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Sustainability Aspects of Administrative Process Management: a Case Study Analysis

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This article offers a detailed analysis of the university enrollment process from a process management perspective, focusing on sustainability aspects like the social cost of carbon. The study utilizes process visualization techniques, such as P-Graphs, to explore how administrative processes can be optimized to reduce environmental impact while maintaining efficiency. Enrollment is a vital yet complex component of university operations, often neglecting sustainability in traditional management approaches. Through a case study, this research demonstrates how process visualization can identify inefficiencies in the enrollment process and suggest improvements. By incorporating P-Graphs, the study evaluates sustainability metrics like carbon costs, guiding decision-makers in reducing environmental harm. The findings reveal that the current enrollment system is unsustainable in terms of operating costs, human factors, and CO_2 emissions. This research underscores the importance of integrating environmental considerations into administrative processes, showing that universities can enhance environmental performance while continuing to provide quality education by combining process management with sustainability principles.

1. Introduction

Today, sustainability issues and practices affect not only manufacturing companies but also the Public Administration sector. The EU Covenant of Mayors for Climate & Energy is an organization of thousands of local authorities who have set themselves the goal of creating a better future for their citizens. By voluntarily joining, they commit to achieving the EU's climate and energy objectives. The Covenant was launched in 2015 with the aim of keeping temperature rises below 1.5 °C at a rate supported by science. Their vision is to live in CO_2-free cities by 2050 and to reduce GHG emissions by 55 % by 2030 (Covenant of Mayors, 2021). The term Green Public Administration (GPA) is used to describe a series of action plans in a number of different areas: combating climate change, protecting biodiversity, protecting the environment, using fiscal and financial instruments, and developing policy coherence to foster sustainable development. Last but not least, and of importance for our research, is the greening of internal organization, reducing and minimizing CO_2 emissions and reducing the environmental footprint of public administrations. The European Committee on Democracy and Governance (CDDG, 2023) published a document on this. Alcaraz-Quiles et al. (2015) point out the lack of conceptual consistency between public administration and sustainability, and the importance of a precise definition and conceptualization in the field. This is also necessary because it is a relatively new subject area and the literature base is accordingly heterogeneous and difficult to define (Alcaraz-Quiles et al., 2015). The intersection and practical feasibility of sustainable development and public administration practice is highlighted by Leuenberger (2006), who stresses that it is primarily applicable to the fields of transportation, public hosting, human services and environmental protection. He also highlights the importance of human services (Leuenberger, 2006). Sustainability practices are not fundamentally developed in the public sector and are often neglected (Myhre et al., 2013). In public services, sustainability measurements are often based on the Global Reporting Initiatives (Adams et al., 2014). Public services are often wrongly assumed to have a lower environmental impact than other organizations. Several further conflicts within public management are highlighted by Oldenhof et al. (2014), who point to the impasse between efficiency and equity, efficiency and democratic legitimacy, and equity and freedom (Oldenhof et al., 2014). A number of government projects have been established to encourage public

