How Digital Transformation Compares to Traditional Methods in Developing eGovernment Services: Elementary School Admissions case

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Abstract

European Commission sets clear targets in Europe's digital decade policy. One of them is digitalization of public services. There are many ways how to reach this objective. The KPI sets by EU Commission is "Key Public Services will be 100% online[3]" Members state can simply build electronic version of paper world. Or they can seize the opportunity and go with the digital transformation path. But what will be the difference? Is it worth it for government and citizens? Despite high expectations regarding digital transformation, failures in transforming public sector organizations in recent years have indicated a lack of understanding of the complexity of digital transformation and the relationships among technologies, information use, organizational contexts, and institutional arrangements (Tassabehji, Hackney, & Popovič, 2016). The ambition of this research paper is to document the difference between electronization and digital transformation of elementary school application process. The sufficient method for this research is production function. Data are mainly from survey collecting time estimations for labor costs calculations. Other data required to fill factors in production function are obtained from government IT project implementing new software solution for elementary schools in Slovakia. Our aim was to explain the opportunity cost of not doing transitioning "electronic government" to the stage of "transformational" domain t-Government. Study shows higher total factor productivity of digital transformation based on the production function comparison of current state of electronization and „to be" state after the project will be delivered. This result indicates the hypothesis that vertical integration as a form of digital transformation yields benefits, not only in terms of cost efficiency on labor side of function but also in overall process effectiveness.

Aims and research topics

This study has three objectives. First is to simulate public service applications to elementary schools respecting the digital transformation definition. For this reason, deep dive in literature review of digital transformation definitions will be necessity. Also, access to data on IT project implementing principles of digital transformation is required.

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[3] https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age/europes-digital-decade-digital-targets-2030_en

Second objective of the study is to measure the change in labor input of locally provided service before and after digital transformation. Preconditions for this objective is to measure in survey time allocations of employees dedicated for processing the public service on back-office site.

Third objective is focused on measuring the change in technological factor of locally provided service before and after digital transformation. Technological factor refers to the level of technology available to a organization that influences how inputs, in this case labor and capital, are converted into the output. It represents the efficiency and effectiveness of production processes and innovation in the use of resources.

Based on these three objectives, we could compare the traditional method of building digital service mirroring physical world and new transformational method of digital services based on new governance model and cross-level implementation across government bodies.

The results can be useful for policy makers implementing KPI of EU policy for digital decade of making 100% key public services online.

1. Literature Review

A lot of research has been done on digital transformation, especially around the key factors that shape government digital transformation. In this section, I'll look at the main studies out there, focusing on the most important theories and methods people have used. We can find a lot of definitions of digital transformation. I would like to mention those that build foundations to this paper.

To understand the challenges that come with digital transformation, it's essential to recognize both its promise and its complexity. Despite high expectations regarding digital transformation, failures in transforming public sector organizations in recent years have indicated a lack of understanding of the complexity of DT and the relationships among technologies, information use, organizational contexts, and institutional arrangements (Tassabehji, Hackney, & Popovič, 2016).

This complexity is further underscored by the scope of existing studies, which often limit their focus to individual organizations rather than addressing cross-level implementation across government bodies. Existing empirical studies have predominantly focused on a single organization at the country level (e.g., Liu & Zheng, 2018; Tassabehji et al., 2016; Weerakkody, Janssen, & Dwivedi, 2011) without considering the cross-level policy implementation in hierarchical bureaucracy.

However, government digital transformation is rarely confined to single organizations; it often requires changes that affect various levels and entities. Digital transformation in government often accompanies cross-level changes that impact multiple organizational elements. Digital technologies can fundamentally transform the infrastructure, products, services, business processes, business models, and strategies of an organization as well as its inter-organizational relationships in extended business networks (Bharadwaj, El Sawy, Pavlou, & Venkatraman, 2013; Chanias, Myers, & Hess, 2019; Sebastian et al., 2017). Responses to various forms of transformation require different forms of flexibility, such as infrastructure flexibility and organizational flexibility, to enable adaptations. The concept of flexibility refers to an organization's ability to efficiently respond to a changing environment (Gong & Janssen, 2012). Organizations lacking flexibility are often prone to failure in transformation, and flexibility is needed to explore digital options (Svahn, Mathiassen, & Lindgren, 2017). Although the need for flexibility has been indicated for governments undergoing DT (Nograšek & Vintar, 2014)

