009 standardized process was less detailed, constituted fewer agreements, milestones, and activities. The sample prepared for each group of projects (completed in 2009 and 2016) had been produced for the same sector: the automotive industry. Project complexity and input data are comparable in terms of expressed customer demands. All projects were implemented for the same production technology. The research study was conducted at a mid-sized company in the automotive sector.

A regression analysis was performed based on a select sample's individual project data.

3. Research results

This section presents the research question, a description of the variables, the course of qualitative and quantitative analyses, and the results obtained.

The research question was as follows: How does the standardization of the development process (the NPD process) impact on the efficiency of the development process in a company in the standard classification of 22.290? The research question is presented in Figure 1 below.

Projects characterized by complexity, novelty, and applied resources are carried out according to the determined NPD process standardized methodology. For example, we have used the standard methodology of the NPD process for 2009 and 2016. Based on the selected indicators, we have evaluated how standardization of the NPD process influences its effectiveness. We wanted to determine whether more standardized processes contribute to greater process effectiveness or vice versa.



Figure 1. Research question

The entry point is an individual research project with its particular characteristics, such as complexity, novelty and required resources. The research project then runs through a standardized NPD process in the form of particular standardized activities, information, and documentation. Efficiency (of cost and time) was measured for each project. Each project was led by an individual project team according to the prescribed steps of a standardized NPD process.

The impact of the Standardization-2009 NPD process was compared with the impact of the Standardization-2016 NPD process. Standardization of the NPD process was defined using the following characteristics: the number of activities implemented (such as review of input data, preparation of quotations, assessment of feasibility, etc.), the number of methods used (such as Production Part Approval Process (PPAP), Measurement Systems Analysis (MSA) and Statistical Process Control (SPC), etc.). The results, or outputs, from each implemented activity comprise documents, information, or records.

In this case study, "standardization" means typification or the prescribed steps for carrying out individual projects. Table 1 below presents a comparison between the degrees of standardization for the years being compared.

Table 1. Comparison of the degree of standardization in 2009 and 2016

Criterion	2009 Standardization	2016 Standardization
Number of activities carried out	25	30
Number of tools/methods used	5	7
Results / Output	25	30
Computerization	/	yes

Project characteristics are defined using the following criteria, which are used in this research study as independent variables: complexity, novelty, and resources. These are expressed in monetary units. Complexity is defined using descriptive variables: less complex project, medium complex project, and complex project. A less complex project means that

only basic technology is being developed. A medium complex project means that at least one operation is being added to the basic technology. A complex project means that several operations, as well as process automation, are being incorporated in addition to the basic technology. Novelty is defined as an existing or repeated project and as a new project. A new project means that the project represents an entirely new project for the company and that the company has no previous experience with this type of process. Resources have been expressed in monetary units and mean the value of human-developmental, material, service, and consulting costs.

Two criteria are selected for project efficiency, expressed in time and monetary units. These are dependent variables. Time variable means the number of days required for project implementation. The second criterion is the difference between planned and actual sources, as expressed in euros. A negative value means that the project incurred a loss.

Given that impact is the focal point of interest in this research, a regression analysis was used to evaluate the case study.

Independent variables are data on complexity expressed as an ordinal variable, data on novelty expressed as a nominal, dichotomous variable and data on resources expressed as a dimensional variable. The dependent variable is data on time (number of days), expressed as a dimensional variable.

3.1. Quantitative research

Standardization – 2009

The Standardization – 2009 was studied first. The following criteria were selected for this analysis: complexity, novelty, and resources allocated for project implementation. The study was conducted on 25 projects that were carried out according to the 2009 methodology (N = 25). The quality of the developed regression model in Table 2 was tested first. This was followed by testing for the statistical significance of effects.

Table 2. Summary of the Regression Model

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.590 ^b	0.348	0.255	6.95181

a –Year: 2009; b – Predictors: (constant), resources _EUR, novelty, complexity; c – Dependent variable: time

The adjusted R-squared indicates that the independent variables account for 25.5% of the variability of the dependent variable.

Table 3. ANOVA Regression Model

Model		R Square	df	Adjusted R Square	F	P
1	Regression	542.160	3	180.720	3.739	.027
	Residual	1014.880	21	48.328		
	Total	1557.040	24			

Table 3 above indicates that the regression model is of sufficient quality for prediction (the degree of freedom of the F statistic is less than 0.05).