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leaders to adopt practices that promote socio-environmental responsibility, while also promoting responsible practices as part of their long-term sustainability strategy (Dias de Souza et al., 2017). The new organizational system of public administration must integrate creativity, innovation and flexibility to be able to achieve sustainability and public value. Public administration is based on meeting two needs: society demands creative, flexible, innovation-oriented management, while economic tensions and budget constraints impose uses and models that focus on efficiency, competitiveness and cost savings (Palmi et al., 2021). However, public administration organizations are also increasingly and more vocally expected to meet sustainability criteria and to improve their processes or develop new criteria for assessing sustainability (Coutinho et al., 2018). As the expectations of the public sector have increased, they have begun to recognise the need to change their operations to take sustainability into account (Ramos et al., 2007), and the public sector requires significant resources. Sustainability research in the field of public services focuses on environmental management systems and sustainability reports on quality management systems (Nogueiro et al., 2014). European local authorities have different levels of intensity and implementation of sustainability policies (Krause et al., 2016) and, at the same time, they are the most active within the public sector (Joas and Grönholm, 2004). In Italy, for an analysis of the city of Melzo, five start-up strategies with different combinations of energy modernization measures were evaluated and compared, which is also a new approach within the field of sustainability and public administration. Using the co-production method to investigate the relationship between sustainability and decision-making in public administration processes, Wyborn et al. (2019) present a new approach to sustainability studies. In Portugal, a questionnaire survey sent to public sector organizations found that the overall results show a low level of acceptance of integrated sustainability policies and practices, despite the expected positive trends in relation to mandatory social and economic practices, and that many actions are still needed to achieve a sustainable social transition (Figueira et al., 2018). Overall, the public sector sustainability issues are complex, currently not fully defined and with a wide variety of models in practice. The present research investigates a public administration process from a sustainability perspective, including hard factors and the human factor. The question we are trying to answer in our model is whether the process is sustainable, and if not, what factors can be changed to make it sustainable or to reduce its CO_2 emissions? The university enrollment process was analyzed using the P-Graph methodology to determine parameters for sustainability calculations. P-Graph serves as a mathematical framework for solving Process Network Synthesis (PNS) problems, initially designed for chemical plant design but now applied to various problems sharing a common structure (Tan et al., 2018). Notably, P-Graph allows the determination of a maximal structure (Friedler et al., 1993), differing from structures in many Process Integration (PI) problems, as it is generated with mathematical rigor, reducing the risk of human error (Tick, 2007). Aviso et al. (2017) outlined a P-Graph-based human resource planning problem, addressing the need to redeploy resources during a crisis. The model generates alternative HR plans, with the selected final plan serving as a benchmark for recruitment and redeployment aligned with strategic goals (Aviso et al., 2019). The P-Graph approach has been effectively used to solve problems similar to PNS, including chemical reaction pathways, economic systems, and labor allocation. Based on the literature review it can be stated that the P-Graph approach was used less commonly for administrative process analysis, especially in case of public services, but based it can be stated that this is a valuable method for this purpose. The goal of this research is to introduce the P-Graph methodology as a new analytical process in the field of public administration processes as a novelty, showing how this application can be utilized to gain deeper understanding and quantifiable results in comparison to other process analysis methods, leading to more detailed improvement suggestions.

2. Materials and Methods

The subject of our study is the university enrolment process and its sustainability, as well as the measurement of CO_2 emissions. In this study only the emissions produced directly from the office operations were considered during the analysis, i.e. the paper used is not considered. The research question is: 'How sustainable is the current system, what are the CO_2 emissions of the different elements of the process, and whether it can be optimized?' For this research first the university enrolment team was approached. As a first step, in-depth interview was conducted with the deputy head of the office, who shared the steps of the current process based on a relatively simple process description. This process was then supplemented by in-depth interviews with staff in the office to get a more accurate picture. Afterwards, the parameters on the basis of which the CO_2 emissions and the social cost were measured were defined. It is important to note that the current process is carried out in both hard copy and digital formats. So the staff in the office do a double job: on the one hand they collect documents on paper and store and check them, and on the other hand they do the same tasks digitally. So even before starting to examine the process, it can be said that staff are doing double work, in whole or in part. With the help of the P-Graph methodology a more detailed and in-depth analysis can be carried out, using the available direct emission data, highlighting more clearly the nature and scale of the emission, especially considering the inefficiencies and anomalies of the process, such as the insufficient time, inefficiently organized process steps and unsatisfied stakeholders (administrators and students), which all justifies the need of a more complex and better organized solution. This highlights the necessity of overall process improvement for which the P-Graph method is a highly useful tool, leading to more practical approaches, effective techniques and less emission in the future. The investigated Hungarian university receives approximately 14,000 students, with 4,000-5,000 new enrollments per year. Analysis of the data reveals consistent trends over the past decade, indicating stable enrollment figures. The challenge is not in fluctuating enrollments, but in getting employees to adapt to changing stress levels and workloads. Staff turnover is high, estimated at around 20 % in the first 2 y, although those who persist tend to stay longer. Weekend work is often required, which increases stress levels.