Flexibility in transformation goes hand in hand with the evolving definitions of digital transformation itself. Scholars continue to refine these definitions to better capture the nuanced requirements of government DT. Vial (2019: 121) defines the digital transformation as "a process that aims to improve an entity by triggering significant changes to its properties through combinations of information, computing, communication, and connectivity technologies". Vogl et al. (2020: 947) highlight digital government transformation from the standpoint of bureaucratic changes arguing the emergence of "algorithmic bureaucracy" as "combining people, computational algorithms, and machine-readable electronic files and forms to deal with complexity and overcome some of the limitations of traditional bureaucracy, whilst preserving core public sector values."

The practical implications of these definitions are seen in how public administrations are envisioned to evolve with digital tools and altered relationships. "The majority of experts interviewed stated that public administrations will be digitally transformed by using new technologies, focusing in particular on achieving an improvement of processes, relationships, and services. They also see a change in the relationship between public administrations and citizens as users of digital public services, as well as the relationships within the organizations themselves." (Mergel, Noella Edelmann, Nathalie Haug , 2019)

As these relationships evolve, government digital transformation projects offer insights into both the opportunities and challenges of this shift, especially through cross-organizational collaborations. Relevant information to this paper is also description of projects implementing government digital transformation from Government inter-organizational, digital transformation projects: five key lessons learned from a Norwegian case study. "In a government context, the digital transformation projects are rooted in a combination of political reforms and organizational changes, designed to enact, support and drive transformation in the public organization (A. Cordella and F. Iannacci 2010). These projects are motivated partly by the new opportunities afforded by digital technology (A. Cordella and C. M. Bonina 2012) and partly by organizational changes related to New Public Management (NPM) and public value management (J. M. Bryson, B. C. Crosby, 2014). The trend is that these projects are increasingly involving inter-organizational and cross-sector collaboration as well as co-creation of value and cross-jurisdictional networks (Y. Gong, J. Yang, and X. Shi, 2020). The resulting organizational configurations implies that digital transformation projects have to deal with increasing numbers of stakeholders and increased complexity" (Bassam Hussein, Antoine R. Rauzy, 2022).

From these definitions and case studies, we see a recurring theme of change and flexibility, particularly in how digital transformation reshapes governance and stakeholder relationships. From all the definitions of government digital transformation we can extrapolate significant change and flexibility as a characteristic that is repeatedly mentioned besides the (digital) technology. Especially change and flexibility in governance and relationship between stakeholders participating on public services provided to citizens.

This focus on governance highlights the importance of maturity models in assessing government digital transformation progress. Governance has even a significant position in measuring the maturity model of government digital transformation. Transitioning from the "electronic" to the stage of "transformational" domain called as t-Government is posing the greatest challenge of how government services respond to changes in the broader economy and society. This issue has raised the argument further that e-Government is not just about creating portals. It is more about transforming the whole government into a complete entity where citizens and businesses seamlessly interact, participate in policy making and participatory budgeting, and with ease, with government agents and services (Bertot and Jaeger, 2008; Caldow, 2001).

One such framework for this transformation is the Layne and Lee e-Government Maturity Model, which traces government progress through specific developmental stages. The Layne and Lee e-Government Maturity Model, introduced in 2001, outlines a four-stage progression for the development of e-government services: A. Cataloguing: At this initial stage, government entities establish an online presence by publishing information about their services, policies, and procedures. This serves as a digital catalog for citizens to access basic information. B. Transaction: Building upon the informational foundation, this stage enables citizens to perform online transactions, such as submitting forms or making payments, facilitating direct interactions between the government and the public. C. Vertical Integration: This phase focuses on integrating e-government services across different levels of government (e.g., local, regional, national) to streamline processes and enhance service delivery. D. Horizontal Integration: The final stage aims to integrate services across various governmental functions and departments, providing a unified and cohesive interface for citizens, thereby improving efficiency and user experience. This model emphasizes the evolutionary nature of e-government development, highlighting the importance of both technical advancements and organizational changes in achieving comprehensive digital transformation.