Table 4. Regression coefficient

Model		Unstandardized Coefficients		Standardized Coefficients	t	p	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	Constant	63.356	4.312		14.693	0.000		
	Complexity	6.935	2.749	0.609	2.523	0.020	0.533	1.876
	Novelty	3.483	3.165	0.219	1.101	0.284	0.783	1.277
	Resources_EUR	0.000	0.000	-0.417	-1.859	0.077	0.619	1.616

Of the three independent variables with a degree of freedom of 0.05, only complexity significantly affects time ($p = 0.020$).

Complexity affects time positively and with a medium level of significance ($Beta = 0.609$); therefore, the more complex the project, the more time is required for new product development as shown in Table 4.

The effect of independent variables on spent financial resources was tested next.

Because the focal point of interest in this study is "effect", a regression analysis was used. Independent variables included data on complexity (ordinal variable), novelty (nominal, dichotomous variable), and resources (dimensional variable). The dependent variable (dimensional variable) is data on the difference between planned and actual costs.

Standardization – 2009

The quality of the developed regression model was first tested. This was followed by testing for the statistical significance of effects.

Table 5. Summary of the Regression Model

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.857 ^b	0.734	0.696	4824.70043

a – Year: 2009; b – Predictors: (constant), resources_EUR, novelty, complexity; c – Dependent variable: time

The adjusted R-square indicates that the independent variables used in the study account for 69.6% of the variability of the dependent variable as shown in Table 5.

Table 6. ANOVA Regression Model

Model		R Square	df	Adjusted R Square	F	P
1	Regression	1350863969.493	3	450287989.831	19.344	0.000
	Residual	488832419.165	21	23277734.246		
	Total	1839696388.658	24			

Table 6 above indicates that the regression model is of sufficient quality for prediction (the degree of freedom of the F statistic is less than 0.05).

Table 7. Regression coefficient

Model		Unstandardized Coefficients		Standardized Coefficients	t	p	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	B
1	Constant	1927.043	2992.588		0.644	0.527		
	Complexity	10155.869	1907.746	0.820	5.323	0.000	0.533	1.876
	Novelty	287.678	2196.498	0.017	0.131	0.897	0.783	1.277
	Resources_EUR	-0.818	0.110	-1.068	-7.469	0.000	0.619	1.616

Of the three independent variables with a degree of freedom of 0.05, complexity ($p = 0.000$) and resources ($p = 0.000$) have a statistically significant effect on the difference in cost. Complexity affects the difference in cost positively and with a strong level of significance ($Beta = 0.820$); therefore, the greater the complexity, the greater the difference of spent resources as shown in Table 7.

Resources affect the difference in cost negatively and with a strong level of significance ($Beta = 1.068$); therefore, the higher the planned resources, the better the coverage of the project and the greater the residual value.

The effect of the independent variables on spent financial resources for The Standardization-2016 was tested next.

Because the focal point of interest in this study is the effect, a regression analysis was used. Independent variables included data on complexity (ordinal variable), novelty (nominal, dichotomous variable), and sources (dimensional variable). The dependent variable (dimensional variable) is data on the difference between planned and actual costs. The study was conducted on 114 completed projects, $N = 114$.

Standardization – 2016

The quality of the developed regression model was first tested. This was followed by testing for the statistical significance of effects.

Table 8. Summary of regression model

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.715 ^b	0.511	0.462	13.26671

A –Year: 2009; b – Predictors: (constant), resources_EUR, novelty, complexity; c – Dependent variable: time

The adjusted R-square indicates that the independent variables used in the study account for 46.2% of the variability of the dependent variable as shown in Table 8.

Table 9. ANOVA Regression Model

Model		R Square	df	Adjusted R Square	F	P
1	Regression	5512.099	3	1837.366	10.439	0.000
	Residual	5280.166	30	176.006		
	Total	10792.265	33			

Table 9 above indicates that the regression model is of sufficient quality for prediction (the degree of freedom of the F statistic is less than 0.05).

Table 10. Regression coefficient

Model		Unstandardized Coefficients		Standardized Coefficients	t	p	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	B
1	Constant	33.690	7.459		4.517	0.000		
	Complexity	11.567	4.370	0.485	2.647	0.013	0.486	2.058
	Novelty	8.845	5.011	0.226	1.765	0.088	0.993	1.007
	Resources_EUR	0.000	0.000	0.229	1.245	0.2230	0.483	2.068

Of the three independent variables, only complexity ($p = 0.013$) has a statistically significant effect on time.

