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The Application of Stochastic ICIM Model in the Decision-Making Processes of Insurance Product Management

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Abstract

Background: The significance of this study arises from the increasing complexity of managing insurance products, driven by the need to accurately model and predict the occurrence of insured events and associated risks. These processes are relevant not only to life insurance companies but to any institution offering personal insurance and supplementary coverages, such as banks, brokerage firms, and others. Existing literature highlights extensive possibilities for the application of stochastic processes in various fields, including finance, biology, and environmental engineering, with notable applicability in insurance.

Purpose: This article aims to explore the application of stochastic models in the decision-making processes for managing insurance products. Specifically, it focuses on the development and utilization of multi-state models for pricing selected insurance products and analysing the impact of parameter changes on the amount of regular net premium.

Study design/methodology/approach: We start with the traditional 'Healthy-Dead' model, which we extend to include the 'Sick' state. By restricting the transition from this state to the 'Healthy' state, we obtain a three-state 'Healthy-Sick-Dead' model for incurable critical illness. This is a non-homogeneous Markov process characterized by the respective transition probabilities. Actuarial calculations of transition probabilities are based on specific statistical data from an unnamed insurance company. The resulting regular net premium represents the real (net) price of the supplementary insurance product for incurable critical illness.

Findings/conclusions: The main findings suggest that incorporating stochastic models into the creation and management of insurance products allows for more accurate predictions of insured events and better risk assessment. The introduced three-state model provides a robust framework for pricing supplementary insurance due to incurable critical illness. The analysis demonstrates how changes in transition probabilities affect the amount of net premium, underscoring the importance of precise parameter estimation.

Limitations/future research: The study's limitations include reliance on accurate historical data, which may not fully capture future trends and changes in health outcomes, as experienced during the Covid-19 pandemic. Future research should explore the integration of a larger amount of real data and advanced computational methods for their processing. Additionally, extending the model to include the 'recovery' transition would enhance its applicability for 'all' types of critical illnesses. The creation of such an insurance product would, however, assume the availability of a large amount of high-quality data (Schmidt, 2021).

Keywords

Stochastic processes, insurance, rider, multi-state models, critical illness, transition probabilities, Markov processes, annual net premium, Incurable Critical Illness Model

Introduction

The turn of the millennium marked a significant expansion in the use of stochastic processes, with extensive applications in modelling financial markets, predicting stock prices and commodity prices, developing financial models and risk management strategies (Shreve, 2004; Cerqueti, 2021), in operations research (Campbell & MacKinlay, 1997; Fu & Hu, 2002), in modelling biological systems (Wilkinson, 2006; Rogers, 2011), and in the development of prognostic models in medicine (Simpson, et al., 2012; Bergés, et al., 2023), biometrics (Hu & Laurière, 2023) and biophysics (He, 2022). Stochastic processes also play a key role in hydrology and environmental engineering for modelling weather conditions, weather forecasting (Weeks, 2010), and climate change analysis and modelling (Palmer, 1999; Hipel, 2000). In geophysics, they are used in modelling geological processes, analysing earth layers (Gautier, 2016), and modelling groundwater contamination (Neuman & Wierenga, 2012).

Currently, stochastic processes remain a focus of active research. New technologies and computational methods allow for more sophisticated analyses and modelling of random processes across many domains. These analyses often employ advanced mathematical and computational techniques to solve complex problems and gain a deeper understanding of the structure and behaviour of random processes. Their flexibility and ability to model unpredictable phenomena make them an indispensable tool in various scientific disciplines, including insurance. In this field, stochastic models are crucial for pricing insurance products and managing risks associated with events such as accidents, natural disasters, or critical illnesses.

Given the constant advancements in medicine and changes in population health outcomes, it is essential to continually adapt and improve existing models to better reflect current conditions and risks. In this context, exploring new approaches to modelling insurance risks is imperative, and this was the motivation behind conducting this study.

The aim of this study is to develop and apply a three-state stochastic process model, called the Incurable Critical Illness Model (ICIM), for assessing premiums for incurable critical illnesses in life insurance. This model extends the traditional two-state 'Healthy–Dead' model by including a 'Sick' state, allowing for a more accurate reflection of health risks and enabling more precise premium determination for products that include critical illness riders.

The proposed method is based on stochastic process theory, as described by Shreve (2004) and Bowers et al. (1997) in the context of actuarial mathematics. A Markov process is used to model transitions between health states, a technique that has already been applied in biostatistical and actuarial studies (Škrovánková & Simonka, 2021).

In this study, the ICIM model is applied to calculate net premiums for critical illness riders.

Based on the nature of this article, several practical research questions can be formulated:

1. How do the transition probabilities between health states affect the calculation of net premiums?
2. How might changes in the transition probabilities within the ICIM model impact the insurer's financial stability?

These research questions lead to an exploration of the relationship between health state transitions and their financial implications for the insurer, offering valuable insights for more accurate risk assessment and premium determination.

1. The Possibilities of Using Stochastic Processes and Modelling in Insurance

Stochastic processes are a key tool in the insurance industry, offering a wide range of applications. Insurance events, such as death due to accidents or other causes, changes in health status (e.g., contracting an incurable disease), accidents, fires, natural disasters, or other catastrophic events, are often random and irregular. To address these uncertainties, stochastic models are employed to estimate the probability of such events occurring over time. These processes are crucial for risk modelling, financial product valuation, and portfolio management. They also offer tools for forecasting future events and developing risk management strategies (Poláček & Páleš, 2012; Brokešová, et al, 2023). Their applications include the design of life insurance products and pension plans, minimising mortality and longevity risks (Choulli et al., 2021; D´Amato, et al., 2020), reinsurance (Colaneri, et al. 2024; Shen, 2024), and capital management.

1.1. Modelling Insurance Claims

Insurance claim modelling uses stochastic processes to predict insurance events. In life insurance, it helps forecast longevity and mortality, while in non-life insurance, it models the number of claims and total damages (Clemente et al., 2023; Tadayon & Ghanbarzadeh, 2024). This process is important for actuarial risk assessment and premium determination. Various models, such as the Poisson process and Binomial model, offer different advantages, making model selection crucial. Accurate claim prediction involves identifying key factors, configuring the model, estimating parameters using historical data, and evaluating performance. Insurers' ability to handle big data significantly impacts this process (Mišút, 2021).

1.2. Development of Insurance Products

Insurance companies offer products with varying returns and risks, and developing new products is a dynamic process aimed at meeting customer needs while ensuring the company's sustainability. Products are designed with goals such as increasing market share, competitiveness, profitability, or offering new protection options. This process involves defining coverage, terms, premiums, and policy duration, followed by actuarial and financial analyses to assess risk and set appropriate premiums. After launch, product performance is monitored and adjusted as necessary. Successful product development requires market analysis, understanding customer needs, and adapting to industry trends (Hellriegel, 2019).

1.3. Risk Management

Risk management involves identifying, assessing, and managing risks that impact an organization's operations and performance. Stochastic processes help insurance companies quantify risks within their insurance portfolios, ensuring solvency and stability. Risks can be internal (operational, HR, technological) or external (market, competition, natural). Risk assessment determines the likelihood and impact of each risk, helping organizations prioritize those that require management. Effective risk management is essential for long-term success, financial stability, and solvency in uncertain environments, leading to improved performance and value protection (McNeil, Frey & Embrechts, 2015).

1.4. Customizable Insurance Premium Rates

Customizable insurance premium rates allow companies to better account for individual risks and customer needs, personalizing prices based on factors like age, gender, residence, driving habits, and health status. This approach is gaining popularity due to increased data availability and advancements in data analysis (Páleš, 2012). Data collection and dynamic pricing are essential, enabling companies to adjust rates based on real-time data. For example, a driver who frequently uses safety features may pay less than one with a poor driving record (Biener, 2019). Stochastic models help ensure fair, risk-based premium rates.

2. Multi-state Models in Applications

Multi-state models (MsM) represent a powerful tool for analysing and predicting the behaviour of complex systems. They are utilised in various scientific and applied fields (some of which are mentioned below) to model the interactions between different parts of a system and to understand the dynamics of these systems.

2.1. Economics

In economics, multi-state models are used to model economic systems, including market interactions, macroeconomic trends, and the behaviour of consumers and producers. These models can help in predicting market developments, analysing economic policy, and assessing economic risks.

One specific example of the use of multi-state models in economics is the modelling of economic cycles using Dynamic Stochastic General Equilibrium (DSGE) models.

In addition to DSGE models, multi-state models are also used to analyse the impact of external shocks, such as pandemics, on the economy. For example, the epidemic–economic delay model has been applied to study the effects of lockdowns on the progression of infectious diseases and economic performance. The model emphasises that well-timed and strict lockdowns can significantly reduce infection rates and delay the epidemic peak, thereby easing pressure on healthcare systems. However, such measures can also negatively impact the economy, particularly if isolated individuals become less productive (Ishikawa, 2022; Mozokhina et al., 2024).

2.2. Social Sphere

Multi-state models in social sciences are used to model social networks, the spread of opinions, and the behaviour of individuals and groups. These models can be useful in analysing the spread of diseases, the dissemination of information, and predicting trends in society.

An example of the use of a multi-state model in the social sphere is the modelling of opinion or behaviour spread in social networks. These models are used to study social phenomena such as trend propagation, political polarisation, group identity formation, or the spread of new technologies. They can also be used to predict social changes or to design strategies to influence social behaviour.

A specific practical example is the "Diffusion of Innovations Model", which is used to study the spread of new products, technologies, or innovations in a population (Rogers, 2003).

2.3. Insurance

Multi-state models are increasingly utilised in insurance to model the complex processes of changes in the health status of insured individuals and their life events. These models enable the analysis of transitions between various health and risk states, which is crucial for product pricing, risk management, and the establishment of insurance reserves (D’Amico, et al., 2017). In insurance, multi-state models are mathematical and statistical tools used to predict risk, de-risking (Levantesi, et al., 2024; D´Amato, et al., 2020) and determine the pricing of insurance products (Christiansen & Niemeyer, 2015). These models take into account not only traditional factors such as age, gender, and health status but also factors like geographic location, lifestyle, and their interactions (D’Amico, et al., 2020). They enable insurance companies to forecast the likelihood of various insurance events, utilising a wide range of statistical methods, probabilistic models, and historical data to predict the number of accidents, extent of damages from accidents, fires, natural disasters, and other events, as well as the spread of diseases and their fatal outcomes.

In the context of critical illness insurance, these models become particularly valuable. For instance, stochastic interest rate models, like the Cox-Ingersoll-Ross model, are used in combination with multi-state Markov models to simulate transitions between health states, such as healthy, critically ill, or deceased, allowing for more accurate premium calculations and risk assessment (Alim, et al., 2019). Similarly, the increasing use of multi-state models in public health, particularly during the Covid-19 pandemic, demonstrates their versatility (Mohammadi et al., 2024; Zhao et al., 2024). The SIRD model (susceptible, infected, recovered, dead), for example, helps estimate the basic reproduction number R_0, providing insights into virus transmission dynamics (Zuhairoh, et al., 2021). Additionally, the SVIRD model (susceptible, vaccinated, infected, recovered, dead), which incorporates vaccination status, has been instrumental in predicting multiple pandemic waves and improving the accuracy of epidemic forecasting (Zuhairoh, et al., 2024). These examples highlight the broad applicability of multi-state models in both insurance and public health, where they serve as critical tools for managing risk and uncertainty.

In the following sections, we will specifically focus on certain types of illnesses – incurable critical illnesses and their modelling.

3. Developing and Application of Multi-state Models of Stochastic Processes in Insurance

3.1. Methodology

The 'Healthy - Dead' two-state model is a simple mathematical model used in epidemiology or biostatistics to describe a population in which each individual is in one of two possible states: 'Healthy' or 'Dead' (Andersen & Ravn, 2023). The equivalent model 'Alive - Dead' (also known as the mortality model or the basic survival model) is the simplest multi-state model applied in insurance.

By extending this model to include the 'Critically Ill' state, we develop a three-state model aimed at modelling the product “Incurable Critical Illness Rider”. We will evaluate the quality and completeness of the collected data to ensure their suitability for applying a multi-state stochastic model. Using theoretical insights from the modelling of stochastic processes with the Markov property, we will construct a three-state model and use it to calculate the premium for a client in a specific age category.

The three-state ICIM model offers significant advantages in the accuracy of premium calculation and risk modelling for critical illnesses, as it includes the intermediate state of 'ill'. This state accounts for the fact that an insured individual may remain in this condition for an extended period before death occurs. Such an extension of the traditional two-state model results in a more precise calculation of premiums.

At the same time, the ICIM model is a 'narrowing' of the classical four-state model for critical illness cover, where state (4) represents 'Death from other causes'. Since the probabilities of transitioning to state (4) do not affect the transitions between states in the ICIM model, ICIM proves to be the most suitable for modelling the 'critical illness rider' product.

This model will also be used to analyse the impact of various parameters on premium calculation. As a result, in addition to determining the standard annual net premium for the incurable critical illness rider, we aim to address our research questions as well.

3.2. Data analyses

The data used in this study were obtained from an unnamed insurance company currently operating in Slovakia, which is a subsidiary of a foreign insurer. The dataset comprised information on the number of insured individuals in the insurance portfolio by age (as relevant to the research), gender, health status, survival, and death. The annual data captured the number of individuals at the start and end of each year for specific critical illnesses (though not all), as well as any disabilities caused by these illnesses. The dataset also included specific real-world probabilities of transitioning from a 'healthy' state to a 'critically ill' state and from a 'critically ill' state to a 'deceased' state across different age groups. These probabilities were derived from the insurer’s historical data, enabling reliable modelling of transitions between health states within the analysed groups. As a result, the data meet all the necessary criteria for the application of a multi-state stochastic model.

Based on the insurance company's data, we can conclude that the probabilities of contracting a critical illness for the age groups 50 – 64 years are very low. A major role in this is played by early diagnosis, which has improved over the last decade due to increased awareness and the need for preventive examinations. On the other hand, the annual probabilities of remaining in a state of critical illness are relatively high. This is due to medical advances in the treatment of critical diseases, as well as improved care for patients.

Table 1 Annual transition probabilities

Age x	p_x^{11}	p_x^{12}	p_x^{13}	$p_x^{11}+p_x^{12}+p_x^{13}$	p_x^{22}	p_x^{23}	$p_x^{22}+p_x^{23}$
50	0,997237	0,000723	0,002040	1	0,871638	0,128362	1
51	0,996966	0,000802	0,002232	1	0,867415	0,132585	1
52	0,996674	0,000896	0,002430	1	0,859097	0,140903	1
53	0,996329	0,000987	0,002684	1	0,851596	0,148404	1
54	0,995964	0,001100	0,002936	1	0,847211	0,152789	1
55	0,995581	0,001216	0,003203	1	0,843891	0,156109	1
56	0,995191	0,001350	0,003459	1	0,839551	0,160449	1
57	0,994718	0,001499	0,003783	1	0,836322	0,163678	1
58	0,994201	0,001641	0,004158	1	0,833285	0,166715	1
59	0,993606	0,001815	0,004579	1	0,826912	0,173088	1
60	0,992940	0,002034	0,005026	1	0,824793	0,175207	1
62	0,992239	0,002226	0,005535	1	0,823071	0,176929	1
63	0,991568	0,002428	0,006004	1	0,820843	0,179157	1
64	0,990849	0,002681	0,006470	1	0,816619	0,183381	1

Source: the authors processing based on specific data from an unnamed insurance company

3.3. Construction of the Three-state Model

For our purposes, we will extend the two-state 'Healthy - Dead' model to include an additional state: critically ill. This introduces the possibility of recovery, thus a reverse transition from the 'Sick' state back to the 'Healthy' state. We will assume the illness is due to an incurable critical illness (ICI), thereby limiting the mutual transition between the 'Healthy' and 'Sick' states, with no reverse transition possible (see Figure 1). This model, for ease of reference in the article, will be called the Incurable Critical Illness Model (ICIM). The three-state ICIM model is a 'narrowing' of the four-state model for critical illnesses covers, in which state (4) is 'Death from other causes' (Haberman & Pitacco, 1998).

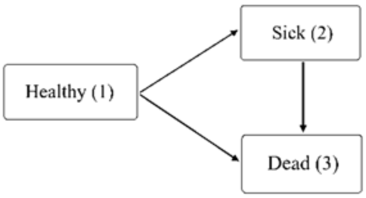

Figure 1 Three-state Model of Incurable Critical Illness
Source: the authors

However, as the article will focus on the 'critical illness rider' product, the probabilities of transition to state (4) will not impact this product.

We consider a time-inhomogeneous Markov chain $\{S(x); 0 \leq x < \infty\}$ with a finite state space, where $S(x)$ we denote the state of the process at time *x*. In our case $S(x) \in \{1, 2, 3\}$.

The model has three states:
(1) – Healthy,
(2) – Sick (ill with an incurable critical illness),
(3) – Death.

Generally, when considering a finite number of states (*n*), the symbol ${}_t p_x^{ab}$ denotes the conditional probability

$${}_t p_x^{ab} = P\left[S(x+t) = b \middle| S(x) = a\right]; a, b \in \{1,2,3,\ldots,n\}$$

that is, the probability that the process was in state (*b*) at time $x + t$ given that it was in state (*a*) at time *x*. This stochastic process can be described as Markovian – we assume that the transition probabilities are not influenced by information about the state of the process prior to time *x*.

For state (*k*) and given probabilities, the following properties apply:

- state (*k*) is absorbing, meaning that once the process enters state (*k*), it remains there indefinitely. For all ages *x* and time *t*, it holds that:

$${}_t p_x^{kk} = 1 \text{ and } {}_t p_x^{kb} = 0 \text{ for all } k \neq b \quad (1)$$

- for all ages *x*, time *t*, and fixed *a*, it applies that:

$$\sum_{b=1}^{n} {}_t p_x^{ab} = 1 \quad (2)$$

The stochastic processes described by our ICIM model can be understood as continuous Markov processes. Therefore, individual transitions between states can be characterized by transition intensities μ_{x+t}^{ab}, with the following conditions:

$${}_t p_x^{ab} = e^{-\int_0^t \mu_{x+s}^{ab} \, ds} \quad (3)$$

To calculate individual probabilities, we can use differential equations, as mentioned in the books by Dicskon et al. (2009) and Škrovánková & Simonka (2021). For further actuarial calculations for the given product, we will consider time *t* in years, thus treating transition probabilities as deterministic data.