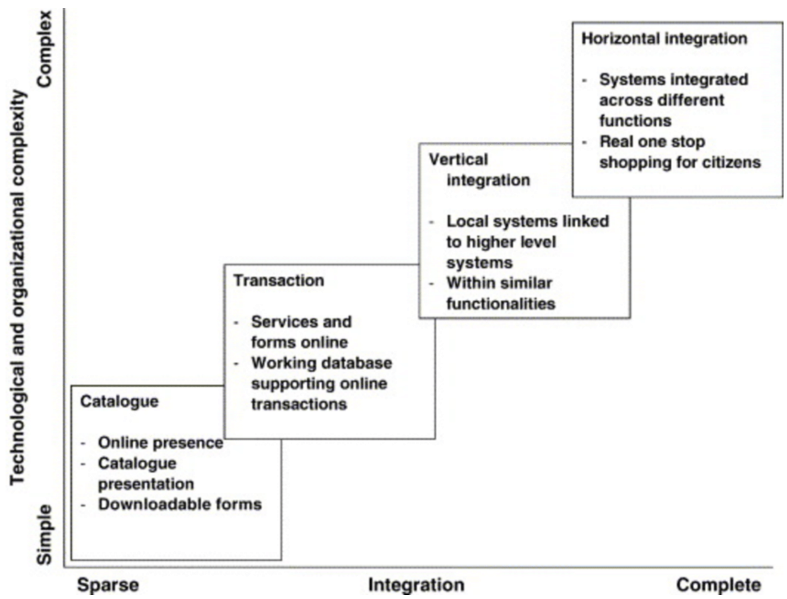
2. Introduction

This research paper measures the difference between electronization and digital transformation of elementary school application process. The actual governance model is very complex. Service in Slovakia is provided by 2 635 elementary schools. Schools are divided into three main groups: public, private and church schools. Above this layer of actors are 2 927 municipalities regulating school districts which some of them even provide financing as a founder body. Municipalities with elementary schools on their territory are also appeal bodies against the decision of the elementary school principal. On the regional level are operating 8 Regional educational offices providing methodological support to elementary schools. They are managed by Ministry of education, research, development and youth of the Slovak republic (ministry). On the state level is ministry, regulating the whole process by several acts: Number 245/2008 On Upbringing and Education (School Act), Number 596/2003 On State Administration in Education and School Self-Governance and Number 597/2003 On the Financing of Primary Schools, Secondary Schools, and Educational Institutions.

The digital level of Slovakia's school system is high in comparison to other public sectors such as healthcare or social care. The great leap forward to digital services was made during the COVID-19. All elementary schools have a school information system, major vendor is ASC with their product Edupage, or ASC agenda. The second vendor with a small portion of the market is company SEVT with their system eSchool. Edupage vendor sells SW to elementary schools from 289 EUR to 639 EUR per year based on the number of students attending elementary schools[4].

The weakness of the current digital service provision lies in the governance model. Digitalization of the last years did not provoke changes in relations between actors in the arena. From the Layne and Lee e-Government Maturity Model admission to elementary schools is on B level: citizens can perform online transactions, such as submitting forms. On the back-office side of the transaction, elementary schools store data in digital form and perform almost the whole process in digital environment. What kind of value can be reached if vertical and horizontal integration were implemented into the process and governance? Is it possible to integrate e-government services across different levels of government?

Scheme 1: Layne and Lee e-Government Maturity Model



source: Viborg Andersen, K., Zinner Henriksen, H. (2006)

3. Theoretical Model

From the elementary schools perspective the number of processed applications is output for admission process. The inputs are capital and labor. Based on these factors, production function is used. However, the goal is not to calculate the output. In this case of public service, output is given by a number of children that need to fulfill compulsory school attendance. The research paper contains a comparison of the production function of the current provision model of service to the new model simulating vertical integration. Factors of new simulated model of vertical integration would have different labor and capital. The simulated TO BE model is based on the ongoing project on Ministry of education,

[4] https://www.ascagenda.com/#!/order

research, development, and youth SR financed by Recover and Resilient Fund, Component 17, investment 1: Better services for citizens and entrepreneurs.