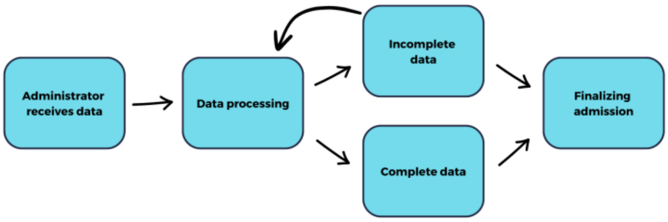

Figure 1: Main steps of digital and paper based enrolment process stages

As seen in Figure 1. after successful admission, the administrators have immediate access to student data and documentation from the central admissions database. The primary goal is the meticulous data recording within a time frame of 2-3 weeks, prior to contract management at a mass meeting. Additionally, administrators collect physical documents during the meeting. The second stage involves the management of paper-based documentation and the integration of ignored student information into the database. This phase, characterized by bureaucratic complexity, requires extensive corrections by administrators working under tight deadlines. Approximately 50-60 % of enrolled students are faced with paperwork, which necessitates multiple data requests. Administrators often work overtime to ensure the enrollment process is completed on time.

3. Calculation

In order to effectively use the P-Graph representation of the process, it is essential to define the input resources and constraints in advance. The primary input resource includes the available administrative human resource (A_n), which can be calculated based on factors such as the number of administrators, daily working hours, and working days per week. It is key to note that administrators have a tight three-week window to complete the first phase of the enrollment process once it begins, to ensure readiness for contract administration, which will follow with a further two weeks. In this context, the office is equipped with a workforce of 19 administrators (N_a) who work 8 h/d (H) for 5 days (D) a week (W). The overarching goal is to optimize the output of the process, and the completed documentation process is the final result. On average, we work with the assumption of NS=4,500 students who provide input documentation and enroll within the specified time frame. The calculation formulas used for these calculations are taken from a comprehensive study by Eisinger and Buics (2024).

$$A_n = N_a \times H \times D \times W \tag{1}$$

Because of the time constraints in the first stage the process will have A_1=2,280 h of human resources and in the second stage A_1=1,520 h of human resources.

Entering the second stage, the administrators follow a parallel process pattern to manage the paper-based documentation presented at the signing of the contract. However, there is a separate time schedule for each stage, and paper-based documentation takes longer to process than its electronic counterpart. It is worth noting that students often encounter errors at different stages, which necessitates several rounds of additional data requests. In addition, the overall time constraints of the entire process should be carefully considered in both stages independently. Another important input resource to consider is the man-hour required per documentation (L_n). Administrators report that the average processing time for each documentation is 30 min per student in the initial digital phase (P_1) and 45 min in the subsequent paper phase (P_2). Recognizing that administrators have additional daily tasks, it is reasonable to spend only 58 % (σ) of their time on the enrollment process. Consequently, the administrators receive a capacity of L_1=2,645 h (working hours) in the first stage and L_2=1,175 h (working hours) in the second stage, which acts as a significant limitation within the process.

$$L_n = \frac{N_a \times H \times D \times W \times (1-\sigma)}{P_n} \tag{2}$$

Essentially, these work time limits describe the maximum workload that administrators can take on at each stage of the enrollment process. It is imperative that these resources are managed and allocated judiciously to ensure that tasks are completed efficiently and on time while maintaining a balance with other organizational needs. By using this knowledge and optimizing resource allocation strategies, we can effectively navigate the complexities inherent in the registration process and improve overall operational efficiency. In this scenario, an additional limitation applies to the administrators' schedule. We assume that all admins work daily and the remaining 48 % are available for other duties, breaks and business hours. Also, although administrator experience indicates a 50-60 % error rate in documentation in the second stage, this model initially assumed a moderate error rate of 10-20 % for this scenario.