According to the directed edges (transitions) between nodes (states) in our ICIM model (Figure 1), we can denote the transition probabilities as follows:

${}_t p_x^{11}$ – the probability that a person who was healthy at age x remains healthy at age $x+t$

${}_t p_x^{12}$ – the probability that a person who was healthy at age x becomes ill by age $x+t$

${}_t p_x^{13}$ – the probability that a person who was healthy at age x dies by age $x+t$

${}_t p_x^{22}$ – the probability that a person who was ill at age x remains ill by age $x+t$

${}_t p_x^{23}$ – the probability that a person who was ill at age x dies by age $x+t$

Given the states and transitions between them (Figure 1), the following holds:

$${}_t p_x^{21} = 0, \; {}_t p_x^{32} = 0 \text{ and } {}_t p_x^{33} = 1$$

Based on property (2) for time *t* in our model, we obtain:

$${}_t p_x^{11} + {}_t p_x^{12} + {}_t p_x^{13} = 1 \text{ and } {}_t p_x^{22} + {}_t p_x^{23} = 1$$

As we discussed in the earlier parts of the article, it is crucial for an insurance company to set appropriate premiums for a specific product.

We will focus on calculating the annual net premium P_x. The calculations will be based on real data provided by the insurance company (Table 1), ensuring that the results accurately reflect the relevant circumstances derived from the provided data.

3.4. Application of ICIM model

We will apply our ICIM model to create critical illness rider. This involves a rider for incurable critical illness (ICI), under which the insurer will pay the insured person a regular annual advance payment of €10,000 as long as they remain in this state and do not die. The price for this product is the standard annual premium set by the insurer, paid by potential clients from the inception of the insurance contract while they are in a healthy state. The rider will only be offered to individuals from the age of 18, and the maximum duration of the insurance is until the age of 65.
Note: Beyond this age, a potential client becomes a risk, i.e., the probability of contracting a critical illness is too high for the insurer.

To calculate the annual net premium, we will use the following formula:

$$P_x = \frac{\sum_{t=0}^{64-x} D \cdot {}_t p_x^{11} \cdot p_{x+t}^{12} \cdot v^{t+1} \cdot \ddot{a}^{22}_{x+t+1,\overline{64-(x+t)}|}}{\ddot{a}^{11}_{x,\overline{64-x}|}} \quad (4)$$

where

D – advance annual payment (in our case €10,000)

${}_t p_x^{11}$ – probability of an x-year-old person remaining in state (1) 'healthy' until age $x+t$

p_{x+t}^{12} – annual probability of an $x+t$-year-old healthy person transitioning to state (2) 'Sick' at age $x+t+1$

v – discount factor $v = \frac{1}{1+i}$, where i is the interest rate (in our case 0.7%)

$\ddot{a}^{22}_{x+t+1,\overline{64-(x+t)}|}$ – temporary annuity-due $x+t+1$-year-old person with a term of $64-(x+t)$ years with probabilities ${}_t p_x^{22}$ of remaining in state (2) 'Sick'

$\ddot{a}^{11}_{x,\overline{64-x}|}$ – temporary annuity-due x-year-old person with a term of $64-x$ years with probabilities ${}_t p_x^{11}$ of remaining in state (1) 'Healthy'.

These annuities should be calculated according to formulas mentioned in the books by Bowers et al. (1997) and Krčová et al. (2022).

We will consider a 50-year-old person, calculate the amount of the standard net premium for them, and in the next part, analyse the impact of changes in some probabilities on its amount. It is assumed that the life insurance company has the following annual transition probabilities (for remaining in the same state and transitioning to another state) for ages 50 to 64.

To calculate the standard net premium for a 50-year-old person, probabilities of remaining in the state will also be needed. These are calculated for all ages x and time $t \geq 0$ using annual probabilities (Gerber, 1997)

$${}_t p_x^{ab} = p_x^{ab} \cdot p_{x+1}^{ab} \cdot p_{x+2}^{ab} \cdot \ldots \cdot p_{x+t-1}^{ab} \quad (5)$$

After substituting all the values into equation (4), we obtain the amount of the standard annual net premium for a client today aged 50 years

$$P_{50} = €52.19 \quad (6)$$

The calculated premium is not high in relation to the insurance benefits (payments) paid out. If we consider that the transition annual probabilities from a healthy to a sick state (see Table 1) are very small, it is clear that such a situation is not a great risk for the insurer.

3.5. Analysis of the impact of input parameters on the premium calculation

In creating and pricing its new product, the insurance company closely analyses the impact of input parameters on the premium amount in an effort to maintain its stability, solvency, and profitability.

From equation (4) it is evident that the amount of the premium is influenced not only by the transition probabilities but also by the actuarial interest rate. We will not explore the impact of its changes in this article; instead, we will focus on the effects of changing probabilities.

We will consider several scenarios and analyse the impact of changes in the annual probabilities of transition from a 'Healthy' state to a 'Sick' state, and the probabilities of remaining in the 'Sick' state, on the amount of the standard net premium.

The standard net premium (6) will serve as the reference premium. Changes in the annual probability of transition from the 'Healthy' to the 'Sick' state, whether an increase (+) or a decrease (–) in percentages, with the annual probability of remaining in the 'Sick' state unchanged, as well as the amount of the annual net premium are presented in Table 2.

Table 2 The impact of changing the annual probability of transition to the state 'Sick' on the net premium amount for a 50-year-old person

Scenario	Rate of change p_x^{12} (%)	P_{50}
1	- 20%	€41.75
2	-10%	€46.97
3	0%	€52.19
4	10%	€57.41
5	20%	€62.63

Source: the authors

A reduction in this probability indicates that potential clients are healthier than those previously recorded in the insurance company's data, and vice versa. According to scenarios 1 and 2 in Table 2, clients would pay less annually than the original premium. From the insurance company's perspective, this is advantageous and contributes to increased profitability of the product. For example, with a 10% reduction in the annual probability of becoming 'ill', clients would only pay 90% of the original premium. Conversely, if health conditions deteriorate (as in scenarios 4 and 5 of Table 2), the original premium would be lower than necessary, potentially resulting in losses from the product's sale.

Further analysis of the product will consider the change in the annual probability of remaining in the 'Sick' state, while the annual probability of transition from the 'Healthy' to the 'Sick' state remains unchanged. The results are presented in Table 3.

Table 3 The impact of changing the annual probability of remaining in the state 'Sick' on the net premium amount for a 50-year-old person

Scenario	Rate of change p_x^{22} (%)	P_{50}
1	- 20%	€35.33
2	- 10%	€42.29
3	0%	€52.19
4	10%	€66.82
5	20%	€89.24

Source: the authors

A decrease (increase) in this probability indicates that critically ill clients die quicker (slower) than reflected in the insurance company's data. From the various scenarios, it is evident how the price of the product would change relative to its reference value. For instance, with a 10% reduction in the annual probability of remaining in the 'Sick' state, clients would only need to pay 81.03% of the original premium, thus allowing the insurance company to offer the product cheaper and potentially increase its competitiveness if needed. With a 20% reduction in the annual probability, clients would pay only 67.70% of the original premium, whereas a 20% increase would result in a 20% higher payment.

As the lower annual probability of remaining in the 'Ill' state means that funds from unclaimed benefits stay with the insurer, the product becomes more profitable. Conversely, if improvements in medical care and advancements in medical science led to a statistically higher annual probability of remaining in the 'Sick' state, i.e., a 'beneficiary', the insurer would need to find additional financial resources from its own funds to cover benefit payments. This increases the risk of 'loss' from selling this product.

Let's consider four additional possible scenarios (Table 4). We will contemplate changes in the annual probability of transition from a 'Healthy' to a 'Sick' state (e.g., due to deteriorated or improved living conditions) and changes in the annual probability of remaining in the 'Sick' state (e.g., due to worsening or improving healthcare depending on the country where the client resides).

Table 4 The impact of changes in both annual probabilities p_x^{12} and p_x^{22} on the net premium amount for a 50-year-old person

Scenario	Rate of change p_x^{12} (%)	Rate of change p_x^{22} (%)	P_{50}	ΔP_{50} (%)
1	- 10%	-10%	€38.06	-40,83%
2	10%	-10%	€46.52	-26,99%
3	0%	0%	€52.19	0%
4	- 10%	10%	€60.13	10,86%
5	10%	10%	€73.50	15,21%

Source: the authors

From Table 4, it is clear that changes in both annual probabilities have a significant impact on the change in the amount of the reference premium. Scenario 1 is considered the best case from the insurer's perspective. The insurer could thus save financial resources, invest them appropriately, and distribute a portion of the return to policyholders, for example, in the form of an additional share of the profit. Conversely, scenario 5 could be detrimental to the insurer. Therefore, the insurer should be cautious when entering into insurance contracts, and clients should at least complete a questionnaire that includes questions related not only to health but also to profession and individual lifestyle.

3.6. Discussion

The results of our study indicate that the implementation of the three-state model (ICIM) for calculating critical illness insurance premiums offers significant benefits to the insurance sector, particularly in the development of products with riders for terminal critical illnesses. Modelling for specific age groups suggests that this approach provides more accurate risk estimates, enabling more effective premium determination.

In contrast to the traditional two-state 'Healthy-Dead' model, which does not account for the 'ill' state, the ICIM incorporates this intermediate state, providing more accurate risk estimates related to incurable critical illnesses. Furthermore, compared to the more complex four-state model, which distinguishes between deaths from critical illnesses and deaths from other causes, the ICIM offers a simpler yet more precise interpretation of financial risk for insurers. Differentiating between causes of death does not add significant value to premium calculation when the primary focus is on insuring risks associated with long-term critical illnesses. The ICIM focuses solely on this key factor, simplifying the model without sacrificing accuracy, while enabling insurers to manage claims costs more effectively. As a result, the ICIM strikes a balance between simplicity and accuracy, delivering better outcomes in premium calculation for products targeting incurable critical illnesses.

Our qualitative data analysis revealed that in the 50-64 age group, the probability of developing a critical illness is relatively low, which can be attributed to early diagnosis and greater awareness of preventive check-ups. Conversely, the likelihood of remaining in a critical illness state is relatively high due to advances in medical care and treatment for individuals with critical illnesses.

The impact of model parameters on premium calculation was explored in the quantitative analysis, where we identified several key factors. For the ICIM model, the annual probability of transition from the “Healthy” to the “Sick” state and the probability of remaining in the “Sick” state are of fundamental importance. Our scenario-based simulations demonstrate that a reduction in the probability of transitioning to the “Sick” state lowers the premium, contributing to the competitiveness of the insurance product. However, an increase in this probability may lead to losses for the insurer, highlighting the need for careful monitoring and adjustment of insurance products.

Additionally, we examined the effect of changes in the probability of remaining in the “Sick” state. If this probability decreases, for example, due to a deterioration in the insured’s health, the premium will decrease, allowing the insurer to achieve higher profitability. On the other hand, an increase in this probability, for instance, due to medical advances, could lead to a higher financial burden for the insurer, as claims payouts would become more frequent and extended.

3.6. Results and limitations

Based on data obtained from an unnamed insurance company operating in Slovakia, we applied the ICIM (Incurable Critical Illness Model) to calculate the pure premium for a rider product covering "critical illnesses – incurable critical illnesses." In this paper, we present the results of scenario-based simulations and the calculation of the annual pure premium for a client aged 50 today. To calculate the annual pure premium, we used annual transition probabilities and a discount factor of 0.7%. The resulting pure annual premium for a 50-year-old policyholder was calculated at €52.19, which served as the reference value for this age group in our subsequent analysis.

The analysis of the impact of changes in input parameters, specifically the annual probabilities of transitioning from the "Healthy" to the "Sick" state and the probabilities of remaining in the "Sick" state, illustrates how corresponding percentage decreases or increases in these probabilities affect the final pure annual premium. For example, a 10% reduction in the probability of remaining in the "ill" state leads to a decrease in the pure premium to €42.29, representing a reduction of 23.41% compared to the reference value.

The final analysis evaluates scenarios where both probabilities – transitioning to the "Sick" state and remaining in the "Sick" state – change simultaneously. These simulations highlighted the significant impact of changes in clients' health status on the stability and profitability of the product for the insurer. In the most optimistic scenario from the insurer’s perspective (Table 4 – Scenario 1), the insurer would be able to achieve considerable savings and enhance the competitiveness of its product.

The study also identified several limitations, including reliance on historical data, which may not fully reflect future trends and changes in health outcomes. Furthermore, the models used may not entirely capture the rapid advancements in medical science or shifts in demographic trends, both of which can significantly impact the incidence and progression of critical illnesses. As insurance markets and the associated risks constantly evolve, it is crucial to regularly analyse and update the parameters of insurance event models. This also involves monitoring and processing a large volume of new data, from the perspective of the insurance company at the Not Small – Not Big Data (NoS-NoB, defined by Schmidt (2024)) level, revising models, and adapting them according to the internal requirements of the insurance company.

Conclusion

The article demonstrated the advantages of using stochastic models in managing insurance products. By extending the traditional 'Healthy-Dead' model to a three-state 'Healthy-Sick-Dead' model, where the illness is due to an incurable critical illness, we introduced the Incurable Critical Illness Model (ICIM). Using the ICIM, we were able to more accurately model and predict the risks associated with incurable critical illnesses. This approach enables insurance companies to set supplementary insurance valuations more effectively. It more precisely reflects actual risks, thereby contributing to the financial stability and solvency of the insurance company in accordance with European Union standards and regulations.

The results of the analysis showed that changes in transition probabilities have a significant impact on the net premium. For instance, reducing the probability of transitioning from the 'Healthy' to the 'Sick' state leads to a lower premium, which can allow the insurance company to offer more competitively priced products. Conversely, improvements in healthcare, which increase the probability of remaining in the 'Sick' state, can lead to higher expenses for the insurance company, highlighting the need for careful estimation of these parameters.

Moreover, the study revealed that changes in these transition probabilities can significantly affect the financial stability of insurers. Adjustments in health status transitions can either reduce costs and increase product competitiveness or raise expenses, emphasising the importance of regular model updates to reflect evolving health conditions. Accurate estimation of these probabilities is necessary for maintaining solvency and financial stability.

While the ICIM model offers significant advantages in modelling critical illnesses and calculating premiums, several limitations need to be considered. The model's reliance on historical data implies that the accuracy of the results could be affected by the availability and quality of these data. Moreover, although the three-state model is effective for analysing transitions between health states, it does not take into account additional factors, such as advancements in healthcare technology, which could substantially affect the expected duration of critical illness.

In the future, extending this model by incorporating additional parameters or adapting it to account for evolving health conditions would allow for more accurate premium calculations. Such improvements could enhance the financial stability of insurers while ensuring more equitable insurance terms for clients.

In conclusion, we can state that stochastic models represent a powerful tool for optimising the processes of managing insurance products and supplementary insurances, leading to a better understanding of risks and more efficient risk valuation arising from insurance contracts. This is key for insurance product management, long-term success, and the stability of insurance institutions.

Declarations Availability of data and materials

The data used and analysed in this article were provided exclusively for the purposes of this research. The dataset is part of the internal data from an unnamed (but real) insurance company, and its availability is governed and restricted by the company's strict internal policies. The data are available only to the extent that they have been processed, as stated by the authors of the article.

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Refining resource management in healthcare delivery processes: Should we look at technology changes another way?

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Abstract

Background: Today's health organizations are under increasing pressure to meet a range of sometimes conflicting, often divisive goals. Consequently, they need to maximize the value created for patients as an overarching goal. Value can be addressed through organizational processes managed through activities, actors and resources. Managers perceive this interaction process mainly through resource and cost dimensions. However, the extent of the change in resources, i.e. the change in value creation caused by a new technology, has not yet been investigated.

Purpose: In our study, we examine the consequences of technological alterations resulting in a change regarding resources that impact value creation. We seek to describe the change patterns in resource compositions that occur when introducing a new technology into an organizational process.

Study design/methodology/approach: We adopted a case study method with a process perspective, where we applied the Time-Driven Activity-based Costing (TDABC) framework to capture the managerial perspective on cost and resource management related to value creation. Five healthcare protocols implemented using different technologies (face-to-face and telemedicine) were analyzed.

Findings/conclusions: Resource changes due to technological modifications seemingly occurred without a distinct pattern. However, we could confirm that the changes not only affected activities in areas where new resources were introduced, but also had spillover effects. Our results reveal that the extent of changes caused by technological alterations can be determined through changes detected in information. The results highlight the importance of the extent of change and information management.

Limitations/future research: The most significant limitation to generalizing our findings is the research context itself. The sector-specific characteristics of the healthcare sector limit the generalizability of our results. Another limitation is the number of observed cases and our research method. This suggests the need for further research, as it seems justified to test the TDABC methodology on multiple other cases.

Keywords

technological change, resource management, technology change patterns, telemedicine, digital platform, Time-Driven Activity Based Cost (TDABC)

Introduction

Technological change is radically reshaping not only market behaviors, but also the way organizations operate and the interactions between actors. For a given technology, specific resources interact with each other to create value for the organization, and in combination provide utility to individuals or actors in the network (Håkansson & Waluszewski 2002; Håkansson, 2009). As technology changes, the range of resources interacting with each other changes, the way in which resources are combined, thus the utility provided by them changes simultaneously (Gressetvold 2001; Håkansson et al., 2009).

However, as technology changes, new resources are emerging in exponential numbers, and new knowledge is needed to bring them into operation and control their costs. In addition, resources are often not even managed independently, as a decision to use a resource results in the "calling up" of more and more resources, transforming the existing use of resources. In many cases, resources also change the information flows of processes and the way actors are involved (Dóra – Szalkai, 2020). Therefore, the implementation of a technology leads to numerous changes, whereby success is far from being determined (Gressetvold, 2001; Håkansson et al., 2009).