The production function is a functional model that reflects the value-creation process by describing the relationship between input and output (Ackerberg, Caves & Frazer, 2015). Marshall (1920) constructed the first gross production function. He proposed that the commodity value could be created jointly by labor, capital, land, and entrepreneurs. However, he did not provide the specific form of the function. Subsequently, Cobb and Douglas (1928) introduced technical factors into the relationship between input and output and proposed the Cobb-Douglas (C-D) production function, which has become the most widely used production function in economics. The C-D production function was further developed into the CES (Qian & Wu, 2020), the VES (Gamlath & Lahiri, 2018), Stochastic Frontier (Banker, Natarajan & Zhang, 2019; Kumbhakar & Tsionas, 2006), and trans-log production functions (B. Lin & Raza, 2020). The main difference between these kinds of production functions lies in the different settings of the elasticity of substitution. The early C-D production function assumes that technological progress is neutral, and the elasticity of substitution is equal to 1. However, many subsequent studies have shown that technological progress was not necessarily neutral (Hicks, 1932a), and biased technical progress was proposed (Acemoglu, 2002, 2007). Subsequently, Arrow, Chenery, Minhas & Solow, 1961 thought that the elasticity of substitution in actual production is not equal to 1. Furthermore, they proposed the CES production function, whose elasticity of substitution is a constant greater than 0.

Based on the theoretical model, production function with constant elasticity of substitution (CES PF) first appears to be sufficient. However, we will not be able to calculate elasticity of capital and labor, the responsiveness of Y (output) to changes in K (capital) or L (labor). The reason is that the public sector in the case of elementary school admission process does not produce different output (admissions) based on the changes inputs. Government process admissions is free and based on the number of parents submitting a form. In this case of public service, output is given by a number of children that need to fulfill compulsory school attendance. We can use simple Cobb-Douglas production function without elasticity variables. The aim is to measure the total factor productivity ratio between AS IS and TO BE model.

Model explain only variables that are in the scope of the research. Capital invested into the SW at the current state and labor allocated for successful admission process. In the TO BE alternative capital represents same investment to the SW as the current state plus capital investment of Ministry of education, research, development and youth SR to the new SW reflecting digital transformation.

$$Y_{asis} = TFP_{asis} \cdot K_{asis} \cdot L_{asis}$$

$$Y_{tobe} = TFP_{tobe} \cdot K_{tobe} \cdot L_{tobe}$$

$$Y_{asis} = Y_{tobe}$$

$$TFP_{asis} \cdot K_{asis} \cdot L_{asis} = TFP_{tobe} \cdot K_{tobe} \cdot L_{tobe}$$

$$\frac{TFP_{asis}}{TFP_{tobe}} = \frac{K_{tobe} \cdot L_{tobe}}{K_{asis} \cdot L_{asis}}$$

4. Data and Methodology

To be able to measure how digital transformation compares to traditional methods in developing eGovernment services for elementary school admissions research paper define process using Business process modeling notation (BPMN) version 2.0[5]

Methodology for BPMN process modeling

The scope of the process starts with stakeholders. In the case of elementary school admissions, it is necessary to document elementary school employees and elementary school principal responsible for admission process and decision delivery to parents. In the scope of the process there is also an additional interaction between parents and school employees to provide necessary information required to complete the admissions process.

Based on the interview with stakeholders, detailed information about the process was collected. Business process model document the key activities, tasks, roles, and decisions involved. Based on the notation dependencies or relationships between different processes or sub-processes was identified. Swim lanes (pools and lanes) were used to represent different roles, departments, or external entities. The final output has BPMN symbols such as events (start, intermediate, end), tasks, and gateways to represent the sequence and decision points. Standard BPMN symbols: Events: start, intermediate, and end events that denote the beginning, intermediate stages, and completion of a process. Activities: Tasks and sub-processes that represent the work performed. Gateways: Decision points where the process can branch based on conditions. Flows: Sequence flows, message flows, and associations to define connections and dependencies. Once validated, review the final model with stakeholders for confirmation and approval.

Methodology survey for time estimations

The first step is to identify employees directly involved in performing the tasks. Break down the questions by specific tasks based on the BMPN model. The survey starts with basic information collecting names of the elementary school and total forms submitted by parents this year. The survey then contains several questions for each task. Each task in the survey creates a section with the same questions, with a few exceptions. The first question in each section was focused on the average time needed to complete the task. Since task times can vary, the survey asks participants another question for each task to provide if this average time takes in some cases longer. The follow up question identifies reasons that trigger longer time than average. To be able to measure the time spent on each task, the last question aims to identify how often the task is repeated per admission form.