Complexity affects time positively and with a medium level of significance ($Beta = 0.485$); therefore, the more complex the project, the more time required for the new product development process, as can be seen in Table 10.

The effect of independent variables on spent resources was tested next.

Standardization 2016

The quality of the developed regression model was first tested. This was followed by testing for the statistical significance of effects.

Table 11. Summary of Regression Model

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.586 ^b	0.343	0.277	5220,74401

A – Year: 2009; b – Predictors: (Constant), resources_EUR, novelty, complexity; c – Dependent Variable: time

The adjusted R-square indicates that the independent variables used in the study account for 27.7% of the variability of the dependent variable as shown in Table 11.

Table 12 above indicates that the regression model is of sufficient quality for prediction (the degree of freedom of the F statistic is less than 0.05).

Table 12. ANOVA Regression Model

Model		R Square	df	Adjusted R Square	F	P
1	Regression	427087235.876	3	142362411.959	5.223	0.005
	Residual	817685041.708	30	27256168.057		
	Total	1244772277.583	33			

Table 13. Regression coefficient

Model		Unstandardized Coefficients		Standardized Coefficients	t	p	Collinearity statistics	
		B	Std. Error	Beta			Tolerance	B
1	Constant	4256.850	2935.162		1.450	0.157		
	Complexity	6002.645	1719.709	0.741	3.490	0.002	0.486	2.058
	Novelty	3394.030	1972.053	0.256	1.721	0.096	0.993	1.007
	Resources_EUR	-.428	.131	-0.697	-3.273	0.003	0.483	2.068

Of the three independent variables with a degree of freedom of 0.05, complexity ($p = 0.002$) and resources ($p = 0.003$) have a statistically significant effect on the difference in cost.

Complexity affects the difference in cost positively and with a strong level of significance ($Beta = 0.741$); therefore, the greater the complexity, the greater the difference in spent resources, can be seen in Table 13.

Conversely, resources affect the difference in cost negatively and with a medium level of significance ($Beta = 0.697$); therefore, the higher the resources, the lower the difference in cost.

A comparison of the results of both standardization degrees

Table 14. Comparison of results

	Time required for project completion	Difference – resources spent (€)
Complexity (2009)	0.609	0.820
Complexity (2016)	0.485	0.741
Development costs (2009)	No effect	-1.068
Development costs (2016)	No effect	-0.697

The results of both degrees of standardization indicate similar trends in all variables; can be seen in Table 14. A comparison of the results of the two degrees of standardization indicates that effects of Standardization-2009 are more intense than the effects of Standardization-2016 are.

Based on these research results, it may be concluded that the degree of standardization does impact on project efficiency. Results are different at different degrees of standardization. The effects at Standardization-2016 are somewhat worse than in 2009, for which there may be several reasons. These are listed below:

The characteristics of the projects carried out in Standardization-2009 differed in several criteria. Most projects were applicative, which means that similar projects had already been carried out in the past. Due to the financial crisis, fewer projects were being carried out at the time. The projects were also less complex and much more time was available for their execution so that the researchers had devoted more time to these projects.

Customer demands during Standardization-2009 were also lower. Customers did not insist on the implementation of certain procedures. At the same time, the company procured standard catalogue materials that did not require sampling or supplier development procedures.

Standardization-2016 was relatively new when the study was implemented. It may, therefore, be concluded that the stage of method implementation in 2016 was even lower than we may expect it to be in, for example, two years' time.

Another difference between Standardization-2016 and Standardisation-2009 is in the fact that Standardization-2016 is supported by an information and documentation system.

Product complexity in Standardization-2016 was greater than it had been at Standardization-2009.

There are also differences in those who implemented the processes, the organization of the company, the knowledge/expertise of the employees, and many other factors.

One other phenomenon arises for projects that were implemented according to the standardization, and this is that all customers were already demanding multi-functional products – meaning that customers were requesting product components or more complex products.

At the same time, there is an emerging trend of rising demand for projects that are designed to replace metal parts with plastic ones. This trend is seen in all industries.

From these research findings, it may be concluded that a very high degree of standardization begins to lower process efficiency. The author of this study recommends that further research work examine the effects that computerization of the standardized process has on standardized procedures.