The literature has so far provided few answers to address these phenomena (Keel et al., 2017). It is not clear along which patterns technology transforms the resource constellations used for a given purpose, nor is it clear how to identify the extent of the changes that result from the development of technology. These questions are critical for value management, and for harnessing the benefits of technological change.

In our study, we examined the emergence of technology-induced change in health service organizations, where the pandemic caused by the SARS-COV-2 virus has accelerated the urgent adaptation of technological developments. There is an increased demand from patients, healthcare providers and policy makers alike for the growing adoption of telemedicine and telehealth applications (Parikh et al., 2020; Middleton et al., 2020). This also implies a transformation in the way health services provide value.

In healthcare services, value can be described as the ratio of the outcomes achieved in a health state to the inputs made to achieve them (Porter 2010, p. 2477). Value, from this perspective, can be enhanced by increasing the outcomes achieved in a health state for a given set of resources, or by minimizing the inputs in the whole healthcare delivery cycle for a given set of outcomes (Kaplan & Porter, 2011). Managing value in this way requires increased control over the resources and resource combinations involved in a given care process, and thus over the inputs. Business processes create value as a result of the interaction of activities, actors and resources (Håkansson & Snehota, 1995), so managing value is in essence managing interactions. However, managers view this management process of interactions through the management of control over resources and costs (Porter, 2010; Kaplan & Porter 2011; Kaplan et al., 2014).

To model the managerial perception and the managerial perspective in controlling expenditures, we applied the Time-driven Activity-based Costing (TDABC) (Kaplan & Anderson, 2004), a costing method widely used in healthcare service organizations. TDABC, because of its approach, has numerous benefits for healthcare organizations. TDABC directly assigns resources to activities required to achieve a given health outcome by calculating the expenditure of the care cycle based on the duration of time required to use the resources in a given activity (Kaplan et al., 2014). It can enhance value by capturing costly steps, creating opportunities to incorporate lower cost resources, or incentivizing the continued use of expensive resources (Kaplan et al., 2014).

We examined the consequences of a change in the technology used by a clinical organization providing patient care. Our focus is on how the introduction of a new technology (in this case telemedicine technology) reshapes patient care activities, resources and capacities involved. Our investigation is conducted from the analytical perspective of TDABC by examining how changes are manifested when applying the TDABC framework. Our results point to the need to identify the extent of change, the importance of information management, and the need to improve TDABC methodology.

In this article, we therefore start with an interpretation of the characteristics of technological change (Chapter 1.1), covering the main literature on the tangibility of resources, technology and resource interaction, and the key contexts in which they are understood as they change. We then turn to an explanation of the concepts of telemedicine and telehealth (Chapter 1.2), interpreting the experiences and contexts identified so far in research on patterns of change in healthcare practices supported by digital tools. Next, we present the perspective of TDABC, a framework commonly used by healthcare providers to control resources, and the cornerstones of its application (Chapter 1.3). We conclude our literature review by summarizing the findings of applying TDABC in healthcare organizations (Chapter 1.4). In the second chapter (Chapter 2), we elaborate on our research question and research methodology, and then focus on the details of our findings (Chapter 3). Following our detailed answers to the research questions (Chapter 4), we draw our main conclusions (Chapter 5) and outline the main directions for theoretical and practical application. We conclude our study by identifying the limitations of the extension of our findings and future research directions (Chapter 6).

1. Theoretical Background

1.1 Characteristics of change regarding technology and resources in interactions

Change in the life of organizations can be seen as a constant feature that is present in every aspect of organizations (Burnes, 2004). It is generally accepted that successful change management is a necessity in an ever-changing business environment, yet around 70 per cent of change efforts fail (By, 2005, p. 370), making the importance of successfully managing change even more salient. The nature of change itself, and thus the subject of organizational change, is extremely diverse, and it is not surprising that a number of studies have been carried out focusing on different aspects of organizational change (Whelan-Berry & Somerville, 2010; Weick & Quinn 1999; Pettigrew, 1985). As we focus on change processes related to specific resource bundles identified as certain kinds of technology, we seek to obtain a deeper understanding of the dynamics of change in the context of resources and the interactions between them. For our investigation, the foundations of the resource-based point of view (RBV) can serve as a starting point. The RBV is one of the most widely used theoretical perspectives today and pioneered the conceptualization of firms as sets of unique resources that form the basis of organizational value creation (Penrose, 1959). Two of the most popular theoretical approaches based on the RBV are the network approach developed by the Industrial Marketing and Purchasing Group (IMP) and the service-centric perspective known as Service-Dominant Logic (S-D-L) by Vargo and Lusch. Both approaches emphasize the key role of resources in business networks, and they assume that the dynamic and evolutionary nature of resources control value and exchange processes (Bocconcelli, et al., 2020, p. 1). Both perspectives can be also used to explore healthcare networks in depth (Dóra & Szalkai, 2020; Wells, et al., 2015). However, the two perspectives describe the nature and value of resources differently, along with the context in which resource interconnection occurs. Because our focus is on resource combinations in healthcare delivery processes, with a particular focus on technology change, we examine this phenomenon from a network perspective. The research of the IMP group, which uses the network approach, points to the complexity of combining resources, managing changes in resource combinations and intense interactions, all of which characterize the technological adaptation that takes place in healthcare organizations (Cantù, et al., 2012; Hu, et al., 2002).

From the IMP point of view, resources are considered economic entities that represent value to an economic actor (Prenkert, et al., 2019, p. 140) that become resources only when a way of using them is revealed (Gressetvold, 2001). However, due to resource heterogeneity, individual resources may be considered passive and lacking in value. Thus, the nature of a given resource and its inherent economic value-creating potential will be determined by how it interacts with other resources (Gressetvold, 2001; Håkansson et al., 2009). In addition, the characteristics, usefulness, and value of resources owned by a given organization depend not only on how they are combined with other resources within the organization but also on how they are combined with related resource combinations within networks (Håkansson et al., 2009, p. 65-66). An important finding of the IMP group is that networks strongly influence the characteristics of organizations' resources as the latter do not have full control over their resources due to interdependencies (the latter are also related to the resources of other organizations) (Prenkert et al., 2019).

Accordingly, one should evaluate resources and resource combinations relative to each other and in relation to the actors who create, activate, and use them (Cantú et al., 2012). The relationships between actors and resources can be clearly traced using the Actor-Resource-Activity (ARA) model

(Håkansson & Snehota, 1995), which describes the content of business relationships. In this, actors can be characterized by the range of activities they undertake and the set of controlled resources that are used. For resources to be combined, they must interact. During this process, they must be transformed, so they change, recombine, evolve, and can be used and reused (Crespin-Mazet, et al., 2014, p. 11). Thus, resource interaction refers to the processes of combining, recombining, and jointly developing resources (Baraldi, et al., 2012, p. 266). The channels of resource interaction processes are called resource interfaces. Interfaces specify how resources are connected (Prenkert et al., 2019, p. 139). A resource interface connects at least two resources but can indirectly connect many others through indirect interfaces (Prenkert et al., 2019, p. 142). The systematic interconnection of resources is a complex process that results in complex and unique interfaces. When changing a resource (i.e., when a new resource is involved or an existing resource is developed) new interfaces will be created that will have a spill-over effect on indirectly related resource combinations (Håkansson et al., 2009).

Different resources are connected in different ways in value creation processes by creating unique interfaces. Every change in the resource level also changes the value creation process. This is especially true for resource constellations that combine many resources that converge around a particular technology. Technology change plays a key role in the proper utilization of technology and ensuring the level of production/service (Hu et al., 2002, p. 198).

A technology is a unique system of relationships based on interdependencies between many different resource entities that can play multiple roles in exchange processes. Technology may be the subject of exchange, but it is more often involved in transforming the resources being exchanged. Håkansson and Waluszewski (2002; 2007) describe technology as resource bundles interconnected through different points of connections, namely a pattern of interfaces. This pattern of interfaces determines the characteristics of each resource element, consistent with the technology (Håkansson & Waluszewski, 2002, p. 211). Consequently, when such patterns change, it is important to understand exactly how this will affect (1) the coherence of the connections of pre-existing resources in the pattern, and (2) how the pattern fits into value-creation processes (Gressetvold, 2001).

Changing the current technology, therefore changing the way value is created leads to a number of challenges in organizations. We examined the context of healthcare organizations where, in the era of Value-based Healthcare, particular attention is being paid to the process of value creation. Exploring technological change and the impact of change on value raises particularly interesting issues, as value creation involves a complex system of resources in healthcare services, where innovative digital platforms are being used to maximize value for patient health.

1.2 Value creation and technological adaptations in healthcare

When venturing to study technological adaptations in healthcare, it is important to understand the main features of healthcare as a service system. One of these is that value creation takes place across organizational boundaries in the form of complex services, as the value perceived by stakeholders is realized as a result of the collaborative activities of vastly different actors (Frow, et al., 2016). Furthermore, organizational units are involved in producing these complex services, from hospitals through specialists offering specialized services to units that provide only basic services (Porter, 2010).

In order to successfully produce value in healthcare, the transformation of a wide variety of resources must take place through the cooperation of a diverse set of actors. Other essential features of the healthcare delivery system are related to the management of these resources. The resources to be utilized are limited, and there is strong demand for them from actors with different interests (Frow et al., 2016). Actors may have different positions and perceptions regarding the healthcare delivery system they are part of (Pauli, et al., 2023), and about the value attainable from it and the limited available resources and their utilization (Edvardsson, et al., 2011).

Based on the above, it is clear that healthcare organizations will be able to successfully maximize value only if they can adequately manage the acquisition and assembly of resources.

To maximize value and improve patient health through resource management, healthcare providers have started using more digital technologies and digital platforms (e.g. social media) (Akdaş & Cismaru, 2022). The various information technology solutions and digital platforms used in healthcare are highly effective at reducing complications in healthcare procedures and positively impact quality of life by increasing social and economic benefits (Sikandar, et al., 2022, p. 35).

However, the advancement of digital technologies in the healthcare sector has been driven not only by opportunity but also by necessity. For example, in 2020 – as a result of the onset of the coronavirus epidemic – access to face-to-face healthcare delivery became limited, resulting in an increase in the use of telemedicine (Parikh et al., 2020; Middleton et al., 2020).

Telemedicine is rather broadly interpreted. It means the use of information technology to provide location-independent healthcare services. Telemedicine applications are implemented in the hope of increasing the quality and accessibility and reducing the cost of healthcare (Paul, et al., 1999). Telemedicine has been applied in the fields of prevention and patient care, including diagnostics, medical care, and rehabilitation (Sisk & Sanders, 1998). Telemedicine applications can take the form of remote monitoring, telecommunication-assisted health consultations, and complex programs involving the complex application of innovative technologies and processes (Reardon, 2005). The concept of telemedicine has now been transformed. Telemedicine today refers to the use of telecommunications devices in healing, while all services that complement healing are described in the literature as telehealth (Puskin, et al., 2006; Schwamm, 2014). Although telemedicine is defined as the use of information technology in health services, it is always accompanied by the development of human resource systems, the redefinition of social and cultural barriers, and the development of organizational structures (LeRouge, et al., 2010).

In the digitally supported healthcare delivery process, various determinants of patient care activities and the resources that are used can be identified, such as the respective digital platform, the way information is managed, additional communication tools and resources, and staff preparedness (Middleton et al., 2020; Zanotto, et al., 2020). The use of digital platforms during the introduction of telemedicine requires the acquisition of platform-compatible devices (e.g., smartphone, platform, and computer) (Middleton et al., 2020). In many cases, the creation of individual facilities for the application of telehealth is necessary (Zanotto et al., 2020; Rodrigues, et al., 2021).

The studies that have compared the efficiency, time, and resource intensity of telemedicine and telehealth with traditional care have found that some activities change, alter, or disappear as technology changes, while in other cases, technology brings new activities to life (Parikh et al., 2020; Portney, et al., 2020; Bauer, et al., 2020; Middleton et al., 2020). Discontinued activities release reserved capacity or resources, while new activities involve new resources into the care process. The resource intensity of telemedicine and telehealth is also found to be changing. As the time activities undergo changes, so does the use of resources, and in some cases the type of resources that are required (Rodrigues et al., 2021; Parikh et al., 2020; Portney et al., 2020). Some telemedicine and telehealth activities free up time, and others lengthen the time that is taken. With some telemedicine and telehealth activities, the resources that are used change (for example, an activity once undertaken by a doctor in the case of face-to-face medicine is carried out by a nurse), modifying the cost of the care process.

1.3 Time-driven activity-based costing (TDABC) methodology and its application in healthcare

The focus of organizations' technological development and adaptation activities is on enhancing their ability to create value. When it comes to value creation, the aim of introducing a new technology is to enhance value, either by improving the outcomes that deliver value or by reducing the level of costs associated with value-creating activities. Managers meet these issues regarding value creation and technological adaptations mainly through cost analyses. Among cost analysis frameworks, various Activity-based costing (ABC) methods are often used as a tool for managerial control. A more accurate and sophisticated version of activity-based costing (ABC) is the Time-driven Activity-based Costing (TDABC) framework.

In contrast to the traditional ABC methods, when applying the TDABC method, the costs of resources are not allocated to activities and then products; instead, managers first estimate the resources required for each transaction, product, or customer. Then, two parameters must be estimated for each resource group, on the one hand, the unit cost of providing a resource, and on the other, the unit time of resource capacity use per product (Kaplan & Anderson, 2004).

TDABC is most commonly applied by healthcare organizations to healthcare systems or healthcare facilities (Etges et al., 2019; Zanotto et al., 2020; Portney et al., 2020; Rodrigues et al., 2021). The growing healthcare application of TDABC is rooted in the value-based healthcare (VBHC) framework. VBHC encourages healthcare organizations to optimize the value equation by maximizing health outcomes while reducing costs (Keel, et al., 2020).

TDABC allows providers to accurately measure the resource requirements and costs of treating patients under specific health conditions throughout the delivery cycle (Kaplan et al., 2014; Cidav et al., 2021). Institutions often use the method to explore opportunities for the development of the delivery cycle, to assess the costs of the healthcare process, to improve information about costs, and to compare traditional and time-based cost information (Etges et al.,2020a; Etges et al., 2020b). Frequent operational applications include redeployment, workflow development, and the modification of the use of facilities (Popat & Guzman, 2018; Etges et al., 2022).

The healthcare application of TDABC is described by Kaplan and Porter (2011) as a seven-step process, although based on practical experience Etges et al. (2019) define eight steps. Experience has shown that critical steps in the application of TDABC are: (1) the definition of study objectives, (2) the identification of medical conditions, (3) the definition of the care delivery value chain (CDVC), (4) the mapping of processes, identification of resources and capacities involved in processes, (5) the estimation of resource and capacity times required by processes, (6) the estimation of costs of resources and capacities (direct and indirect), (7) the definition of capacity cost rate, (8) the cost estimation of care processes, (9) cost-data analytics, and (10) support for management decision-making (Allin, et al., 2020; Choudhery, et al., 2021; Etges et al., 2019; Etges et al., 2020a; Kaplan & Porter, 2011; Kaplan et al., 2014; Keel et al., 2017; Pathak, et al., 2019).

TDABC works well when applied to standardized protocols through which services are provided in a repeatable manner. Based on this, the healthcare delivery process can be defined and mapped (Keel et al., 2020). This is an important issue, as an essential element of health-tailored TDABC is defining CDVC, through which activities are described from the beginning to the end of the delivery cycle (Keel et al., 2020; Thaker, et al., 2017). This step includes identifying activities, locating them, mapping the whole care process, and helping to identify the resources and measurements that are needed. The step is thus associated with a myriad of benefits; however, few studies have addressed the location of the care process, methods of measurement, the flow of information, and the involvement of patients (Keel et al., 2017). This requires an examination of care activities, the related resources and capacities, and the interactions of patients who are involved.

During the application of TDABC, the issue of incorporating alternative (non-standard) activities into the care process model arises. Alternative activities may be due to specific complications or differences between patient groups. These activities happen separately (without affecting the occurrence of other activities). As a result of their occurrence, the utilization time of existing resources either increases or their realization requires the use of additional capacities and resources (Sadri, et al., 2021; Fang, et al., 2021).

Using TDABC allows organizations to manage the implementation of specific activities with different resources. For example, a different resource can change the capacity that is used in a given activity, raw material, the learning curve, or needed competencies (Thaker et al., 2017). In this regard, the TDABC method focuses on learning. According to the TDABC methodology, if the analyst identifies a change in the cost of the resource or the practical capacity of the required resources, the resource cost per time unit or the capacity cost rate should be updated. Through this, a given activity can be easily updated, along with the cost estimate of the whole process (Kaplan & Anderson, 2004).

However, the baseline method does not take into account interaction between resources in the case of new or changed resources, the modification of activities, and the consequent spill-over effects that may be caused by technological change. Experience has shown that the use of a new resource (capacity) can affect other resources. For example, using a new device can affect lead time and information flow, thus capacity utilization. In addition, the use of a new capacity may justify additional new activities, requiring new resources (Bodar, et al., 2020; Basto, et al., 2019).

Some studies that focus on technology change do not take into account the spill-over effects of technology change, nor do they address how technology change alters the resource or capacity requirements of activities not directly affected. Other studies (Kukreja, et al., 2021) suggest that the technological modification of one activity in the care process affects the nature and/or timing, and therefore the cost, of further activities.

Examining the cost management effectiveness of telemedicine-supported care processes compared to traditional care processes is a current and increasingly studied question (Garoon, et al., 2018; Bauer et al., 2020; Parikh et al., 2020; Rodrigues et al., 2021). Researchers have used the TDABC method to examine changes in activities and their cost implications to compare telemedicine and the telehealth process to face-to-face healthcare protocols. However, changes in resources and interactions between new technology and resources have not yet been examined.