The survey has 33 questions, divided into 10 sections and 37 responses. The first and second sections were dedicated to introduction and basic data collection, the last gave a respondent opportunity to leave a general comment. In total the survey was aimed to document 8 key processes.

[5] https://www.omg.org/spec/BPMN/2.0/PDF

Simulating Time Savings in "To-Be" BPMN Model

The Ministry of education, research, development SR is implementing an IT project focused on digital transformation of elementary school admission process. Project builds GUI for parents to submit admission form and GUI for elementary school employees to execute the whole business process from receiving form to completion and delivery of the decision to parents. Changes focused on vertical integration are extrapolated from the requirement catalogue. The requirement catalogue is part of the IT project documentation in accordance with Act number 401/2023 about IT project implementation.

The effect of vertical integration requirements on the AS IS business process and time durations of each task is represented by % time savings on labor cost. Vertical integration requirements change the governance model, decrease the amount of work needed to finish tasks by adding data from central registers and automate tasks.

Based on the change of the governance model between central authority and elementary schools from decentralization to

Summary of variables used in production function:

$Labor_{as\ is}$, is measured by survey with employees dedicated to process submissions. The survey measure time spend on activities in BPMN model. Time allocations multiplicated by average wage in educational sector gives cost of labor.

$Labor_{tobe}$, is expressed by time savings on activates affected by digital transformation project (increase of capital of to be), New time allocations was again multiplicated by average wage in educational sector which gives a cost of labor for to be alternative.

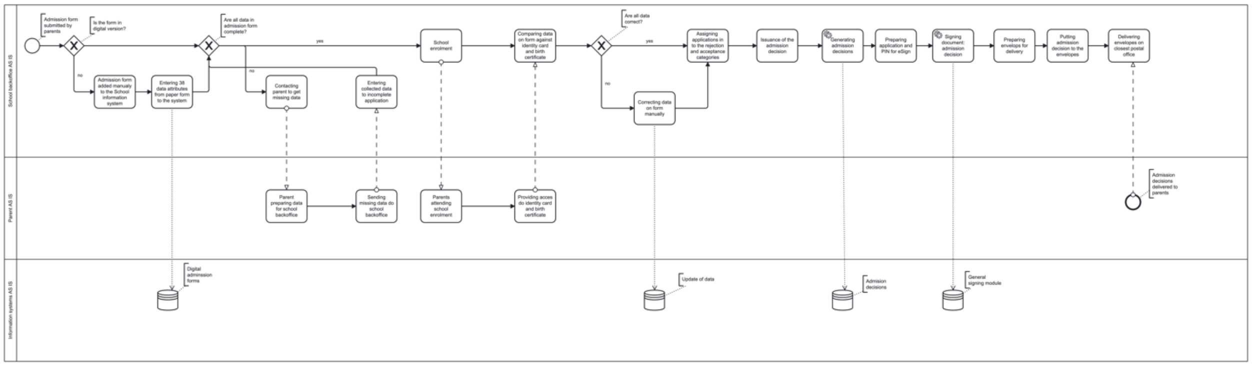
$Capital_{asis}$ = was measured by list price of main SW vendor selling product do schools. The list prices is based on the number of children attending the school. The cost of SW was computed by creating groups of schools based on their size multiplied with the different price policy of SW vendor.