3.2. Qualitative research results

All project managers have evaluated Standardization 2016 as the more detailed standardization, with a larger number of process steps, methods used, outputs or development results (information, documentation, instructions, procedures, etc.) compared to Standardization 2009. According to the project manager group, subjective assessment in terms of the results or the evaluation of the effectiveness of the individual standardized process, standardized processes such as the one from 2016, obstruct the work due to excessively bureaucratic procedures, document completion, and rigorous IT support. The group estimates that the efficiency of the process is worse in the short term but pays off in the long term, due to a higher quality of products in the production phase.

Conclusions

This research study was aimed at examining how the degree of standardization of the NPD process impacts on its efficiency. Based on the quantitative and qualitative results of the research, we have determined that the degree of standardization affects the efficiency of the NPD process. A review of relevant literature has revealed that researchers have found that a standardized NPD process can have a positive effect on efficiency. In contrast, too much standardization produces precisely the opposite effect. Given that past research has not defined what a degree of standardization even is, future research could also address this question. In this study, the degree of standardization of the NPD process is evaluated on the basis of relevant industry expertise as well as a subjective assessment on the part of the researchers.

A review of relevant literature has revealed only one similar study that deals specifically with the impact of standardization on the efficiency of the NPD process. This is the case study done by Rupani in 2011, whose doctoral dissertation explored the impact of the standardization of the NPD process by examining a company that works in the automotive industry. The conclusion of his research was that standardization contributes to a company's success and provides positive results even in very diversified projects.

It is necessary to emphasize that these studies differ in their methodology of conducting their respective research. The 2011 study by Rupani was carried out based on a subjective assessment of the implementers, was obtained on the basis of a questionnaire – an interview with those who implemented the NPD process. Based on the comparative study, Rupani (2011) determines that novelty and complexity have a significant impact on time but that only complexity has a significant impact on required financial resources. With our study, we have arrived at the conclusion that time is impacted only by the complexity of an executed project and not also by novelty. This study also determines that complexity also has a significant impact on available resources.

Another interesting study would be to investigate the efficiency of the NPD process if users of the standardized process could independently decide during which phase(s) a standardized activity or standardized step could be skipped. A subject of research could also focus on how the efficiency of the NPD process would be impacted if only certain activities or certain segments of activities were standardized. One such example is the course of internal communication – i.e. how does communication run between members of a team and how does it run between departments? What steps are necessary in a given process and what standard documentation is used for a particular activity?

In light of this premise, future research could explore to what extent processes should be standardized as well as what should be standardized and/or what criteria should be established when standardizing the NPD process.

It appears that the size of an enterprise or organization is also a very significant factor/consideration to the development of standardized processes. Similar future case studies could, therefore, explore the ways in which NPD process standardization impacts on project efficiency within small, medium and large-sized enterprises.

The limitations of this study are as follow: first, in the literature, we cannot find a definition about the standardization of NPD processes, so we set the definition of the standardization

of NPD processes based on best practice of the company. Second, selected projects in both standardization degree were heterogeneous, from the both point of view so as from type of customer as from the perspective of the set of requirements. In the future, this research could explore only the projects from one customer at each standardization degree. Finally, for the research method, we could also use different methods for evaluating the efficiency of the standardization degree of NPD processes, as well as chose other impact parameters.