2. Method

The original aim of our research was to study the managerial point of view regarding organizational change by detecting business interactions occurring during technological adaptations in healthcare organizations. To capture the managerial point of view related to business interactions impacting value creation in healthcare delivery processes, we applied the research dimensions of the TDABC framework in our research design. Along the TDABC dimensions, changes in business interactions in organizational processes can be well explored, as managers encounter changes in value creation brought about by technological changes primarily through cost and resource management.

However, during our initial data collection, we observed that technological change caused changes in various steps and resources in the healthcare process at numerous points, seemingly without pattern. Some protocols were radically changed, while for others only a single change could be identified. Following this initial experience, we modified our research objective to focus on the impact of technological changes on resource composition and the intensity of resource use in healthcare delivery processes.

Among our other analyses (Dóra, et al., 2022), the present study seeks to identify what patterns are identified with the impact of technological change on resource sets that are used, and the intensity of use. Based on our literature review, and, as previously emphasized, there is a research gap in this area. TDABC methodology suggests calculating capacity cost rates and estimating the intensity of use when a new resource is implemented into a process (Kaplan & Anderson, 2004). However, if spillover effects of the change are assumed, the need to re-model the whole process arises (Ostrenga, et al., 1992). However, the TDABC method does not help specify the extent to which remodeling of the healthcare delivery process might be justified (Basto et al., 2019; Bodar et al., 2020; Kukreja et al., 2021). The central question of our research is thus how to identify the extent of change(s) in resources caused by a modification in technology. How can the extent of this change be identified and modeled?

We adopted a process perspective – an approach quite often applied in parallel with qualitative case studies (Langley, 1999; Van de Ven & Huber, 1990; Bizzi & Langley, 2012). Although there are different interpretations of processes in the literature (Van de Ven, 1992), our starting point was Pettigrew's (1997) definition of a process as a series of individual or collective events, actions, or activities that take shape over time in a given context. We analyzed and compared healthcare protocols as processes implemented through different technologies (face-to-face and telemedicine) that served the same healthcare delivery process goal. The methodological application of a case study with a process perspective (Langley, 1999; Pettigrew, 1997) is appropriate for comparing healthcare protocols implemented in parallel using different technologies and identifying distinctive patterns in the former.

In line with the above-mentioned methodological approaches, we systematically analyzed five patient routes implemented through face-to-face medicine and telemedicine technologies. They include diagnosis and therapy assessment of ear, nose and throat diseases (Case ENT), application of peritoneal dialysis (Case DIAL), risk reduction for patients with metabolic syndrome (Case METSY), strengthening daily physical activity in patients with peripheral artery disease (Case PERIPHART), and monitoring of patients with heart failure (Case CARDIO).

The study was conducted at the University of Szeged, Albert Szent-Györgyi Medical and Pharmaceutical Centre between October 1, 2020 and June 30, 2021. The cases had business-to-business-to-customer characteristics. From a healthcare delivery process perspective, value was created as a result of the interaction between four types of actors associated with the studied protocols. The former were the patients and the clinical departments involved in patient care. Also involved were the actors who provided the IT infrastructure for patient care (T-Systems

Magyarország Zrt., related to e-MedSolution - MedSol, and the National Healthcare Service Center in connection with the National eHealth Infrastructure) and, in the case of telemedicine protocols, the operator of the system that provides the IT infrastructure for patient care. The observed processes were analyzed according to the TDABC framework commonly used to study healthcare delivery process changes. The TDABC framework was well suited to the study objective, as the approach requires detailed exploration of the service process, detailed identification of the resources and capacities involved in the service, and an estimation of the intensity of use (utilization time) of resources (Kaplan & Anderson, 2004). Although the healthcare adaptation of the TDABC method is specific at some points, the mapping of processes, the identification of the resources involved, and the estimation of required capacity times remain central steps (Kaplan & Porter 2011; Kaplan et al., 2014; Keel et al., 2017; Etges et al., 2019). Accordingly, the TDABC framework was appropriate for our investigation as it does not require an analysis of the unit costs of resources (direct and indirect) or the total costs of processes.

The research was carried out in three steps. First, process maps of the observed protocols (those implemented with face-to-face and telemedicine technology) were compiled using document analysis. This included the baseline recording of the activities associated with a given healthcare protocol carried out through face-to-face and telemedicine technology simultaneously in accordance with the TDABC methodology. Subsequently, we examined the resources involved for each activity associated with both of the technologies, distinguishing between human and other tangible and intangible resources. When considering human resources (H), we distinguished between patients involved in the process and medical (H1), nursing (H2), auxiliary (H3), and managerial staff (H4) (Ley, 1991; Byrnes & Valdmanis, 1993; Lopez-Valcarcel & Perez, 1996; Maniadakis & Thanassoulis, 2000; Farmer, et al., 2014). In terms of the additional resources directly used for the activities, we distinguished three types: raw materials (inputs) (A1-A4), medical equipment/tools and facilities (F1-F6), and input and output information (I / O) (input and output data transmitted through input and output information systems).

Second, we conducted in-depth interviews with senior specialists responsible for the observed healthcare delivery processes in order to confirm and refine the data collected in the first step. In addition, based on the TDABC methodology, a financial controller responsible for the observed protocols and a program manager responsible for the pilot program were involved in the evaluation and refinement of the data. With this step, the aim was to gather additional information about the experience of introducing new technology and changes in activities and resources.

Third, the content of the interviews was coded for transparency and comparability to identify systematic patterns. This method of data processing allowed us to identify, besides the (initial) activities in face-to-face patient care, the number of actors (H), facilities (F), raw materials (A), input (I) and output (O) information (data and information systems) and the intensity of resource use for each activity. This latter information is indicated by the time needed to complete a given activity. Here, based on Kaplan et al. (2014), we assumed that inputs are used in line with a given activity, and additional resources are consumed over the entire duration of the latter. The focus was on the change in activities and resource quantities and the change in intensity of use that occurred in parallel with the change in technology. Changes identified in a given protocol are highlighted in different shades of gray (see Table 1-5). If a new activity, new actor, new resource or new information has been added to the protocol, it is marked in light gray. If the change occurred in the opposite direction, i.e. the number of activities, actors, resources, information or time used decreased, these changes were highlighted in dark gray.

The processing of the data, as described above, facilitates the analysis of the quantitative and qualitative changes in the structure of each healthcare delivery process and the types of resources used as a result of changes in technology. In the following chapter, we summarize our findings regarding the case studies and illustrate the results using the analytical framework applied in the third step.

3. Results

3.1 Diagnosis and therapy of ear, nose and throat diseases (Case ENT)

The telemedicine support of the healthcare delivery process for diagnosing and treating ear, nose and throat diseases includes the introduction of otoscopic imaging and the installation of telemedicine software for transmitting and analyzing clinical data (Table 1).

In the original face-to-face healthcare process, a patient meets a specialist and an administrator in the outpatient room after checking in at the outpatient clinic (Act. 1) and is waiting for a short time in the waiting room (Act. 2). The entire healthcare process takes place in the outpatient clinic with the participation of these three actors. In the course of the treatment, using the computer software available in the outpatient room, a specialist first records patient's medical history with the assistance of an administrator while interacting with a patient (Act. 3). Then, with the help of specialized equipment available in the outpatient department, a specialist makes a diagnosis (Act. 4), on the basis of which an ICD (International Statistical Classification of Diseases and Related Health Problem) code is determined (Act. 5). Last, a suggestion for therapy (Act. 6) is proposed by a specialist.

Developers have transformed the activities of the healthcare delivery process by introducing and implementing two new resources (an otoscope and telemedicine software) into the telemedicine healthcare process. Following check-in at the outpatient clinic (Act. 1) and waiting in the waiting room (Act. 2), the process of care has been modified. First, the possibility of a patient participating in the telemedicine protocol is examined (Act. 3.1) and a patient is informed about the characteristics of the telemedicine protocol (Act. 3.2). Then comes the identification of patients in the telemedicine system (Act. 3.3) and the recording of their medical history (Act. 3.4). The steps in the telemedicine healthcare delivery process reflect the initial intended change. An otoscopic image is taken of a patient (Act. 4.1), which is evaluated and diagnosed remotely by an ENT specialist (Act. 4.2). As in the case of the face-to-face protocol, the telemedicine healthcare process is also concluded by a specialist choosing an ICD code (Act. 5) and proposing a therapy based on the diagnosis and the latter code (Act. 6).

While the role and use of administrative staff, materials and equipment, and infrastructure remain unchanged during the first two activities, radical changes are observed from the third activity onwards. In the case of the telemedicine protocol, during the latter the number of medical staff who are involved changes (the presence of a general practitioner is sufficient, instead of a specialist), as does the extent of equipment use (no examination chairs and examination desks are used). The sets of data generated by the third activity and the information systems they are coded into also change. New data emerge related to the patient's willingness to undergo treatment and the identification of the patient in the telemedicine system, and the telemedicine system itself qualifies as a new information system. Changes in the fourth activity also extend beyond changes in activities; first, the set of human resources that is involved changes radically. A general practitioner replaces a specialist when preparing for admission, while the supporting role of an assistant in the assessment of the otoscopic images is eliminated. In terms of equipment, some of the equipment formerly deployed in the outpatient room (outpatient room facilities, basic ear, nose and throat tray set) is no longer required under the telemedicine protocol. In contrast, new equipment (otoscopic camera, computer used for analysis) is introduced. Likewise, the role of disposable equipment for examination is no longer relevant due to the use of recording and analysis by the otoscope; moreover, the outpatient room is not used during the diagnosis. However, the medical room emerges as a new resource compared to the face-to-face protocol. In the case of the former, the video file shared by the telemedicine system and the diagnosis shared within the telemedicine system are identified as additional data. During the final (fifth and sixth) activities of the protocol, although the activities did not change in principle, the resources that were used did. The supporting role of the assistant disappeared, but the online IT equipment used by the specialist emerges as an additional necessary resource. For these activities, the role of the equipment used in the outpatient room (examination chair, examination table) and disposable equipment (paper, pen, mask) is eliminated, as the location, where the activities are undertaken, changes (in the medical room instead of the outpatient room). For the final activities, there is no change in the required or generated datasets, but the telemedicine system emerges as a new data information system, in addition to the traditionally used healthcare information system.

Table 1 Changes in the protocol ‘Diagnosis and therapy of ear, nose and throat diseases’ due to technological change

							F2	F5		
							H1	F2		
							A4	A4		
							A4	A4		
							A4	A4	F5	F5
			H1	H1	H1	H1	A4	A4	F2	F2
			A4	A4	A4	A4	A4	A4	A4	A4
			A4	A4	A4	A4	A4	A4	A4	A4
			A4	A4	A4	A4	A4	A4	A4	A4
			A4	A4	A4	A4	A4	A4	A4	A4
			A4	A4	A4	A4	A4	A4	A4	A4
			A4	A4	A4	A4	A2	A2	A4	A4
			A4	A4	A4	A4	A2	A2	A4	A4
			A4	A4	A4	A4	F5	F5	A4	A4
			A4	A4	A4	A4	F4	F4	A4	A4
			F5	F5	F5	F5	F4	F4	F5	F5
	A4		F4	F4	F4	F4	F4	F4	F4	F4
	A4		F4	F4	F4	F4	F4	F4	F4	F4
	A4		F4	F4	F4	F4	F4	F4	F4	F4
	A4		F4	F4	F4	F4	F4	F4	F4	F4
	F5		F4	F4	F4	F4	F3	F3	F4	F4
	F5		F4	F4	F4	F4	F3	F3	F4	F4
	F4		F3	F3	F3	F3	F1	F1	F3	F3
	F4	F5	F3	F3	F3	F3	F1	F1	F3	F3
	F4	F5	H3	H3	H3	H3	H3	H3	H3	H3
	H3	F4	H1	H1	H1	H1	H1	H1	H1	H1
Activities	**1**	**2**	**3.1**	**3.2**	**3.3**	**3.4**	**4.1**	**4.2**	**5**	**6**
Time	5	60	15		5		3	5		
Data			O	I / O	O		I / O			
Inf. system			O	I / O	I / O	I / O	I / O	O	I / O	I / O

Source: the authors’ compilation

Analysis of the processes shows that changes in the protocol were not only made where activities were modified as a result of technology change (Act. 5, Act. 6). However, it may be noted that when there were changes in activities and/or resources and/or the intensity of resource use, there were always changes in the data and/or the information system that was used. In this case, two patterns of change were identified: (1) change in activities undertaken, the set of resources used, and the intensity of resource use. All this occurred in parallel with the use of new data and the application of a new information system (Act. 3 and Act. 4). (2) Only the set of resources and their intensity of use changed, in parallel with the application of a new information system, but no change was identified in activities carried out or data used (Act. 5, Act. 6).

3.2 Risk reduction for patients with metabolic syndrome (Case METSY)

In order to support the care of patients with metabolic syndrome, the development of telemedicine – as originally intended – focused on the use of a telemedicine system and smart devices that can track patients' lifestyles and health data (Table 2).

A nurse and a patient initiate the face-to-face healthcare delivery process (after prior appointment). First, patient admission (Act. 1) is carried out in the outpatient clinic (with the help of IT tools and other equipment). Then, with the assistance of the specialist doctor, the nurse, and the patient, the patient's medications and nutritional supplements (Act. 2), physical parameters (weight, height, blood pressure, etc.) (Act. 3) are recorded using the computer and medical equipment in the outpatient room. In addition to the above, the specialist conducts various tests (ECG, i.e. echocardiography) to define the patient’s health status (Act. 4). In the next step, the specialist derives further parameters that describe the patient's condition (creation of derived data, calculation of BMI, calculation of THR) (Acts. 5-7). After verifying eligibility to continue with the protocol (Act. 8), during a three-week hospital stay, the patient is informed on the therapy to be followed with the assistance of a specialist (Act. 9), a dietician (Act. 10), and a physiotherapist (Act. 11). During the hospital stay (Act. 12), the patient obtains access to the necessary materials, hospital facilities, and supervision by a nurse, a head nurse, a specialist, and a chief physician. Finally, the patient continues the therapy at home (Act. 13) for 90 days, in accordance with the recommendations, recording their diet, heart rate, weight, and blood pressure (using a monitoring watch, body weight scale, and sphygmomanometer) on a daily basis using a report sheet. The procedure ends with a final control examination after 90 days, when the initial examination is repeated (Act. 14-19).

Due to telemedicine development, the use of six new resources (telemedicine software, smart weight scale, smart monitoring watch, smart blood pressure monitor, data transmission unit, and smartphone) are identified. The introduction of the telemedicine technology led to minor and major changes in six activities. The initial examination resulted in the assessment of the patient's eligibility for the telemedicine protocol (Act. 8.1), followed by informing the patient of the telemedicine protocol and registering the patient’s information and consent (Act. 8.2). Although the set or use of resources did not change with the modification of this activity, new data (consent form, patient identified in the telemedicine system) were coded into a new information system in the telemedicine software.

Likewise, without any change in the resources used (due to the training on the use of different tools), the training of patients for therapy (Act. 9-12) was modified; moreover, its duration (thus the intensity of resource use) was reduced to five days.

Table 2 Changes in the protocol ‘Risk reduction for patients with metabolic syndrome’ due to technology change

				A4																A4			
				A4																A4			
				A4																A4			
				A4																A4			
			A4	A4															A4	A4			
			A4	A2												A4	A4		A4	A2			
			A4	A2												F5	F5		A4	A2			
			A4	F5												F5	F5		A4	F5			
		A4	A4	F4												F4	F4	A4	A4	F4			
		A4	F5	F4	A4	A4	A4	A4	A4							F4	F4	A4	F5	F4	A4	A4	A4
	A4	A4	F4	F4	A4	A4	A4	A4	A4							F4	F4	A4	F4	F4	A4	A4	A4
	A4	A4	F4	F4	A4	A4	A4	A4	A4			A4			F2	F4	F4	A4	F4	F4	A4	A4	A4
	A4	A4	F4	F4	A4	A4	A4	A4	A4	A4	A4	A4			F2	F4	F4	A4	F4	F4	A4	A4	A4
	A4	F5	F4	F3	A4	A4	A4	F5	F5	A4	A4	F5	A4		F2	H3	H2	F5	F4	F3	A4	A4	A4
	F5	F4	F4	F2	F5	F5	F5	F4	F4	F5	F5	F4	A4		F2	H3	H1	F4	F4	F2	F5	F5	F5
	F4	F4	F3	F2	F4	F4	F4	F4	F4	F4	F4	F4	A1	A4	A4	A4	A4	F4	F3	F2	F4	F4	F4
	F4	F4	F2	F2	F4	F4	F4	F4	F4	F4	F4	F4	H4	F6	A4	A4	A4	F4	F2	F2	F4	F4	F4
	F4	F4	F2	F2	F4	F4	F4	F4	F4	F4	F4	F4	H4	F5	F5	F5	F5	F4	F2	F2	F4	F4	F4
	F4	F4	F2	F2	F4	F4	F4	F4	F4	F4	F4	F4	H3	F5	F2	F2	F2	F4	F2	F2	F4	F4	F4
	F4	H2	H2	H2	F4	F4	F4	H2	H2	F4	F4	F3	H2	F4	F2	F2	F2	H2	H2	H2	F4	F4	F4
	H2	H1	H1	H1	H1	H1	H1	H1	H1	H1	H3	H3	H1	F4	F2	F2	F2	H1	H1	H1	H1	H1	H1
Activities	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8.1**	**8.2**	**9**	**10**	**11**	**12.1**	**12.2**	**13.1**	**13.2**	**13.3**	**14**	**15**	**16**	**17**	**18**	**19**
Time	5	50						5		150	60	600	1323	7200	16200	360	156	50					
Data										I / O	I					I / O	I / O						
Inf. system									O	I / O	I	I	I	I	I / O	I / O	I / O	I	I	I			

Source: the authors’ compilation

The necessary information was (also) recorded in the telemedicine system, along with the (new) data on participation in training. However, the patient's home therapy has been radically transformed, with the patient using smart devices (smart monitoring watch, smart weight scale, smart blood pressure monitor, data transmission unit, smartphone) instead of traditional devices, and data are immediately recorded in the database of the telemedicine system (Act. 13.1). New activities naturally occur due to the changes above. The recorded data are analyzed by a dietician and a physiotherapist on a weekly basis (Act. 13.2), and, based on their assessment, a specialist assistant carries out consultations by telephone/online with patients, also on a weekly basis. Based on the results of the analysis and the weekly consultations, a specialist physician consults with the patient if necessary, potentially through telephone or online support (Act. 13.3). In this case, the new activities require additional office infrastructure (dietician's room, physiotherapist's room, medical room, and nurses’ station), equipment (desk, chair, computer, monitor, and printer), consumables (paper, pen, suitable clothes) and an additional time commitment of specific resources. Regarding the check-up examinations, the activities, the resources used and the intensity of use of the latter do not change; only the input information system for the data originating from the tests that use medical devices (Acts 14 - 16) changed: details are recorded in the telemedicine system.