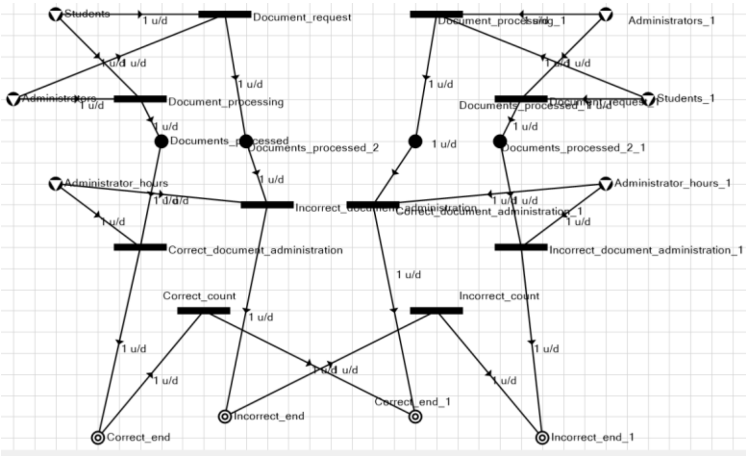

Figure 2: P-Graph visualization of the university enrolment process

Figure 2. shows a P-Graph representation of the university enrollment process, showing the resources, operational units and intermediate operations generated by the P-Graph Studio software. In this framework, administrators, their capacity and students are identified as key resources in the process. In the initial stage, the task of the administrators is either to process the documents submitted by the students, or in case of inaccuracy or incompleteness, to request further clarification, and then to process the received data.

4. Results

According to the model results, based on the assigned resources in this this model, administrators could process 2,011 (45 %) documents during the first stage and 906 (20 %) documents maximum during the second stage, far from the initially considered 4,500 student documents. This means that in order to finish the administrative processing of the documents according to the set time constraints administrators have to work overtime both in the first and in the second stage of the process in order to not delay the whole process itself. From a sustainability perspective this significant amount of overtime work creates a huge burden regarding the university infrastructure, utilities and CO_2 emissions as well (Table 2).

From sustainability perspective four utilities cost items were considered, whose unit prices per processed documentations including VAT were as follows for the organization under study: gas energy (0.34 €/m^3), Heating (1.01 €/GJ), Electricity (0.57 €/kWh), Water and sewerage (0.16 €/m^3), which were determined based on the data from the Hungarian Central Statistical Office (KSH, 2023).

$$\sum_{I=1}^{n} \frac{(CN_1 * PT_1 * C_I) + (CN_2 * PT_2 * C_I)}{Q_I} * E_I \qquad (3)$$

The following formula was used to determine the overall CO_2 emissions based on the used quantities and costs of the considered utilities, where CN is the number of documentation processed and finished during normal office our and overtime, PT is the process time associated with the first and second phase process steps, C_I is the associated costs of the considered utilities, Q_I is the price per used quantity, and E_I is the associated CO_2 emission per utility unit (World Bank, 2024). As we can see in Table 2, according to the results of this scenario administrators were able to process 45 % of the student documentation (2,011 units) in the first phase and 20 % of the documentation (906 units) in the second phase of the enrollment process during normal working hours, leading to an overall 5,098.87 $kgCO_2$ emission based on the associated utility costs and quantities.

55 % of the first phase (2489 units) and 80 % of the second phase (3,594 units) documentation was processed overtime in order to meet with the deadlines of the enrollment process. As a result of the inefficiencies in the data processing and handling (hybrid electronic and paper-based data collection and processing) overall 8,204.32 € overtime expenses were generated with an overall 11,922.57 $kgCO_2$ emission, which could be avoided by making the process more efficient and more sustainable regarding energy consumption.