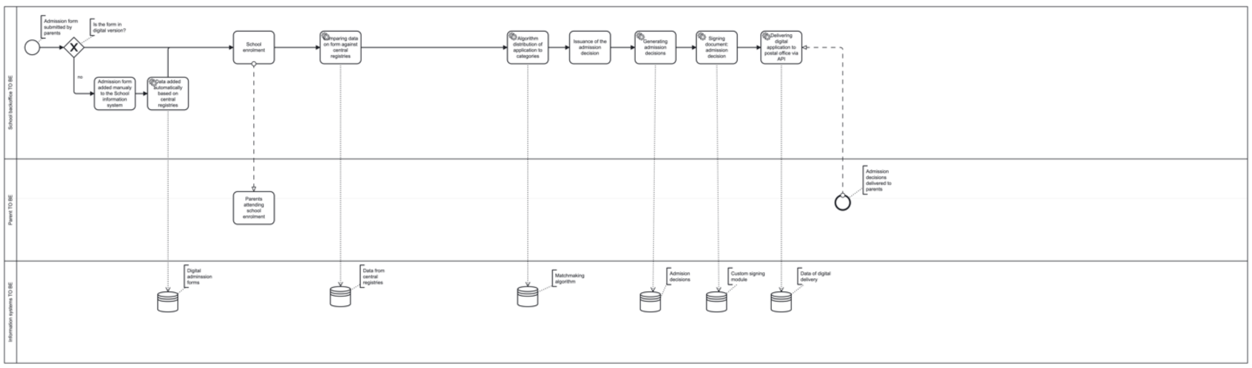
$Capital_{tobe}$ = was measured as a summary of Capital in as is alternative, plus new investment lead by IT project implementing principles of digital transformation. The investment was based on total SW expenditures of the project budget, that was part of the study.

5. Empirical Analysis

Based on the BPMN 2.0 methodology business model was created. Model starts with starting event admission form submitted by parents. The diagram provides a clear and structured workflow for handling the school enrollment process, accounting for both electronic and manual submissions, and ensuring data quality through verification steps.

Table 1: AS IS and TO BE BPMN model





source: authors

End event finishes when the parents receive the statement of acceptance.

Table 2: Time duration of tasks executed during admission process

Tasks	Average duration per transaction (minutes)	Average occurrence (%)	Duration of all submissions (minutes)
Manual submission adding to school system	9,1	14%	81516,89
Data control of submission	5,4	100,00%	345519
Communication with parents	13,1	30,00%	251461,05
School enrollments	6,9	100,00%	441496,5
Preparation of submission into the groups	1,3	100,00%	83180,5
Issue a statement of acceptance	10,7	100,00%	684639,5
Sign a statement of acceptance	1,5	100,00%	95977,5
Deliver a statement of acceptance	11,4	100,00%	729429

source: authors

This table provides a detailed analysis of the time duration for various tasks executed during the admission process. Most Frequent Tasks: Tasks like "Data control of submission," "School enrollments," and "Preparation of submission into the groups" occur in 100% of transactions, indicating they are mandatory for every admission. Time-Intensive Tasks: Tasks like "Deliver a statement of acceptance" (11,4 minutes on average) and "Issue a statement of acceptance" (10,7 minutes) are some of the longest per transaction, which significantly impact the total time. Rare Task: "Manual submission adding to school system" is the least frequent (14%) but still consumes significant total time (81 516 minutes), showing it may benefit from automation. Task with High Total Duration: "Deliver a statement of acceptance" takes the highest total time (729 429 minutes), even though it occurs in all cases. Improving this step could optimize the process substantially. Duration of all submissions calculates process duration for one transaction times number of all submissions per year that are 63 985.

Table 3: IT improvements reducing time durations

Tasks	IT improvements	Savings %
Manual submission adding to school system	Instead of entering the entire application, only personal identification numbers will be entered	70%
Data control of submission	The data will not need to be verified manually; the system will validate them against state registers	80%
Communication with parents	Communication will not be necessary , as most of the data will be correct.	30%
School enrollments		0%
Preparation of submission into the groups		0%
Issue a statement of acceptance	The algorithm will determine a single decision for each child and eliminate duplicate issuance of decisions	80%
Sign a statement of acceptance	Instead of signing with a card and entering codes, signing will be on the server side on one click	80%
Deliver a statement of acceptance	Delivery will use integration with the postal service, eliminating the need to print documents and insert them into envelopes	80%
Per year		
Per 10 years		

source: Project documents

Table 4: Calculation of labor costs for AS IS and TO BE based on duration

Tasks	Labor AS IS EUR	Savings EUR	Labor TO BE EUR
Manual submission adding to school system	14 411	10 087	4 323
Data control of submission	61 082	48 866	12 216

Communication with parents	44 454	13 336	31 118
School enrollments	78 050	0	78 050
Preparation of submission into the groups	14 705	0	14 705
Issue a statement of acceptance	121 034	96 827	24 206
Sign a statement of acceptance	16 967	13 573	3 393
Deliver a statement of acceptance	128 952	103 162	25 790
Per year	479 658	285 854	193 804
Per 10 years	4 796 585	2 858 540	1 938 044

source: authors

This analysis emphasizes the importance of targeted digital transformation and efficiency improvements in reducing labor costs while maintaining operational effectiveness. To elaborate labor costs for ASIS the average wage in school sector was multiplied by total duration for each process.