The modification of the protocol, as in the previous cases, involves a very wide range of changes, but it is worth emphasizing that the changes in the set and/or intensity of the resources used as a result of the technology change were not always accompanied by changes in the activities (e.g., Act. 8, Acts. 9-11). However, the changes were accompanied by the use of new data and/or new information systems during the related activities.

Five patterns of change were identified during the processing of the present case: (1) Changes during an activity that were not accompanied by changes in the set of resources or the intensity of their use. However, the changes in activity were accompanied by changes in the data set and the information system used (Act. 8). (2) The activity did not change, but the intensity of resource use involved in carrying out the activity changed, while the set of resources remained unchanged, and the set of data generated related to undertaking the activity and the information system that was used changed (Act. 9). (3) The activity did not change but the intensity of use of the resources did, while the set of resources remained unchanged. Only the information system used during the activity changed, while the data that was generated remained unchanged (Act. 10; Act. 11; Act. 12). (4) Both the activity and the set of used resources changed, as well as the intensity of their use. The change also generated data not previously used in this activity and used a new information system (Act. 13). (5) Neither the activities that were undertaken, the set of related resources, nor the intensity of use of resources changed. No changes were made to data generated during the activity, but a new information system was used in addition to that which existed (Actions 14-16).

3.3 Monitoring patients with heart failure (Case CARDIO)

As in the previous cases, the healthcare process related to monitoring patients with heart failure was carried out by integrating and utilizing smart devices based on the development of telemedicine technology. With the introduction of the new technology, a smart blood pressure monitor, a smart body weight scale, and telemedicine software for data transmission, data storage and data access were conceptualized as new devices.

In this case (Table 3), the care process starts with identification and registration (Act. 1) in a dedicated outpatient department. Then, after a short wait in the waiting room (Act. 2) at the ECG outpatient department, the ECG examination of the patient is undertaken (Act. 3) with the assistance of an ECG assistant and the appropriate IT/medical infrastructure and equipment. After the ECG examination and another short waiting period in the waiting room, 30% of patients undergo an echocardiogram scan (Act. 5). The echocardiogram is undertaken in a specific examination room by a cardiologist and a cardiology assistant with specific infrastructure, medical instruments, and IT equipment. After another waiting period, patients meet their cardiologist and their assistant. Again, interaction between the actors takes place in a dedicated examination room equipped with the necessary medical and IT infrastructure and specific equipment needed for the examination. During the examination, the patient's demographic data (Act. 7) and medical history (Act. 8) are recorded, followed by a physical examination (Act. 9), checking of vital signs (Act. 10), and an assessment of currently used medications (Act. 11). The examination also includes an evaluation of the ECG (Act. 12) and the echocardiogram results (Act. 13), and the patient's questioning (Act. 14) to help avoid adverse effects and/or events. The examination concludes with an agreement on the patient's home treatment prescription and the writing of a prescription (Act. 15). Depending on the examination results, one in five patients must have a blood test after another waiting room visit (Act. 17). Following the traditional healthcare delivery process, after three to six months of home treatment and follow-ups (Act. 19), the patient undergoes further control examinations (Act. 20-33), as described above. This results in discussion with the patient about the treatment outcome, other treatment options, and anything further that needs to be done (Act. 34).

The introduction of telemedicine technology has changed the face-to-face healthcare delivery process in two ways. First, during the identification of patients, it is necessary to check exclusion criteria and inform a patient and answer the patient's questions (Act. 7.1; 7.2). Another change results from the need to educate patients on the use of smart devices prior to self-monitoring at home (Act. 19.1). Other changes include the implementation of digital data collection and summarization (Act. 19.2) and the systematic analysis of digitally available data (Act. 19.3).

Changes in these activities were accompanied by changes in resources, data, and information systems used. For example, establishing exclusion criteria and the task of informing a patient no longer require the presence of consumables (paper towels). In the case of the seventh activity (Act. 7), the commitment of additional human resources, tools, and facilities is prolonged due to the observed changes. On the other hand, the start of the same activities requires recording the exclusion criteria data and the consent form for treatment as new data in line with the telemedicine protocol. Although these are still coded in the traditional way (on paper and in the existing healthcare information system), this allows the actors to use an additional data element (the identification of patients) in the telemedicine system. Patient education requires the presence of an additional human resource (cardiology specialist), the use of consumables (mask), and office infrastructure (examination room, rack, table, chair, computer, monitor, printer, telephone) necessary for their work, as well as smart devices (smart weight scale, smart blood pressure monitor, data transmission unit) necessary for training the patient and home treatment.

Calculating the measured data also requires the use of smart devices (smart weight scale, smart blood pressure monitor, data transmission unit), the patient's home, and the availability of the necessary consumables (paper, pen). The data analysis requires a cardiology assistant, office infrastructure (nursing station, desk, chair, computer, monitor, and printer), and office consumables (paper, pen, mask). As for changes in information, the application of the telemedicine system was identified as a new information system for the latter activities, in which the instructions for home therapy and the measured data describing the patient's condition are recorded.

Table 3 Changes in the protocol ‘Monitoring patients with heart failure’ due to technological change

			A4																							A4												
			A4		A4							A4									A4					A4		A4					A4					
			A4		A4							A4									F5					A4		A4					A4					
			A4		A4						A4	A4							A4		F5					A4		A4				A4	A4					
			A4		A4						A4	A4							A4		F4					A4		A4				A4	A4					
			A2		A2					A4	A4	F5	A4	A4	A4	A4	A4		A4		F4					A2		A2		A4	A4	A4	F5	A4	A4	A4	A4	A4
			A2		F5					A4	A4	F5	A4	A4	A4	A4	A4		A4		F4		A4			A2		F5		A4	A4	A4	F5	A4	A4	A4	A4	A4
			F5		F5					A4	F5	F4	A4	A4	A4	A4	A4		A4		F4		F4			F5		F5		A4	A4	F5	F4	A4	A4	A4	A4	A4
	A4		F5		F4					A4	F5	F4	A4	A4	A4	A4	A4		A2		F4		F4	A4		F5		F4		A4	A4	F5	F4	A4	A4	A4	A4	A4
	A4		F4		F4					F5	F4	F4	F5	F5	F5	F5	F5		F5		F4		F4	A4		F4		F4		F5	F5	F4	F4	F5	F5	F5	F5	F5
	A4		F4		F4					F5	F4	F4	F5	F5	F5	F5	F5		F5		F2		F4	A4		F4		F4		F5	F5	F4	F4	F5	F5	F5	F5	F5
	F5		F4		F4		A4	A4	A4	F4	F4	F4	F4	F4	F4	F4	F4		F4		F2	F2	F4	F5		F4		F4		F4	F4	F4	F4	F4	F4	F4	F4	F4
	F4		F4		F4		A4	A4	A4	F4	F4	F4	F4	F4	F4	F4	F4		F4		F2	F2	F4	F4		F4		F4		F4	F4	F4	F4	F4	F4	F4	F4	F4
	F4		F4		F4		A4	A4	A4	F4	F4	F2	F4	F4	F4	F4	F4		F4		H1	F2	H2	F4		F4		F4		F4	F4	F4	F2	F4	F4	F4	F4	F4
	F4		F4		F2		A4	A4	A4	F4	F4	F2	F4	F4	F4	F4	F4		F4		A4	A4	A4	F4		F4		F2		F4	F4	F4	F2	F4	F4	F4	F4	F4
	F4		F3		F2		F5	F5	F5	F4	F3	F2	F4	F4	F4	F4	F4		F4		A4	A4	A4	F4		F3		F2		F4	F4	F3	F2	F4	F4	F4	F4	F4
	F4	F5	F3	F5	F2	F5	F5	F5	F5	F4	F2	F2	F4	F4	F4	F4	F4	F5	F4	F5	F5	F5	F5	F4	F5	F3	F5	F2	F5	F4	F4	F2	F2	F4	F4	F4	F4	F4
	F4	F5	F2	F5	H2	F5	H2	H2	H2	H2	H2	H2	H2	H2	H2	H2	H2	F5	F3	F5	F2	F2	F2	F4	F5	F2	F5	H2	F5	H2	H2	H2	H2	H2	H2	H2	H2	H2
	H2	F4	H2	F4	H1	F4	H1	H1	H1	H1	H1	H1	H1	H1	H1	H1	H1	F4	H2	F4	F2	F2	F2	H2	F4	H2	F4	H1	F4	H1	H1	H1	H1	H1	H1	H1	H1	H1
Activities	**1**	**2**	**3**	**4**	**5**	**6**	**7.1**	**7.2**	**7.3**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19.1**	**19.2**	**19.3**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**
Time	5	30	10	30	13	30	5		30									30	1	30	30	1360	360	10	60	20	60	26	60	60								
Data							O	I / O	I												I / O	I / O	I															
Inf. system							O	I / O	I												I / O	I / O	I															

Source: the authors’ compilation

The necessary information was (also) recorded.

In the last observed case, *telemedicine technology led to changes in two activities*. For both activities, the set of tasks to be undertaken, the resources used to carry out these tasks, and the intensity of their use changed. In parallel, the data generated by both activities and the number of information systems that are used also changed. However, in the present case, only this abovementioned pattern of change could be observed.

3.4 Application of peritoneal dialysis (Case DIAL)

Telemedicine support for the healthcare delivery process related to peritoneal dialysis included installing telemedicine software and smart devices capable of monitoring the characteristics of patients' dialysis at home.

In this case (Table 4), the patient route in the context of traditional medicine is carried out in such a way that apatient, already surgically prepared for peritoneal dialysis, is admitted by a nurse to a nursing room at the dialysis center, where a patient is identified with the help of IT tools (Act. 1). Patient is then seen by a specialist in an examination room, who uses the examination room equipment and IT equipment to record the patient's demographic data (Act. 2) and medical history (Act. 3), then examines the patient's physical characteristics (Act. 4), vital signs (Act. 5), dialysis-related data (Act. 6), and currently used medication (Act. 7). After the home dialysis parameters have been established, a patient is educated by a nephrology nurse on how to perform dialysis at home (Act. 8). Patient then continues the daily dialysis routine at home (Act. 9). Patients use their own facilities, kitchen scale, bodyweight scale, and blood pressure monitor. Finally, patients record their results on a report sheet provided by the clinic. The above-described visit to the dialysis center is repeated monthly, where – after patients are admitted – a specialist checks their dialysis data and, if necessary, adjusts the dialysis parameters (Act. 10-15).

The adaptation of telemedicine technology is conceptualized by the developers as the integration of four new resources (tablet, smart devices that can be connected to a tablet such as kitchen scale, body weight scale, blood pressure monitor, and telemedicine software) into the healthcare delivery process. This transforms three activities in the process: the recording of demographic data (Act. 2), patient education (Act. 8), and the dialysis routine at the patient's home (Act. 9). Prior to recording demographic data, it is necessary to verify the patient's eligibility for participation in the telemedicine protocol (Act. 2.1) and to inform patients and answer their questions about the care process (Act. 2.2). During patient education, training about the use of the telemedicine system and smart devices was a modification compared to the face-to-face patient route. The home dialysis routine was changed by the use of smart devices (Act. 9.1) and the regular clinical analysis of data (Act. 9.2) and the introduction of interventions in the case of unexpected adverse events (Act. 9.3) was a new activity.

The new activities that emerged while recording demographic data did not require mobilizing additional resources, but they did modify the deployment of existing resources.

Furthermore, this activity resulted in new data (patient consent form and identification in the telemedicine system) and the use of a new information system (telemedicine system). The change in patient education shows a different picture. Although the time required for the activity did not change, new resources (smart kitchen scale, body weight scale, blood pressure monitor) were used. New data were not interpreted in this case, but pre-existing input and output data were recorded in the telemedicine system. Finally, the modification of home dialysis involved a change in the resources (traditional devices were replaced by smart devices), and the analysis of the data required the presence of a nephrology nurse with an office and IT infrastructure. In the case of unexpected adverse events, the intervention required an additional resource; the presence of a specialist physician with an outpatient room and disposable materials (paper, pen, appropriate clothes, paper towels) necessary for an examination. These last two activities require more time than the traditional protocol. In the case of a change in home dialysis, the therapeutic suggestion of a change in therapy is a new data element; furthermore, data already present in the traditional protocol (data on blood pressure and body weight) are also included in the telemedicine system.

This case confirms that in the case of technology change not only do resources change in line with the modified activities, but in some cases the change in technology can result in a change in the set of resources or the intensity of their use without changing the activity itself (e.g., Act. 8). In the present case, however, it is identified that changes in the set of resources and/or the intensity of their use and/or the activities carried out are accompanied by changes in the data and/or information systems used during the related activity.

Four patterns of change could be observed in the peritoneal dialysis protocol supported by telemedicine technology: (1) Changes in the activities undertaken and the intensity of use of resources without changes in the set of resources. In this case, the information system and data used during the activity changed (Act. 2). (2) The activities, the set of resources, and the intensity of resource use changed with no change in the information systems and data used (Act. 9). (3) Only the set of resources changed, with no change in the activities used or resource-use intensity. The data employed here remained unchanged while a new information system was introduced (Act. 8). (4) Neither the activities, the set of resources used, nor the intensity of the resources that were used changed; only the information system used during the related activities was supplemented with a new information system – the telemedicine software (Act. 13).

Table 4 Changes in the protocol 'Application of peritoneal dialysis' due to technological change

													A4						
										F2			A4						
										F2			A4						
						A4				F2			A4		A4				
						A4				A4		F5	F5		A4				
						A4				A4		F4	F4	A4	A4				
						A4				A4		F4	F4	A4	A4				
		A4	A4	A4	A4	A4	A4	A4		A4		F4	F4	A4	A4	A4	A4	A4	A4
	A4	A4	A4	A4	A4	F5	A4	A4		A4	F2	F4	F4	A4	F5	A4	A4	A4	A4
	A4	A4	A4	A4	A4	F4	A4	A4		F5	F2	F4	F4	A4	F4	A4	A4	A4	A4
	A4	A4	A4	A4	A4	F4	A4	A4		F4	F2	H2	H1	A2	F4	A4	A4	A4	A4
	A4	A4	A4	A4	A4	F4	A4	A4		F4	A4	A4	A4	F5	F4	A4	A4	A4	A4
	F5	F5	F5	F5	F5	F4	F5	F5		F4	A4	A4	A4	F4	F4	F5	F5	F5	F5
	F4	F4	F4	F4	F4	F4	F4	F4	A4	F4	A4	A4	A4	F4	F4	F4	F4	F4	F4
	F4	F4	F4	F4	F4	F2	F4	F4	A4	F4	A3	A3	A3	F4	F2	F4	F4	F4	F4
	F4	F4	F4	F4	F4	F2	F4	F4	A4	F2	F5	F5	F5	F4	F2	F4	F4	F4	F4
	F4	F4	F4	F4	F4	F2	F4	F4	A4	F2	F2	F2	F2	F4	F2	F4	F4	F4	F4
	F4	F4	F4	F4	F4	F2	F4	F4	A4	F2	F2	F2	F2	F3	F2	F4	F4	F4	F4
	H2	H1	H1	H1	H1	H1	H1	H1	H1	H2	F2	F2	F2	H2	H1	H1	H1	H1	H1
Activities	**1**	**2.1**	**2.2**	**2.3**	**3**	**4**	**5**	**6**	**7**	**8**	**9.1**	**9.2**	**9.3**	**10**	**11**	**12**	**13**	**14**	**15**
Time	3	20		15						20	43800	120	15	33	165				
Data		O	I / O																
Inf. system		O	I / O							I / O	I / O	I	I / O				I		

Source: the authors' compilation

3.5 Increasing daily physical activity in patients with peripheral artery disease (Case PERIPHART)

For the treatment of patients with peripheral artery disease, the development of telemedicine technology also led to monitoring patients' activity at home using telemedicine software and smart devices. In this case, smart devices and telemedicine software were defined as new resources that support the home-based physical exercise of patients that are able to measure and transmit the results of physical exercise.

The process of patient care in the framework of traditional medicine starts in the outpatient department (Table 4), where a specialist assistant identifies and registers a patient through a referral (Act. 1). After checking the patient's eligibility for treatment (Act. 2), a specialist (with the help of a specialist assistant) informs a patient about the nature of the treatment and answers any questions that may arise (Act. 3). Then, with the assistance of the same actors and the help of the outpatient department infrastructure, IT, and medical equipment, the patient's initial assessment is carried out, involving recording demographic data (Act. 4), medical history (Act. 5), vital signs (Act. 6), and currently used medication (Act. 7). The examination includes a physical examination of a patient: first, a functional examination (Act. 8) is

undertaken, then one of objective walking distance (Act. 9), and the Ankle Brachial Index (Act. 10) is calculated. The initial examination concludes with a summary of the therapy and consultation with a patient (Actions 11-12). Patient then regularly carries out the therapy-recommended physical exercises at home, using equipment, and records the results on a report sheet (Act. 13). After three and six months, a patient is examined again in the same way as at the initial examination, and a physiotherapist participates in the examination alongside the original practitioners (Act. 15-20). The follow-up examinations lead to agreement with a patient regarding the continuation of the therapy and what further actions should be taken (Act 21).
Telemedicine technology development resulted in use of a smart scale, a smart blood pressure monitor, a smartwatch, a stair climber, a transceiver, and telemedicine software to support the patient's home mobility, causing changes in four activities in the protocol. First, the activity related to informing a patient (Act. 3) was modified (the focus changed to explaining the telemedicine protocol). Further, the therapy suggestion was (also) recorded in the telemedicine system (Act. 12). Third, the parameters of the patients' home exercise (Act. 13) were routinely recorded and transmitted by the smart devices (Act. 13.1) and then analyzed and reported back to patients by a cardiology nurse (Act. 13.2). Finally, modification is recognized in the need to identify patients in the telemedicine system for further checks; moreover, their activity-related data becomes available (Act. 15).