Table 2: Processed cases and associated utility costs

	Gas	Heating	Electricity	Water	SUM
Office work (€)	580.07	1,695.77	955.41	277.45	3,508.70
CO_2 emission ($kgCO_2$)	154.20	31.23	4,877.64	35.80	5,098.87
Overtime work (€)	1,356.36	3,965.18	2,234.02	648.75	8,204.32
CO_2 emission ($kgCO_2$)	360.55	73.04	11,405.28	83.71	11,922.57

5. Discussion and Conclusion

In this study, the enrollment process and its sustainability at a Hungarian university were examined as a case study. The goal of this research was to analyze this enrollment process to provide improvement opportunities. While similar enrollment processes are found at other Hungarian universities, differences might exist in universities in the rest of the European Union and the rest of the world. Because of this, the generalizability of this particular approach is limited, but a similar approach could certainly be used, taking into account the intricate details of the examined process. In the primary data collection 4,500 enrolled students were estimated (usually the number of students who enroll in the university in the autumn semester) and 19 administrators. The enrolment process is divided into two phases, with administrators able to process 2011 (45 %) documents in the first phase and up to 906 (20 %) documents in the second phase, far below the originally planned 4500 student documents. Therefore, administrators in both the first and second phases have to work overtime to ensure that enrolment is completed on time and does not delay the whole process. Significant overtime is not sustainable, it is a significant additional burden on university infrastructure, utilities and human factor. In this research four utility cost items were considered, whose unit prices per processed documentations including VAT for the organization under study were: gas energy (0.34 €/m3), heating (1.01 €/GJ), electricity (0.57 €/kWh), water and sewerage (0.16 €/m3), based on data from the Central Statistical Office (KSH, 2023). As a result of the research conducted using the P-Graph, it was found that the administrators were able to process 45 % of the student documentation (2011 items) in the first phase of the enrolment process and 20 % of the documentation (906 items) in the second phase during normal working hours, i.e. 8 h/d, without being able to spend the whole day on enrolment. 55 % (2,489 units) of the documentation for the first phase and 80 % (3,594 units) of the documentation for the second phase were processed overtime in order to meet the deadline for the enrolment process. Based on the analysis, the inefficiencies in data processing and management (hybrid electronic and paper data collection and processing) resulted in a total overtime cost of 8,204.32 EUR, which could be avoided by making the process more efficient and more sustainable in terms of energy consumption. During normal working hours an overall of 5,098.87 $kgCO_2$ emission were generated, while due to the required overtime working hours an additional 11,922.57 $kgCO_2$ emission was generated, which could be avoided by making the process more efficient. It can be concluded that the current university enrolment system in this form, with this process, is not at all sustainable in terms of operating costs, human factor and CO_2 load. It is not beneficial from the point of view of the efficiency and sustainability of the process, the high turnover of staff, which requires additional training time for experienced administrators, is an additional cost and CO_2 burden. Since the process under study is similar in all Hungarian universities, the results can be generalized to all universities in Hungary. The results of this study, although focused on the enrollment process of a specific Hungarian university, provide broader insights that can be applied in a similar context in Hungary and potentially in other regions. The revealed shortcomings, especially in the hybrid electronic and paper-based data management system, probably reflect the challenge that many Hungarian universities have to face due to similar administrative structures and resource constraints. Therefore, the conclusions drawn on the unsustainability of the current enrollment process in terms of operating costs, human resources and CO_2 emissions are likely valid in Hungarian higher education institutions. However, the generalization of these results to universities outside Hungary requires caution due to differences in administrative processes and infrastructure. Nevertheless, the applied methodology, especially the application of P-Graphs, can be adapted to other contexts, allowing universities to assess and improve the sustainability of their own enrollment processes, taking into account local specificities. At the same time, we recommend to university decision-makers that, as the transition to digital administration (client gateway) and its potential has already been made in the field of public administration, enrolment and other university administrative tasks should be fully digitized, making the process more sustainable in the long term.

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