High-Cost Tasks with Significant Savings: Issue a statement of acceptance, Deliver a statement of acceptance, Data control of submission. Labor costs are calculated based on the average wage in educational sector at level 1 782 EUR. This sum represents brutto wage, that need to be multiplied by 1,435 to include social and health insurance.

Table 5: Calculation of Capital AS IS costs.

School capacity	Price per year	Number of schools	SW cost per year	SW cost in 10 years
0 - 99	289	670	193 630,00 €	1 936 300,00 €
100 - 199	469	451	211 519,00 €	2 115 190,00 €
200 - 299	519	281	145 839,00 €	1 458 390,00 €
300 - 399	549	202	110 898,00 €	1 108 980,00 €
400 - 499	589	159	93 651,00 €	936 510,00 €
500 - 699	619	179	110 801,00 €	1 108 010,00 €
700+	639	97	61 983,00 €	619 830,00 €
Capital AS IS				9 283 210,00 €

Capital TO BE is based on IT project budget financed by Resilience and recovery fund on Ministry of education, research, development and youth SR.

Table 6: Project budget implementing vertical integration.

Budget item	Budget
Software	1 632 793 EUR
IT Services	1 010 000 EUR
Hardware	350 000 EUR
License	120 000 EUR

Total	3 112 793 EUR

source: *https://www.crz.gov.sk/data/att/4880574.pdf*

Formula:

$$\frac{TFP_{asis}}{TFP_{tobe}} = \frac{K_{tobe} \cdot L_{tobe}}{K_{asis} \cdot L_{asis}}$$

Values:

K_{asis}= 9 283 210

K_{tobe}= 12 396 003

L_{asis}= 4 796 585

L_{tobe}= 1 938 044

$$\frac{TFP_{asis}}{TFP_{tobe}} = \frac{K_{tobe} \cdot L_{tobe}}{K_{asis} \cdot L_{asis}} = \frac{24\,023\,999\,238\,132}{41\,557\,100\,000\,000} = 0{,}58$$

The formula shows that the TFP in the "to-be" state is higher relative to the "as-is" state because the result is less than 1. Specifically, this means the "to-be" state is **more productive.** Moving to the "to-be" state requires higher costs, but it significantly reduces labor inputs.

6. Conclusion

This research provides an analysis of how digital transformation, particularly vertical and horizontal integration, enhances the elementary school admission process in Slovakia compared to traditional digitization methods. By employing the Constant Elasticity of Substitution (CES) production function, BPMN methodology, and a structured survey approach, the study quantifies the operational and financial impacts of transitioning from an "AS IS" model to a simulated "TO BE" digital transformation scenario.

The proposed "TO BE" model reduces labor costs by tens of % and achieves noticeable time savings across key tasks, such as issuing and delivering acceptance statements. This reduction is attributed to process automation, improved governance models, and centralized data integration. This result validates the hypothesis that moving beyond basic digitization to integrated digital transformation yields benefits, not only in terms of cost efficiency but also in overall process effectiveness.

To improve the overall findings of this study, several areas can be improved. Simulation Tools: Utilize advanced simulation software such as AnyLogic to model dynamic process changes. This would allow for the inclusion of variables like task dependencies and bottlenecks yielding more accurate predictions for time and cost savings. Enhanced Survey Design: Improve the survey methodology to better capture nuanced time allocations and identify specific challenges faced by stakeholders. Including follow-up interviews and qualitative feedback could provide richer data for analysis. From the methodology perspective further improvements can be reach in data collection with bigger sample and randomization.

Finally, this research illustrates that digital transformation is not merely about the adoption of new technologies; it is about fundamentally rethinking how public services are delivered. By addressing organizational silos, enhancing inter-organizational collaboration, and streamlining interactions between stakeholders, digital transformation can foster flexibility and adaptability in governance, ultimately benefiting both citizens and service providers.

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