Due to the changes in technology, changes in resources and information occurred in parallel with changes in activities. In fact, the change in the information provided to patients involved the introduction of new input data (meeting selection criteria) and a new information system (patient identification in the telemedicine system), which was accompanied by the completion of a consent form by a patient. In fact, recording the therapeutic suggestion in the telemedicine system also involved the introduction (and use) of the telemedicine system. Furthermore, changing the patients' physical exercise routine at home required smart devices (smart weight scale, smart blood pressure monitor, data transmission unit, stair machine, smartwatch). Furthermore, the data analysis required the additional workload of a cardiology nurse in the analysis, as well as the use of office and IT infrastructure (nursing station, desk, chair, computer, monitor, printer, telephone) and consumables (paper, pen, appropriate clothes). Finally, a new data element (patient identification) and the telemedicine system were resources additionally required for the checkups.

Table 5 Changes in the protocol 'Risk reduction for patients with metabolic syndrome' due to technology change

																A4				A4	
						A4				A4						A4				A4	
						A4				A4						A4		A4		A4	
						A4		A4		A4					A4	A4	A4	A4	A4	A4	A4
				A4	A4	A4	A4	A4	A4	A4		A4		A4		A4	A4	A4	A4	A4	A4	A4
				A4	A4	A4	A4	A4	A4	A4	A4	A4		A4		A4	F5	A4	A4	A4	A2	A4
				A4	A4	F5	A4	A4	A4	A2	A4	A4		A4		A4	F4	A4	A4	A4	F5	A4
	A4	A4		A4	A4	F4	A4	A4	A4	F5	A4	A4		F5		A4	F4	A4	F5	A4	F4	A4
	A4	A4	A4	A4	A4	F4	A4	F5	A4	F4	A4	F5		F4	A4	F5	F4	F5	F4	F5	F4	F5
	A4	A4	A4	F5	F5	F4	F5	F4	F5	F4	F5	F4		F4	A4	F4	F4	F4	F4	F4	F4	F4
	A4	A4	A4	F4	F4	F4	F4	F4	F4	F4	F4	F4	F2	F4	A4	F4	F4	F4	F4	F4	F4	F4
	F5	F5	A4	F4	F4	F4	F4	F4	F4	F4	F4	F4	F2	F4	A4	F4	F4	F4	F4	F4	F4	F4
	F4	F4	F5	F4	F4	F4	F4	F4	F4	F4	F4	F4	F2	F4	F5	F4	F3	F4	F4	F4	F4	F4
	F4	F4	F4	F4	F4	F3	F4	F4	F4	F4	F4	F4	F2	F4	F4	F4	F2	F4	F4	F4	F3	F4
	F4	F4	F4	F4	F4	F2	F4	F4	F4	F3	F4	F4	F2	H3	F4	F4	F2	F4	F3	F4	F2	F4
	F4	F4	F4	F4	F4	F2	F4	F3	F4	F2	F4	F2	A3	A3	F4	F3	F2	F3	F2	F3	F2	F3
	F4	F4	F4	F3	F3	F2	F3	F2	F3	F2	H3	H3	A3	A3	F4	H3	H3	H3	H3	H3	H3	H3
	H2	H2	F4	H2	H2	H2	H2	H2	H2	H2	H2	H2	A3	A3	F4	H2	H2	H2	H2	H2	H2	H2
	H1	H1	H2	H1	H1	H1	H1	H1	H1	H1	H1	H1	F5	F5	H2	H1	H1	H1	H1	H1	H1	H1
Activities	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**13.2**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**
Time	5	5		15							5	5	3600	360	5	80						
Data			I / O									I / O	I / O	I		I						
Inf. system			I / O									I / O	I / O	I		I						

Source: the authors' compilation

The analyses show that, two activities changed due to the use of telemedicine technology (Act. 3 and Act. 13), while the change in activities was accompanied by a change in resources in only one case. Three patterns of change that occurred during the case could be identified. (1) Change in an activity that did not cause a change in either the set of resources or the intensity of their use, but resulted in new data coded into a new information system (Act. 3). (2) The set of activities and resources and the intensity of their use changed. The set of data that was generated and the scope of the information systems used also changed (Act. 13). (3) Neither the activities, the set of resources, nor their intensity of use changed. No change could be detected in the set of data reported, but there was a change in the information system used (Act. 12; Act. 15).

Conclusion

Our research confirms the findings of Basto et al. (2019) and Dóra and Szalkai (2020) that changes related to activities, resources, and information pathways are intertwined in healthcare processes. Our analysis further demonstrates, in line with the findings of Middleton et al. (2020) and Zanotto et al. (2020), that the digital platform that is used and the way information is managed define the characteristics of both patient care activities and resources used.

On the other hand, the results confirm the correlations identified in previous studies of resource interaction. According to the latter, technology is considered more as an interface than a resource, where changes in interfaces (namely, interconnections between resources) inevitably induce changes in activities, resource constellations, or the intensity of resource use (Baraldi et al., 2012; Prenkert et al., 2019). However, our findings go beyond these observations and show that technological change can be captured through changes in information systems and the data that is used when digital technologies (telemedicine, telehealth applications) are introduced or modified. Changes in information systems and such data indicate changes in activities, resource constellations, and resource-use intensity.

In some cases the technological change concerned the configuration and exploitation of digital technology in specific healthcare protocols, where the introduction of the new technology led to numerous spill-over effects. These findings are consistent with both the general experience of interpreting the effects of technological change (Håkansson et al., 2009; Hu et al., 2002) and observations about telemedicine and telehealth developments (Parikh et al., 2020; Portney et al., 2020; Bauer et al., 2020; Middleton et al., 2020; Rodrigues et al., 2021).

In the cases that were studied, the observed changes in resources as a result of technological change seemed to occur without any apparent pattern. In some cases, the new technology generated new/changed activities, new/changed resource sets, and – in parallel – a change in the intensity of resource use. In other cases, only the resources involved in the activities and the intensity of resource use changed, while the activities that were carried out remained unchanged. Last, we also identified a few cases in which only the activities undertaken, or the resource set, or the intensity of resource use changed. However, for all the cases examined, the changes not only affected the activities for which the new tools/resources were introduced, but there were also spill-over effects. These took many forms, which shows the nature and characteristics of the changes (Δ) that occurred based on the patterns of change summarized in the analysis of each case study.

We can see in all cases, the changes observed as a result of technological change occurred in parallel with changes in the data that was used and the information systems employed. If there is a change in the data that is used and the information system at the same time, in all cases there are changes in the observed characteristics; i.e. in the activities to be carried out and/or in the resources used and/or in the intensity of resource use. These changes may be classified into four groups: all three observed characteristics changed (activity, resource composition, resource intensity) (Group A); the activities and the intensity of resource use changed (Group B); only the activities changed (Group C); or only the intensity of resource use changed (Group D).

It was also discovered that if the change in technology only leads to a change in the information system that is used (with no change in the data used), in some cases there is a change in the activities, the resources used, and/or the intensity of resource use, while in other cases there is no observed change. However, as the information system changed, there were changes in the resource set and the intensity of their use in the ENT protocol (ENT 2). Moreover, changes only in the resource set in the DIAL protocol (DIAL 3) and changes only in the intensity of resource use in the METSY protocol (METSY 3) were detected when a change in the information system applied was identified.

Finally, changes exclusively in the data being used (without modification of the information system) could not be identified. Furthermore, no change could be identified when an adjustment was made to activities and/or in the resource set and/or the intensity of resource use without a change in the data or information system.

In our research we sought to answer the research question of how to identify the extent of change in resources caused by a technological change. Our investigation led us to the following conclusion: we found that a technological change transforms a business process, and hence value creation itself, to the extent that its steps (activities) use new information encoded in a changed information system.

Our research focused on examining the emergence of technology induced change and identifying patterns of change in activities and resources, and the intensity of resource use in health service organizations. The research produced a number of striking results. On the one hand, our results confirm that in the case of telemedicine and telehealth applications, the impact of technological change is not limited to the process steps whereby new tools and equipment are introduced. Instead, spillover effects with apparently unpredictable patterns are generated, which may be reflected in changes in the activities undertaken during different process steps, resource sets to be used, or the intensity of their use.

Our results also showed that, due to technological change, changes in information systems were likely to result, while simultaneous changes in data used and information systems together clearly predicted changes in activities, resources, and the intensity of resource use in the observed cases. In the case of changes due to modifications of technology, we found no examples of changes in activities, resources, or resource use intensity without changes in data and/or information systems.

Our research suggests that applying the TDABC methodology can help trace such changes. Furthermore, it suggests that TDABC methodology should be complemented by systematic monitoring of the information system and data content, allowing greater localization and analysis of the scope of changes in the case of technological change. Our investigations suggest that monitoring the data and information systems used to track and implement activities can be used as predictors of change.

The most significant limitation to generalizing our findings is the research context itself. Our study was conducted in the context of healthcare protocols, where we were able to take into account a number of specificities (such as the healthcare-process-specific context of the TDABC methodology), and the specific circumstances and sector-specific characteristics of the healthcare sector limit the generalizability of our results. A further limitation is the number of cases that were observed and the research method itself. We investigated the consequences of technological change in the context of five healthcare protocols within the framework of an organization using case-study methodology. Although the number of observations and the chosen research method allowed us to make in-depth observations, they do not permit us to make organization- and sector-independent observations. This suggests the need for further research, which can also lead to the opportunity to investigate the effectiveness of traditional and telemedicine-supported healthcare delivery processes. Furthermore, it also seems justified to test TDABC methodology and examine its potential added value based on the approach described in this study.

Declarations

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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The euro exchange rate's resistance to the exogenous shock caused by COVID-19

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Abstract

Background: The COVID-19 pandemic represents the greatest exogenous global shock in the last few decades, which has deeply affected the macro-economic aggregates around the world. Bearing in mind that COVID–19 pandemic is an exogenous shock; its effect on the macro-economic aggregates will take time to be analysed, while it has a persistent impact on the financial markets.

Purpose: One-third of the transactions worldwide includes the euro. Hence, the main objective of this study is to estimate the euro exchange rate's resistance to the exogenous shock caused by the COVID-19 pandemic.

Study design/methodology/approach: This paper employs the General AutoRegressive Conditional Heteroskedasticity (GARCH) model to examine the EUR/USD exchange rate's resistance to the global exogenous shock caused by the COVID–19. In other words, the authors try to find an answer to question whether the COVID–19 pandemic affects the EUR/USD exchange rate volatility.

Finding/conclusions: The results show that the COVID–19 pandemic has no effect on the EUR/USD exchange rate volatility in the long run. These results may confirm our assumption of the resistance of the financial market to the exogenous shock and are useful for anyone needing forecasts of the exchange rate futures movements. The obtained results produce pragmatic expertise in order to manage exchange rate risk and should support policymakers to advance exchange rate policy.

Limitations/future research: As a limitation of this study, the authors state the estimation of the euro exchange rate`s resistance to only one exogenous shock, caused by COVID-19. Bearing in mind that in the considered period was also the world economic crises which might have caused a higher volatility then COVID-19, for further research the authors propose an examination of the detailed estimation of the euro exchange rate`s resistance to different exogenous shocks.

Keywords

COVID–19, GARCH, EUR/USD volatility, Financial market, Shock resistance

Introduction

It can already been argued that the COVID-19 pandemic inevitably led to the decline in GDP, increase in the unemployment rate and general government deficit in almost all economies around the world. It caused a high uncertainty that has destabilized global markets. The COVID-19 pandemic led to severe modification in the way people work (Szeiner et al., 2021) and had a significant impact on supply chains and almost all aspects of government and business activities (Ubi et al., 2021; Zečević et al., 2022) (Joksimović et al., 2021)

Bearing in mind that COVID–19 was an exogenous shock, its effect on the macro-economic aggregates will take time to be analysed, while it had a persistent impact on the financial markets. There is a common belief that the global crises lead to a sharp depreciation of all currencies (Barro, 2006; Gabaix, 2012). However, during the 21st century, the exchange rate volatility has been decreasing among the G3 currencies. Was this stability maintained through the COVID–19 pandemic? The authors' main objective is to estimate the euro exchange rate's resistance to the exogenous shock caused by the COVID-19 pandemic.

The influence of the COVID-19 pandemic on the exchange rate markets was usually realised through the channel of changing the relative expectations of the future economic growth. In this paper, the authors focus on the euro's stability. Revealed that during the COVID-19 pandemic the euro (EUR) had strengthened in relation to the United States dollar (USD). According to OECD database, the European Union's debt was lower than that of the United States and Japan, the European Union gravitated to sustain account surpluses and one third of the transactions worldwide included the euro. Eichengreen & Gros (2020) considered that the European Union should to strengthen the attractiveness of the euro as a reserve currency. However, the political divergences were leading to the euro not being considered as a safe haven currency. To become even more attractive in international payments and considered as a safe currency, the euro should be stable in the long run. The authors assume the hypothesis H_{01}: The COVID-19 pandemic did not influence the euro exchange rate's resistance to the shock, and H_{02}: The GARCH (1,1) is an optimal model for an estimation of this influence.

In the Introduction section, the authors define the main objective of this paper and the hypotheses the authors estimate. In Literature review section, there are presented the relevant theoretical and practical works that deal with exchange rate volatility during the COVID-19 pandemic. The underlying model and data set are shown in the second section. The third section describes the used methodology and empirical results, while the last section concludes.

1. Literature review

According to Handoyo (2020), Franz (2021), Umar, M (2021), Hung et al. (2022), Aloui (2021), Abedin et al. (2021) the COVID-19 pandemic caused worldwide economic, investment and trade crisis. Devpura (2021), Iuga et al. (2022), Wei et al. (2020) showed that the COVID-19 pandemic had a significant influence on the global financial system. Simion and Mihai (2021) agreed with this opinion adding that the governments around the word had to react in completely unforeseen circumstances and make unusual decisions. To remain stable and survive throughout the time of the COVID-19 pandemic, a lot of companies made an attempt to invent innovative options and transform their activities (Youssef et al., 2022; Adekoya et al., 2021; Ozturk et al., 2021).

However, one of the most unexpected characteristics of the COVID–19 pandemic shock was the stability in the exchange rates, in spite of a global recession. Dias and Santos (2020) concluded that the exchange rate markets had persistence and long memories, while Park et al. (2020) revealed more stability in the exchange rate worldwide throughout the first three months of the COVID-19 pandemic. Ilzetzki et al. (2020) found that the rising G3 currencies' (dollar, euro and yen) stability over the COVID–19 pandemic shock was an acceleration of a long–term trend. Following the authors' opinion the G3 currencies' exchange rate volatility reached its lowest values since the Bretton Woods agreement. Benzid & Chebbi (2020) showed that an increase in the new cases and deaths caused by the COVID-19 pandemic in the United States had a positive effect on the daily stability of the USD/EUR, USD/Yuan and USD/LivreSterling calculated by GARCH (1,1) model. Njindan Iyke (2020) analysed the COVID–19 upsurge channel of the exchange rate return predictability. The author showed that the COVID–19 pandemic had better prognostic power over the exchange rate volatility than over returns for a one–day in advance prognosis horizon, while it tended to lean returns more than volatility over a five–day in advance prognosis horizon. Ratho et al. (2020); Salehi et al. (2021); Moussa et al. (2021) considered that forex market interventions, inclusive of other monetary and regulatory measures upheld contributed to the exchange market stability and reduced the possible risks to the financial stability. Garg and Prabheesh (2021) showed that the interest rate differentials intensify the predictability of the exchange rate movement in the BRICS countries during the pandemic.

On the other hand, Barro et al. (2020), Das (2021), Cauwenberge et al. (2021) and Sim et al. (2022) claimed that the growing volatility in the financial market around the world had been caused by the high level of uncertainty. Employing wavelet coherence and partial wavelet coherence model, Singh et al. (2021) found the high degree of correlation between exchange rate movement and the pandemic in G7 countries during the period from January 4, 2021 to July 31, 2021. Using a regression analysis, Gongkhonkwa (2021) drew a similar conclusion for Thailand covering the period from January 2, 2020 to December 15, 2020. Based on an examination of twenty countries Feng et al (2021) showed that a growth in new cases of COVID–19 remarkably increased the exchange rate instability in twenty observed countries covering the period from January 13, 2020 to July 21, 2020. Koç (2021) came to the similar conclusion for Turkey. Namely, using the MS–ARCH model on the USD/TRY exchange rate return the author found that the COVID-19 pandemic had significant impact on the exchange rate stability during the period from March 2020 to Octobar 2021. Furthermore, the author concluded that this impact is permanent. Olasehinde-Williams et al. (2021) argued that the financial system stability should be considered as a main goal of economic policy during the COVID-19 pandemic.

Employing the autoregressive distributed lag model Chuanjian et al. (2021) found the short and long run negative impact of the pandemic on the exchange rate stability in the United States and China during the time from January 22, 2020, till May 7, 2021. Contrary to that, using the error correction model, Gbadebo (2022) found that the COVID-19 pandemic caused an increase in Nigerian exchange rate instability cover the period from February 29, 2020 to March 31, 2021. At the same time, the author concluded that the COVID-19 pandemic had an impact on all macroeconomic indicators in Nigeria. Beckmann and Czudaj (2022) draw a similar conclusion for fifty currency pairs (twenty nine major currencies and thirty three minor currencies) during the different time horizons. Employing the panel autoregressive distributed lag model Jamal and Mudaser (2022) revealed that the COVID-19 pandemic significantly affected the exchange rate movements in the countries most affected by the COVID-19 pandemic (Brazil, China, India, Italy, Turkey, and the United Kingdom) during the period from March 11, 2020 to December 31, 2020. Moreover, the authors concluded that the COVID-19 pandemic modified the market expectations about the future exchange rate movements.