References

- Abdi, K., Mardani, A., Senin, A., Tupenaite, L., Naimaviciene, J., Kanapeckiene, L., & Kutut, V. (2018). The effect of knowledge management, organizational culture and organizational learning on innovation in automotive industry. *Journal of Business Economics and Management*, 19(1), 1-19. <https://doi.org/10.3846/jbem.2018.1477>
- Al-Ashaab, A., Golob, M., Urrutia, U. A., Gourdin, M., Petritsch, C., Summers, M., & El-Nounu, A. (2015). Development and application of lean product development performance measurement tool. *International Journal of Computer Integrated Manufacturing*, 29(3), 342-354. <https://doi.org/10.1080/0951192x.2015.1066858>
- Baud-Lavigne, B., Agard, B., & Penz, B. (2012). Mutual impacts of product standardization and supply chain design. *International Journal of Production Economics*, 135(1), 50-60. <https://doi.org/10.1016/j.ijpe.2010.09.024>
- Blind, K. (2002). Driving forces for standardization at standardization development organizations. *Applied Economics*, 34(16), 1985-1998. <https://doi.org/10.1080/00036840110111158>
- Blind, K. (2006). Explanatory factors for participation in formal standardisation processes: Empirical evidence at firm level. *Economics of Innovation and New Technology*, 15(2), 157-170. <https://doi.org/10.1080/10438590500143970>
- Blind, K., & Hipp, C. (2003). The role of quality standards in innovative service companies: An empirical analysis for Germany. *Technological Forecasting and Social Change*, 70(7), 653-669. [https://doi.org/10.1016/s0040-1625\(03\)00029-5](https://doi.org/10.1016/s0040-1625(03)00029-5)
- Borchardt, A. K. (2015). Standardized communication – a way to shorten cycle time? *5th IBA Bachelor Thesis Conference*. Enschede, The Netherlands.
- Buganza, T., Chiaroni, D., Colombo, G., & Frattini, F. (2011). Organisational implications of open innovation: an analysis of inter-industry patterns. *International Journal of Innovation Management*, 15(2), 423-455. <https://doi.org/10.1142/S1363919611003210>
- Ciarapica, F. E., Bevilacqua, M., & Mazzuto, G. (2016). Performance analysis of new product development projects. *International Journal of Productivity and Performance Management*, 65(2), 177-206. <https://doi.org/10.1108/ijppm-06-2014-0087>
- Cooper, R. G., & Edgett, S. J. (2008). Maximizing productivity in product innovation. *Research-Technology Management*, 51(2), 47-58. <https://doi.org/10.1080/08956308.2008.11657495>
- Cooper, R. G. (2001). *Winning at new products: Accelerating the process from idea to launch* (3rd ed.). New York: Basic Books.
- Cooper, R. G. (1995). Developing new products on time, in time. *Research-Technology Management*, 38(5), 49-57. <https://doi.org/10.1080/08956308.1995.11674295>
- Cooper, R. G., & Kleinschmidt, E. J. (2007). Winning businesses in product development: The critical success factors. *Research-Technology Management*, 50(3), 52-66. <https://doi.org/10.1080/08956308.2007.11657441>

- David, P. A., & Rothwell, G. S. (1996). Standardization, diversity and learning: Strategies for the coevolution of technology and industrial capacity. *International Journal of Industrial Organization*, 14(2), 181–201. [https://doi.org/10.1016/0167-7187\(95\)00475-0](https://doi.org/10.1016/0167-7187(95)00475-0)
- Davila, A. (Tony), & Wouters, M. (2004). Designing cost-competitive technology products through cost management. *Accounting Horizons*, 18(1), 13–26. <https://doi.org/10.2308/acch.2004.18.1.13>
- Fredriksson, P., & Gadde, L.-E. (2005). Flexibility and rigidity in customization and build-to-order production. *Industrial Marketing Management*, 34(7), 695–705. <https://doi.org/10.1016/j.indmarman.2005.05.010>
- Funk, J. L., & Luo, J. (2015). Open standards, vertical disintegration and entrepreneurial opportunities: How vertically-specialized firms entered the U.S. semiconductor industry. *Technovation*, 45–46, 52–62. <https://doi.org/10.1016/j.technovation.2015.07.001>
- Gable, G. G. (1994). Integrating case study and survey research methods: an example in information systems. *European Journal of Information Systems*, 3(2), 112–126. <https://doi.org/10.1057/ejis.1994.12>
- Gudem, M., Steinert, M., & Welo, T. (2014). From lean product development to lean innovation: searching for a more valid approach for promoting utilitarian and emotional value. *International Journal of Innovation and Technology Management*, 11(2), 1450008. <https://doi.org/10.1142/s0219877014500084>
- Griffin, A. (1997). PDMA research on new product development practices: Updating trends and benchmarking best practices. *Journal of Product Innovation Management*, 14(6), 429–458. <https://doi.org/10.1111/1540-5885.1460429>
- Hansson, K., & Smith, S. (2018). *Standardization of the project management process for new product development* (Master's Thesis in the Master's Programme International Project Management). Göteborg, Sweden.
- Holmes, J. (2011). *A quantitative study of factors contributing to productivity in new product development* (Ph. Thesis). Northcentral University, Arizona.
- Costa, J. M. H., Rozenfeld, H., Amaral, C. S. T., Marcacini, R. M., & Rezende, S. O. (2013). Systematization of recurrent new product development management problems. *Engineering Management Journal*, 25(1), 19–34. <https://doi.org/10.1080/10429247.2013.11431963>
- Jang, Y., & Lee, J. (1998). Factors influencing the success of management consulting projects. *International Journal of Project Management*, 16(2), 67–72. [https://doi.org/10.1016/s0263-7863\(97\)00005-7](https://doi.org/10.1016/s0263-7863(97)00005-7)
- Johnson, B., & Christensen, L. B. (2012). *Educational research: Quantitative, qualitative, and mixed approaches*. Thousand Oaks, CA: SAGE.
- Johnsen, T. E. (2009). Supplier involvement in new product development and innovation: Taking stock and looking to the future. *Journal of Purchasing and Supply Management*, 15(3), 187–197. <https://doi.org/10.1016/j.pursup.2009.03.008>
- Kerzner, H. (2000). *Applied project management: Best practices on implementation*. New York: J. Wiley.
- Krubasik, E. G. (1988). Customize your product development. *Harvard Business Review*, (November–December), 46–51. Retrieved from <https://hbr.org/1988/11/customize-your-product-development>
- Lawson, M. B. (2002). In the praise of slack: time is of the essence. *IEEE Engineering Management Review*, 30(1), 4–4. <https://doi.org/10.1109/emr.2002.1022400>
- Lee, A. H. I., Chen, H. H., & Tong, Y. (2008). Developing new products in a network with efficiency and innovation. *International Journal of Production Research*, 46(17), 4687–4707. <https://doi.org/10.1080/00207540701233484>
- Lee, H. L., & Tang, C. S. (1997). Modelling the costs and benefits of delayed product differentiation. *Management Science*, 43(1), 40–53. <https://doi.org/10.1287/mnsc.43.1.40>