Aquilante et al. (2022) showed that the COVID-19 pandemic induces a depreciation of the domestic currencies relative to currencies of the trading partners confirming that the exchange rate reacted quickly to the exogenous shocks. Conducting an analysis on nine exchange rates of European countries, Klose (2022) revealed that the COVID-19 pandemic caused the depreciation of the domestic currencies relative to euro.

Li et al. (2022) tried to answer a question whether the relationship between oil prices and observed exchange rates (CAD/USD, EUR/USD, JPY/USD, and GBP/USD) differed during the COVID-19 pandemic. Using a shock spillover index, the authors estimated the significance of return and volatility spillover before and during the COVID-19 pandemic. They find that observed effect was more powerful during the COVID-19 pandemic time. Yildirim et al. (2022) showed that real effective exchange rate and commodity prices volatility transmission significantly differed in periods of crisis compared to the stable periods in Mexico, Indonesia and Turkey. Employing DECO-GARCH and transfer entropy approaches, Hung et al. (2022) showed that the risk caused by the COVID-19 pandemic from one exchange rate market had been very quickly and easily transferred to other markets around the world. Yilmazkuday (2022) partially confirmed these claims analysing the spillover effects of United States monetary policy on the movements of exchange rates of twenty three emerging and developed economies. Konstantakis et al. (2023) claimed that during the COVID-19 pandemic there is higher EUR/USD volatility than in the period before the pandemic. That should be very important information for making investment decisions during the periods of crisis.

2. Data and model

The most of recent studies recommended the GARCH for modelling the exchange rate volatility (see Balaban et al., 2019; Simion and Mihai, 2021; Almisshal and Emir, 2021; Basma and Mustafa, 2021; Rakshit and Neog, 2022; Charfi and Mselmi, 2022). In accordance with these studies, the authors measure the EUR/USD volatility using the conditional variance (h_t) of the daily nominal exchange rate return derived from the following GARCH model that the authors assume as the most appropriate:

$$h_t = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 h_{t-1} + \gamma_1 Z_t' + Dummy \ (1)$$

where

α estimates the ARCH effect,

β estimates the GARCH effect,

Z_t' presents the new cases of COVID–19 – a standardized variable calculated using a following formula $z = \frac{X-\mu}{\sigma}$, where μ is a mean, σ is a standard deviation,

ε_t is the stochastic term,

Dummy variable included in the model takes a value 1 during the COVID–19 pandemic time, a value 0 in another case.

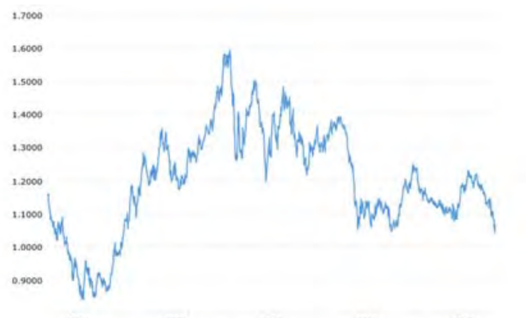

Chart 1 Euro-Dollar exchange rate – Historical Chart
Source: the authors' calculation based on data from https://www.macrotrends.net

The modelled variable is the logarithmic exchange rate return. The GARCH model is employed in order to the authors examined whether the COVID–19 influences the EUR/USD volatility. The authors cover the period from January 1, 1999 to March 31, 2022.

In the Chart 1 the horizontal axis represents the observed period, while the vertical axis represents the daily values of EUR/USD. As Chart 1 shows the euro's fluctuations were high at the first period, while they decreased later. It is worth mentioning that the euro had been strengthened against both currencies through the COVID-19 pandemic. This fact may strengthen the role of euro bearing in mind that a "multipolar" structure is increasingly visible in the financial system worldwide. The OECD Statistics reveal that the euro has been the second most significant global currency through the last year, while the euro is the most used invoicing currency in the international trade.

3. Methodology and results

The GARCH model takes into account several common characteristics of financial time series. One of them is the grouping of volatility, which can be clearly seen in the Chart 2. In the Chart 2 the horizontal axis represents the observed period, while the vertical axis represents the value of the estimated daily nominal exchange rate returns.

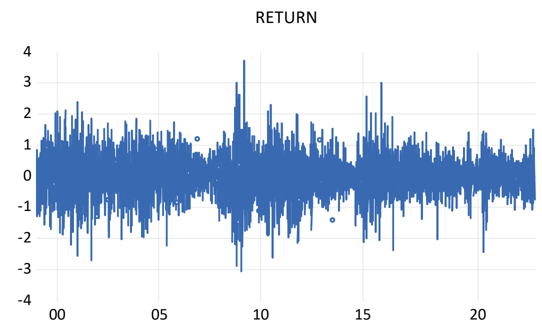

Chart 2 Nominal EUR/USD EXR return – historical data
Source: the authors` calculation based on data from https://www.oecd.org/

Following the descriptive statistics presented in Table 1, the authors may conclude that the EUR/USD have a leptokurtic distribution (high kurtosis). Jarque-Bera (JB) statistics also suggest that obtained variable is not normally distributed which is confirmed with Quantile-Quantile (QQ) plot given in the Chart 3. Hence, the estimated GARCH model may follow the student *t*-distributions rather than normal one.

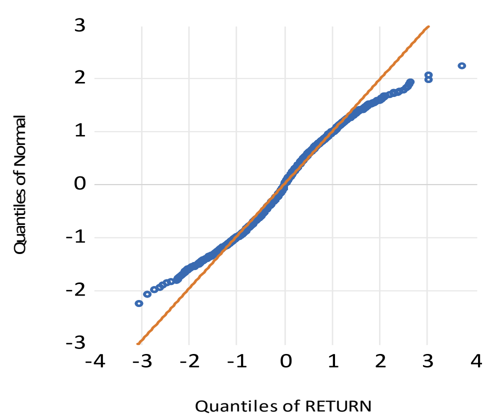

Chart 3 Nominal EUR/USD return QQ plot - - historical data
Source: the authors` calculation based on data from https://www.oecd.org/

To detect the structural breaks, the authors apply Bai and Perron procedure, which estimates the multiple break points based on the Quandt-Andrews structural fracture test. Following Schwarz and LWZ criterion selected breaks; the authors may conclude that in the EUR/USD return series there is no structural break, while in COVID-19 series data there is one structural break. Hence, in the case of the first series we apply two complementary tests; the Augmented Dickey-Fuller (ADF) test and Kwiatkowski–Phillips–Schmidt–Shin (KPSS) test while for the second series we apply the ADF test. The tests show the stationarity of all observed variables (see Table 2). Ljung-Box Q statistics and Breusch-Godfrey Largange Multiplier (LM) test are used to detect autocorrelation. According to the findings in the Table 2, the authors may conclude that there is no autocorrelation.

Table 1 Descriptive statistics

	Mean	Median	Max	Min	Std. Dev.	Skewness	Kurtosis	JB
EUR/USD	0.001034	0.000000	3.725359	3.056473	0.593815	0.008835	5.068595	1097.844
COVID-19	438.9109	0.000000	2817.330	0.000000	215.2557	8.624968	88.16214	1937243

Source: the authors` calculation based on data from https://www.oecd.org/

Table 2 Unit Root tests, Ljung-Box statistics, LM test and heteroskedasticity test

	Unit root tests			
	ADF test		KPSS test	
	Intercept	Trend and intercept	Intercept	Trend and intercept
EUR/USD	-80.51522	-80.50971	1.960212	1.800062
	Augmented DF test			
COVID-19	-14.12566	-15.17059		
		Autocorrelation tests		
	Ljung-Box Q statistics			LM test
	Q(10)	Q(20)	Q(30)	
COVID-19→EUR/USD	-0.026	-0.003	0.967	1438554
Heteroskedasticity test – ARCH effect				
COVID-19→EUR/USD	90.34863			

Note: ADF – Lag length: Schwarz Info Criterion, KPSS – Bandwith: Newey-West Bandwidth

Source: the authors` calculation based on data from https://www.oecd.org/

Table 3 Selection of the optimal GARCH model – the value of Schwarz criterion (SIC)

Estimated models	Value of SIC				
	GARCH	TGARCH	EGARCH	PGARCH	CGARCH
COVID-19→EUR/USD	1.624163	1.625194	1.627748	1.625561	1.625039

Source: the authors` calculation based on data from https://www.oecd.org/

In order to answer whether the GARCH model is adequate for modeling EUR/USD volatility, the authors estimate the residual fluctuation. In Chart 4, the horizontal axis represents the observed period, while the vertical axis represents the value of the estimated residuals. It is noticeable from the Chart 4 that periods of low/high EUR/USD volatility are followed by periods of low/high EUR/USD volatility for a prolonged period. Hence, the authors conclude that GARCH model will be adequate for EUR/USD volatility modelling.

The heteroskedasticity tests (see Table 2) show that in all observed models the ARCH effects are detected; hence the some type of GARCH models should be used for answering the question whether the COVID–19 affects euro's exchange rate resistance to the shock caused by COVID-19.

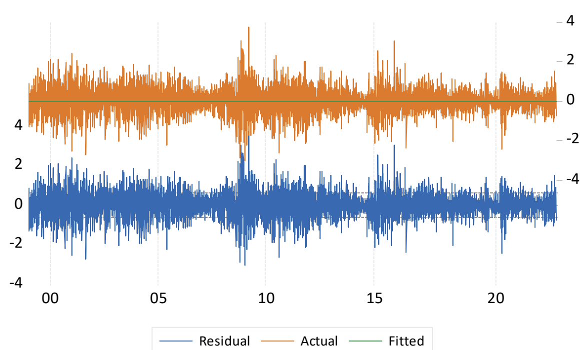

Chart 4 Residual fluctuation
Source: the authors` calculation based on data from https://www.oecd.org/

To select the optimal type of GARCH model the authors use the lowest Schwarz criterion (see Penezić et al., 2020). Besides the GARCH model in the Table 3, we estimate the following models:

TGARCH (Threshold GARCH) model

$$\sigma_{e,t}^2 = C + (\alpha_e + \gamma_e I_{t-1})\varepsilon_{e,t-1}^2 + \beta_e \sigma_{e,t-1}^2 + \sum_{i=1}^{k} \tau_e V_{e,i} + Z_t' \qquad (2)$$

EGARCH (Exponential GARCH) model

$$ln(\sigma_{e,t}^2) = C + \beta_e ln(\sigma_{r,t-1}^2) + \alpha_e(\varepsilon_{r,t-1}) + \sum_{i=1}^{k} \tau_e V_{e,i} + Z_t' \qquad (3)$$

$$\alpha(\varepsilon_{e,t-1}) = \psi_{e,1}\varepsilon_{e,t-1} + \psi_{e,2}\left(|\varepsilon_{e,t-1}| - \sqrt{2/\pi}\right) \qquad (4)$$

PGARCH (Power GARCH) model

$$\sigma_{e,t}^{\delta} = C + \alpha_e\left(|\varepsilon_{e,t-1}| - \mu_e \varepsilon_{e,t-1}\right)^{\delta} + \beta_e \sigma_{e,t-1}^{\delta} + \sum_{i=1}^{k} \tau_e V_{e,i} + Z_t' \qquad (5)$$

CGARCH (Component GARCH) model

$$\sigma_{e,t}^2 = \overline{w} + \alpha_e(\varepsilon_{e,t-1}^2 - \overline{w}) + \beta_e(\sigma_{e,t-1}^2 - \overline{w}) + \sum_{i=1}^{k} \tau_e V_{e,i} + Z_t' \qquad (6)$$

where α estimates the ARCH effect, β estimates the GARCH effect, γ measures asymmetric effect in the TGARCH model, ψ_1 and ψ_2 measures asymmetric effect in the EGARCH model, μ and δ measures asymmetric effect in the PGARCH model, while τ estimates the dummy variables (V) that are introduced when the structural breaks are detected.

According to the obtained findings in Table 3, as an optimal model, the authors select the GARCH (1,1) which is consistent with our hypothesis. Following the results presented in the Table 4 the COVID-19 does not affect euro exchange rate's resistance to the exogenous shock caused by the COVID-19 pandemic in the long-run time period; the obtained coefficients of COVID-19 and Dummy variable are not statistically significant. The diagnostic tests show that the models are well specified. Bearing in mind that $\alpha + \beta < 1$, the authors may claim that the estimated model is stable, while the obtained results of Q(20) suggest that there is no serious correlation. Heteroskedasticity test show that there is no ARCH effect in the residuals of the evaluated model. Pearson statistic shows that the estimated model is well specified.

Table 4 Estimated GARCH (1,1) models

Variable	Coefficient
C	0.002103
COVID–19	-5.48e-07
Dummy	-0.006139
Variance Equation	
C	0.001078
RESID(-1)^2	0.035656
GARCH(-1)	0.961523
Diagnostic Tests	
$\alpha + \beta$	0.997179
Q(20)	-0.009
ARCH	3.2684
Pearson	6.89

Source: the authors` calculation based on data from https://www.oecd.org/

Conclusion

The COVID-19 pandemic represents the greatest exogenous global shock in the last few decades that has deeply affected the macro-economic aggregates around the world. As an exogenous shock, its effect on the macro-economic aggregates will take time to be analysed, while it is expected to have a persistent impact on the financial markets. However, one of the most unexpected characteristics of the COVID–19 shock has been the stability in the majority of exchange rates, in spite of a global recession. The authors' main objective is to estimate the euro exchange rate's resistance to the exogenous shock caused by the COVID-19 pandemic. Using the GARCH (1,1) models the authors examine the euro exchange rate's resistance to the shock caused by the COVID–19 pandemic in the long run. According to the obtained results, the authors can draw a conclusion that the COVID-19 pandemic does not affect the euro exchange rate's resistance to the shock in the long-run. The obtained results confirm the authors' first assumption about the euro's resistance to the exogenous shock and the authors' second assumption that EUR/USD exchange rate volatility should be measured by GARCH (1,1) model. The euro was strengthened against the U.S. dollar during the COVID-19 pandemic. Following by the euro exchange rate's stability, these facts may strengthen the role of the euro considering that a multipolar structure has been necessary in the financial system worldwide.

The findings obtained in this study provide valuable information for policy makers and financial managers taking into account that high exchange rate volatility may cause growth of transaction costs and reduction of international trade. The obtained findings may make it easier for policy makers to improve the efficiency of exchange rate. In the authors' opinion, this study contributes to the literature explaining EUR/USD volatility during the COVID-19 pandemic. The obtained findings may be useful to anyone needing forecasts of the euro futures movements, especially for investors who desire to hedge exchange rate risk in their net foreign asset positions and researches who analyse the volatility in foreign markets.

As a limitation of this study, the authors state the estimation of the euro exchange rate's resistance to only one exogenous shock, caused by COVID-19. Bearing in mind that in the considered period the world was also in an economic crises which might have caused a higher volatility then COVID-19, for further research the authors propose an examination of the detailed estimation of the euro exchange rate's resistance to different exogenous shocks. It is worth to mentioning that the GARCH models can overestimate the estimated volatility in certain circumstances (Hamilton and Susmel, 1994). The obtained results produce pragmatic expertise in order to manage exchange rate risk and should support policymakers to advance exchange rate policy.

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Socially Responsible Behavior of Companies from the Young Generation Perspective – an Empiric Study from Four European Union Member States[1]

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Abstract

Background: Since adopting the Non-Financial Reporting Directive, companies have been required to report information on environmental, social, and employee matters. After adopting the Corporate Sustainability Reporting Directive and its gradual transposition into the European Union (EU) Member States' national legislation, the Environmental Social, and Governance (ESG) reporting requirements are becoming stricter to ensure transparency and comparability of reported sustainability information, to prevent greenwashing, and to ensure that companies behave in a socially responsible manner to the environment, society, and governance, and report this information in the Sustainability Report.

Purpose: The paper aims to analyze how the young generation from four different EU member states perceives companies' socially responsible behavior and what importance they give to various attributes of corporate social responsibility.

Study design/methodology/approach: To meet the paper's purpose, a standard methodology of legislation and literature review was performed. Afterward, a questionnaire survey was conducted in which the attitudes of the young generation to the socially responsible behavior of companies were investigated. Software SAS Enterprise Guide and SAS programming language have been used for the analysis.

Findings/conclusions: The research results showed that the young generation perceives social responsibility in companies' behavior and takes it as a competitive advantage in the market. The results, among others, showed which aspects of responsible business are the most important for the young generation. The young people were able to name socially responsible companies, and according to their responses, they would prefer to buy products or services from companies that behave responsibly to society and the environment, even if these products or services were more expensive.

Limitations/future research: The paper analyzes the attitudes only of the young generation which can be a limited factor in the research. More detailed analysis within all the age groups could bring different results. The number of respondents is another limitation.

Keywords

ESG reporting, Corporate Social Responsibility, ESRS, CSRD, Green Deal, sustainability

Introduction

The expansion of the world economy, which intensified after the Industrial Revolution, led to pressures on the use of natural resources, the growth in the production of consumer goods, the conversion of forests and grasslands into built-up areas, and an increase in urbanization. Such development has had (Khodoparast Shirazi et al., 2020; Taghvaee et al., 2022; Chen et al., 2023; Kotzian, 2024) a positive impact on the livelihoods of society, however, on the other hand, its impact

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and demand on natural resources have raised considerable concerns about this transition. The lack and depletion of resources, climate change, pollution, and degradation of the environment, as well as increasing amounts of greenhouse gases leading to global warming, forced governments all around the world to consider sustainable development. The future of the planet and mankind has become a priority for economies, governments, and communities.