- Lettice, F., Roth, N., & Forstenlechner, I. (2006). Measuring knowledge in the new product development process. *International Journal of Productivity and Performance Management*, 55(3/4), 217-241. <https://doi.org/10.1108/17410400610653200>
- Liker, J. K., & Morgan, J. (2011). Lean product development as a system: a case study of body and stamping development at Ford. *Engineering Management Journal*, 23(1), 16-28. <https://doi.org/10.1080/10429247.2011.11431884>
- Manrodt, K. B., & Vitasek, K. (2004). Global process standardization: A case study. *Journal of Business Logistics*, 25(1), 1-23. <https://doi.org/10.1002/j.2158-1592.2004.tb00168.x>
- Marion, T. J., Friar, J. H., & Simpson, T. W. (2012). New product development practices and early-stage firms: two in-depth case studies. *Journal of Product Innovation Management*, 29(4), 639-654. <https://doi.org/10.1111/j.1540-5885.2012.00930.x>
- Millson, M. R., Wilemon, D., & Kim, J. (2011). Exploring the NPD strategy development proficiency & new product market success relationship: a study of mediation and moderation. *International Journal of Technology Intelligence and Planning*, 7(1), 54. <https://doi.org/10.1504/ijtip.2011.041253>
- Münstermann, B., & Weitzel, T. (2008). What is process standardization?. *CONF-IRM 2008 Proceedings*, 64. Retrieved from <http://aisel.aisnet.org/confirm2008/64>
- Naveh *, E. (2005). The effect of integrated product development on efficiency and innovation. *International Journal of Production Research*, 43(13), 2789-2808. <https://doi.org/10.1080/00207540500031873>
- Neely, A., Gregory, M., & Platts, K. (1995). Performance measurement system design. *International Journal of Operations & Production Management*, 15(4), 80-116. <https://doi.org/10.1108/01443579510083622>
- Nepal, B. P., Yadav, O. P., & Solanki, R. (2011). Improving the NPD Process by applying lean principles: A case study. *Engineering Management Journal*, 23(3), 65-81. <https://doi.org/10.1080/10429247.2011.11431910>
- Pahl, G., & Beitz, W. (1988). *Engineering design a systematic approach*. Berlin: Springer.
- Perera, H. S., Nagarur, N., & Tabucanon, M. T. (1999). Component part standardization: A way to reduce the life-cycle costs of products. *International Journal of Production Economics*, 60-61, 109-116. [https://doi.org/10.1016/s0925-5273\(98\)00179-0](https://doi.org/10.1016/s0925-5273(98)00179-0)
- Ramakumar, A., & Cooper, B. (2004). Process standardization proves profitable. *Quality*, 43(2), 42-45.
- Roblek, M., & Kern, T. (2017). Pristop k prenovi in informacijski podpori razvojnega procesa v srednje velikem podjetju. *Uporabna informatika (Ljubljana)*, 24(1), 3-16. URN:NBN:SI:doc-1BR1ZJ5J. Retrieved from <http://www.dlib.si>
- Rozenfeld, H., Daniel, C., Amaral, C. S. T., & Costa, J. M. H. (2008). NPD improvement through process, maturity, BPM and body-of-knowledge integration. *Proceedings of the 4th International Conference on Production Research – ICPR Americas*. Polytechnic School of the University of Sao Paulo.
- Rupani, S. (2011). *Standardisations of product development processes in multi project organisations* (PhD thesis). Massachusetts Institut of Technology, Massachusetts.
- Saltzman, J., Chatterjee, S., & Raman, M. (2008). A framework for ICT standards creation: *The case of ITU-T standard H.350*. *Information Systems*, 33(3), 285-299. <https://doi.org/10.1016/j.is.2007.10.001>
- Shenhar, A. J. (2001). One size does not fit all projects: exploring classical contingency domains. *Management Science*, 47(3), 394-414. <https://doi.org/10.1287/mnsc.47.3.394.9772>
- Sobek, D. K., Liker, J. K., & Ward, A. C. (1998). Another look at how Toyota integrates product development. *Harvard Business Review*, (July-August), 36-49. Retrieved from <https://hbr.org/1998/07/another-look-at-how-toyota-integrates-product-development>
- Song, W., Ming, X., & Wang, P. (2012). Collaborative product innovation network: Status review, framework, and technology solutions. *Concurrent Engineering*, 21(1), 55-64. <https://doi.org/10.1177/1063293x12468457>

- Spear, S., & Bowen, H. K. (1999). Decoding the DNA of the Toyota Production System. *Harvard Business Review* 77, 5 (September–October 1999), 96–106. Retrieved from <https://hbr.org/1999/09/decoding-the-dna-of-the-toyota-production-system>
- Marasquini Stipp, D., Lopes Pimenta, M., & Jugend, D. (2018). Innovation and cross-functional teams: Analysis of innovative initiatives in a Brazilian public organization. *Team Performance Management: An International Journal*, 24(1/2), 84–105. <https://doi.org/10.1108/TPM-12-2016-0056>
- Swaminathan, J. M. (2001). Enabling customization using standardized operations. *California Management Review*, 43(3), 125–135. <https://doi.org/10.2307/41166092>
- Tatikonda, M. V., & Rosenthal, S. R. (2000). Successful execution of product development projects: Balancing firmness and flexibility in the innovation process. *Journal of Operations Management*, 18(4), 401–425. [https://doi.org/10.1016/S0272-6963\(00\)00028-0](https://doi.org/10.1016/S0272-6963(00)00028-0)
- Thompson, V. A. (1965). Bureaucracy and innovation. *Administrative Science Quarterly*, 10(1), 1. <https://doi.org/10.2307/2391646>
- Toney, F. & Powers, R. (1997). *Best practices of project management groups in large functional organizations*. Upper Darby, Pa., USA: Project Management Institute.
- Tyagi, S., Choudhary, A., Cai, X., & Yang, K. (2015). Value stream mapping to reduce the lead-time of a product development process. *International Journal of Production Economics*, 160, 202–212. <https://doi.org/10.1016/j.ijpe.2014.11.002>
- Wang, Z., Zhang, M., Sun, H., & Zhu, G. (2016). Effects of standardization and innovation on mass customization: An empirical investigation. *Technovation*, 48–49, 79–86. <https://doi.org/10.1016/j.technovation.2016.01.003>
- Wright, C., Sturdy, A., & Wylie, N. (2012). Management innovation through standardization: Consultants as standardizers of organizational practice. *Research Policy*, 41(3), 652–662. <https://doi.org/10.1016/j.respol.2011.12.004>
- Zhu, X., & Lin, Y. (2017). Does lean manufacturing improve firm value? *Journal of Manufacturing Technology Management*, 28(4). <https://doi.org/10.1108/jmtm-05-2016-0071>