Companies, as well as governments, are aware of the potential impact of their activities on the environment, society, or employees and are beginning to minimize these impacts and look for opportunities to innovate actively. As a result, an increase in the sustainable activities of companies, and pressure on their environmental and social behavior to protect the environment and create good conditions for living can be seen.

As Kidd (1992) states, since the 1950s, six opinion strands have appeared in the debate on the interrelationships among population growth rates, natural resource use, and environmental pressures. 'They are the ecological/capacity root, the resource/environment root, the biosphere root, the technology critique root, the 'no growth'/'slow growth' root, and the ecological development root' (Kidd, 1992, p. 1). All the roots had been fully formed before the term 'sustainable' was introduced. Sustainability and sustainable development have stimulated intense public and scientific debate since their recognition in the Brundtland Commission report in 1987 which for the first time introduced the overall concept of sustainable development (Boyer et al., 2016; Diaz-Sarachaga, 2021). After this, the term sustainability, despite not having a specific definition, became very popular (Silva et al., 2022) and many definitions of the term sustainability have appeared as well (Abdusalomova et al., 2025; Bansal, 2005; Basile et al., 2021; Ruggerio, 2021).

1. Methods

The paper aims to analyze how the young generation from four EU member states perceives the socially responsible behavior of companies and what importance it gives to different attributes of corporate social responsibility.

To meet the objective of the paper, relevant sources of literature, as well as legislation related to sustainability and ESG reporting have been studied. The literature included mainly academic articles obtained from the Web of Science and SCOPUS database, professional papers from websites of the biggest accounting and auditing organizations, professional bodies on sustainability, and ESG reporting matters. The literature review was based on the legislation as of June 30, 2024.

Subsequently, the questionnaire survey at five faculties of economic orientation and one law faculty in four EU member states was carried out, namely at the Faculty of Economic Informatics, University of Economics in Bratislava, Slovakia; at the Faculty of Economics, VSB – Technical University of Ostrava, Czech Republic; at the Faculty of Law, Palacky University Olomouc, Czech Republic; at the Faculty of Economics and Business, University of Maribor, Slovenia; at Institute of Economics, Finance, and Management, Jagiellonian University, in Krakow, Poland; at Department of Costing, Tax Management and Controlling, Wroclaw University of Economics and Business, Poland, to investigate, analyze, and compare the perception of sustainability among the young generation. Altogether, 296 respondents took part in the survey. The breakdown of respondents by country, age, and gender is shown in Table 1.

Table 1 Breakdown of respondents according to country, age, and gender

Country	Number of respondents
Slovakia	132
Czech Republic	100
Poland	39
Slovenia	25
Age	Number of respondents
Up to 25	273
More than 25 years	23
Gender	Number of respondents
Male	107
Female	189

Source: the author

SAS Enterprise Guide software and the SAS programming language were used for the analysis. Multiple comparisons, interval estimates, and probability predictions have been calculated through them. The results obtained were interpreted qualitatively.

2. Results and Discussion

This chapter focuses on explaining the concepts of corporate social responsibility (CSR) and ESG reporting, including an overview of legislation related to these topics. The results of a questionnaire survey are also included in this chapter.

2.1. The Triple Bottom Line of Sustainability

IISD (1992) defines corporate sustainability as 'business strategies and activities that meet the needs of the enterprise and its stakeholders today while protecting, sustaining, and enhancing the human and natural resources that will be needed in the future'. According to Basile et al. (2021), sustainability has become one of the key factors for long-term business success. The implementation of sustainability principles has been pursued by companies worldwide, not only because it is a key factor for the livelihood of companies, but also because it is essential for the survival of future generations (Silva et al., 2022; Khamisu et al., 2024).

To be marked as socially responsible, companies must manage their businesses with respect for the environment, have good relationships with their customers, suppliers, employees, and business partners, and act in harmony with the needs of the local community. Taghvaee et al. (2022) point out that sustainability means creating the conditions for humanity and nature to coexist in productive harmony, enabling the socio-economic development of present and future generations.

Thus, sustainability is not just about environmental matters. Sustainability is based on three pillars, economic, environmental, and social, which interact in harmony. According to Boyer et al., (2016), these three dimensions form what is currently known as the tripod of sustainability, or 'the Triple Bottom Line' (TBL). This is confirmed by Hicks and Nergard (2023) who state that in general, most definitions of sustainability, although they may differ to some extent, agree that three main pillars need to be considered, environment, economy, and society.

The economic pillar is considered the essential pillar of TBL. It is the pillar that all companies have continuously and increasingly tried to improve before because generating profit is the main purpose of business. Nowadays, the companies show to society in general, and the market in particular, the respect they have for the social and environmental pillars of sustainability (Silva et al., 2022). If a company generates profit, it can, subsequently, contribute to achieving social and environmental goals. This is confirmed by Maas and Boons (2010), who state that companies raise awareness of the environmental and social impacts resulting from their activities in addition to their economic goals.

According to Estoque and Murayama (2014), the three pillars of the Triple Bottom Line of Sustainability (TBLS) create a nested hierarchy because societies cannot thrive without a functional life support system, and economies cannot thrive without the existence of functional social systems and infrastructure. The economic pillar is based on running a business to generate positive financial results. Without profit, there would be no investments in environment-protecting technologies, and no investments in improving working conditions, quality of life, leisure, and security. The environmental pillar is based on behavior and activities that protect the environment (Santos et al., 2017; Purvis et al., 2019; Bravi et al., 2020), such as natural resource conservation, decreasing greenhouse gases, use of renewable sources, reduction of solid waste emissions, and recycling trash. The third pillar of TBL, the social pillar, is related to the social factors, including working conditions, equality, non-discrimination, diversity and inclusion, human rights, and the development of better policies in areas such as education, leisure, and security (Silva et al., 2022).

According to Ruggerio (2021), the concept of sustainability is often associated with the sustainable development concept. Thus, both terms are used as synonyms. WCED (1987, p. 43) defines sustainable development, also known as sustainable economic development, as 'a development that meets the needs of the present, without compromising the ability of future generations to meet their own needs'.

Governments in many countries are also becoming increasingly aware of their responsibility to ensure sustainability. They are requiring project companies to develop strategies and action plans that will contribute to sustainable development (Aarseth et al., 2017). According to Székely and Knirsch (2005), economic growth, shareholder value, firm reputation, and customer relationships are the main attributes of corporate sustainability. Bansal (2005) defines sustainability at the corporate level as economic prosperity, social justice, and environmental protection through value creation, corporate social responsibility, and corporate environmental management. According to Racic Jelavic and Pajdakovic Vulic (2021, p. 46), 'the level of incorporating sustainability in business objectives and strategy will depend, among others, on environmental context, and external incentives (the industry type and sector, environmental legislation, market demand for environmentally-friendly products, social demand, the demand of responsible investors, etc.), and internal motives (image improvement, brand improvement, marketing improvement, increase in sale of environmentally-friendly products, resource productivity improvement, risk control, better employee motivation, better competitiveness, etc.)'.

2.2. Relation between CSR and ESG reporting

Presenting information on companies' social and environmental aspects plays a key role in the organizations' sustainable development (Bednarova & Bonson, 2015; Aluchna et al., 2023). Serious concerns about the future of mankind have inspired governments, companies, and investors to make sustainability a top business priority.

As part of the European Green Deal, the European Union (EU) has started the green transformation by redirecting private capital into green investments, leading organizations towards more sustainable ways of operating and financing. The aim was to foster economic growth while reducing pressure on the environment, helping to achieve the EU's climate and environmental goals, considering social and governance aspects. Considering the impact on the environment and society is also important for keeping businesses competitive and building their resilience to the effects of climate change (Skyrta & Semjanova, n.d.).

Starting from the intense debate on Corporate Social Responsibility (CSR) issues, governments of EU member states have launched innovative projects on the social responsibility of companies (Tencati et al., 2004; Bednarova & Bonson, 2015; Arvidsson & Dumay, 2022).

Nowadays, the shift from traditional financial reporting to new reporting based on the TBL approach that includes CSR disclosure because the financial statements are no longer enough to persuade investors of business opportunities can be seen. It demonstrates the need to incorporate ESG attributes into company's strategies. According to Diwan and Amarayil Sreeraman (2023), the companies' non-financial performance is becoming an increasingly important criterion for assessing the performance of companies in general.

In the beginning, and over the past three decades, CSR reporting was voluntarily based. Some organizations have reported their sustainable information within annual reports where only the minimum information was disclosed. Much more information was published on the companies' websites.

As the praxis proved, the companies have used to provide basic information for each of the pillars of TBL (impact on the environment, social, and employment area) but have not provided all the information on a point-by-point basis. Information was general, without direct evidence about the company's sustainable behavior activities, risks, and opportunities. Companies have applied various standards and regulations regarding CSR reporting. The most popular standards in the EU were and still are the Global Reporting Initiative (GRI), the Sustainability Accounting Standards Board (SASB), The Task Force on Climate-related Financial Disclosures (TCFD), the EU Taxonomy, etc. According to Arvidsson and Dumay (2022), voluntary and mandatory reporting frameworks improved ESG information quality slightly but did little to improve companies' ESG performance.

Several ESG Ratings and Rankings Agencies, such as Bloomberg, MCSI, ISS ESG, and S&P SAM (DJSI) started to assess the level of companies' ESG reporting. Kimbrough et al. (2024) found that disagreement among ESG rating agencies is lower for companies that voluntarily issue sustainability reports. Hence, publishing information on the environmental and social aspects helps decrease misunderstandings about the company's performance in these aspects.

In recent decades (Noronha et al., 2013), mankind has witnessed the growing importance of companies' socially responsible behavior and the increasing need for CSR reporting as well. This is due to corporate scandals, financial crises, climate change, greenhouse gas reductions, concerns about labor rights, product safety, etc. CSR reporting, or ESG Reporting has become even more important.

The ESG concept was first introduced by the United Nations in its 2006 *Principles for Responsible Investment*. The ESG concept itself is based on corporate social responsibility. The concept reflects the need for investors and other stakeholders to gain insight into the environmental, governance, and social behavior of companies. According to Skyrta and Semjanova (n.d.), ESG sets out criteria and standards for companies' environmental and social performance and their governance and management. ESG reporting should help to understand the impact of the company on its environment as well as the impact of the environment on the company.

ESG reporting is connected with CSR, which role in improving corporate financial position, and reputation, and attracting potential investors is becoming more important (Yang et al., 2018; Salehi et al., 2019). Therefore, it is important to remember that sustainability refers to the ability to maintain or support a process or activity over time. It is based on economic, environmental, and social pillars and considers the preservation of life and natural resources for future generations.

While sustainability can be viewed primarily through various forms of reducing the negative impact of companies' actions on their surroundings, the ESG field is specific and measurable. According to KPMG (n.d.), ESG is a framework that helps investors evaluate a company's risk, performance, and impacts based on environmental, social, and governance criteria. Sustainability, on the other hand, is a principle that promotes responsible and ethical business practices by considering the interplay of environmental, social, and economic factors. CSR focuses primarily on the qualitative side, while ESG focuses more on the quantitative, measurable side. Both CSR and ESG typically cover a wide range of topics, namely from sustainability initiatives that address climate change, water shortage, and pollution, to activities in the areas of human rights, workers' rights, education and raising skills, compliance, diversity, and inclusion. According to KPMG Business Institute (2024), CSR represents a company's efforts to have a positive impact on its employees, consumers, the environment, and the wider community. It is the integration of social and environmental issues into the company's business activities and relationships with stakeholders. While sustainability represents the relationship between society and the environment, and the circle on which basis investments are made, an ESG strategy is measurable and provides a specific ESG framework that helps investors evaluate risk and the company's performance.

2.2.1. EU Legislation on Non-Financial / Sustainability Reporting

In 2014, *Directive 2014/95/EU of the European Parliament and of the Council of 22 October 2014 amending Directive 2013/34/EU as regards disclosure of non-financial and diversity information by certain large undertakings and groups*, also known as Non-Financial Reporting Directive (NFRD) amended the provisions of *Directive 2013/34/EU of the European Parliament and of the Council of 26 June 2013 on the annual financial statements, consolidated financial statements and related reports of certain types of undertakings, amending Directive 2006/43/EC of the European Parliament and of the Council and repealing Council Directives 78/660/EEC and 86/349/EEC*. NFRD has required large companies (public-interest entities) with more than 500 employees to prepare a non-financial statement reporting non-financial information related to sustainability, environmental, social, and employee matters, and respect for human rights.

The non-financial statement should have contained information on the current and foreseeable impacts of the company's operations on the environment, on the health and safety of employees, information on the use of renewable and non-renewable energy, greenhouse gas emission, water use, and air pollution, information on actions taken to ensure gender equality, working conditions, the employees right to be informed, information on anti-corruption, bribery matters, etc.

In November 2022, *Directive (EU) 2022/2464 of the European Parliament and of the Council of 14 December 2022 amending Regulation No 537/2014, Directive 2004/109/EC, Directive 2006/43/EC, and Directive 2013/34/EU, as regards corporate sustainability reporting*, also known as the Corporate Sustainability Reporting Directive (CSRD), was adopted by the European Parliament and the European Council. CSRD entered into force on January 6, 2023. EU member states had to transpose the CSRD into national law by July 6, 2024.

The CSRD is a key component of the EU's sustainable finance action plan and the European Green Deal. The CSRD obliged companies to disclose information on their sustainability performance with the ambition to provide stakeholders, particularly investors, with access to information needed for investment risks related to climate change and other sustainability factors assessment and for establishing a transparent culture regarding a company's impact on society and the environment (Frikkee et al., 2023). The CSRD aims for companies to disclose more transparent, comparable, understandable, relevant, and verifiable information that will faithfully represent the company's impact on the environment, society, and employees.

Furthermore, the European Financial Reporting Advisory Group (EFRAG) has been authorized by the European Commission to draft standards detailing what is required to be disclosed under CSRD. These standards are the European Sustainability Reporting Standards (ESRSs). On July 31, 2023, the European Commission adopted the Delegated Act on the first set of ESRSs for use by all companies under the CSRD. The standards cover a wide range of environmental, social, and governance issues, including climate change, pollution, circular economy, biodiversity, workforce, bribery matters, human rights, and business conduct. They provide information for investors and other stakeholders to understand the sustainability impact of the companies they invest in. They also consider debates with the International Sustainability Standards Board and the Global Reporting Initiative to ensure a very high degree of interoperability between EU and global standards and to avoid unnecessary double reporting by companies (European Commission, 2023, 31 July).

ESRSs include two cross-cutting standards and ten topic-specific standards divided into three sets, environmental, social, and governance. Two cross-cutting standards are:

- ESRS 1 General requirements,
- ESRS 2 General disclosures.

Ten topic-specific standards divided into three sets are:

- Environmental
  - ESRS E1 Climate change
  - ESRS E2 Pollution
  - ESRS E3 Water and marine resources
  - ESRS E4 Biodiversity and ecosystems
  - ESRS E5 Resource use and circular economy
- Social
  - ESRS S1 Own workforce
  - ESRS S2 Workers in the value chain
  - ESRS S3 Affected communities
  - ESRS S4 Consumers and end-users
  - Governance
  - ESRS G1 Business conduct.

ESRSs will be gradually applied for accounting periods beginning on/after January 1, 2024. The first companies reporting under ESRSs will be the EU large public-interest companies and non-EU companies with securities listed on a regulated market in the EU and having more than 500 employees. These are the companies that already report under the NFRD.

Reporting under CSRD and ESRSs will continuously extend to other large companies, listed Small and Medium-sized Enterprises, non-EU parent companies, and small and non-complex institutions.

Under CSRD and ESRSs, the companies are obliged to disclose information on environmental, social, and governance matters in the sustainability report (statement) which should be prepared in a single electronic reporting format. Statutory auditors and audit companies will have to carry out the assurance of sustainability reporting in compliance with the assurance standards adopted by the European Commission.

In the Slovak Republic, the CSRD was transposed into the accounting and auditing legislation with effect from June 1, 2024.

2.2.2. The Impact of CSR and ESG Reporting on Credibility of the Company

Martinez et al. (2016) state that sustainability reporting has over the past decades established itself as a key tool to help companies and organizations meet the growing demand for transparency from stakeholders, customers and investors in particular, and society at large. Organizations disclose information on the economic, environmental, and social impacts of their activities through non-financial (sustainability) reports. This leads to increasing transparency on their sustainability performance. According to Giron et al. (2021, p. 1742), 'this increased transparency provides investors with the possibility to make more appropriate valuations and to better orient their investments towards companies with a more positive impact'. Darnall et al., (2022) consider ESG reporting guidelines as the institutional rules that can increase the credibility of a company's ESG disclosures.

According to stakeholder theory (Gray et al., 1995; Adams & Larrinaga-Gonzalez, 2007), the disclosure of financial (economic), environmental, and social information is a part of the dialogue between the company and its stakeholders. It provides information on a company's activities that legitimize its behavior, and inform and change perceptions and expectations. This is confirmed by Raghavan (2022, p. 1) who admits that 'companies have turned to ESG reporting to meet the information needs of their stakeholders and be transparent about their commitments to ESG risk management'.

ESG reporting helps investors to identify risks and opportunities. It becomes a criterion for performance assessment, thus, it can have an impact on the company's value. Its integration into decision-making can improve risk management and contribute to sustainable growth. ESG should be the base for sustainability and corporate social responsibility.

KPMG Business Institute (2024) states four practical applications of ESG in business:

- Integration of ESG into the company's strategy – integration of ESG into the company's strategy and risk management can improve the company's financial performance and competitiveness,
- Basis for responsible business – ESG criteria are becoming a basis of responsible business and creating of positive impact on society and the environment,
- Assessment of business partners – companies can use ESG criteria for the assessment of their suppliers and business partners,
- Motivation and development – integration of ESG into corporate assessment and employee benefits can encourage responsible behavior and motivate innovation.

Michelon and Parbonetti (2012) have investigated the effects of good corporate governance on sustainability disclosures and claimed that sustainability reporting may be a function of board attributes. Pan et al., (2022) have investigated the correlation between organizational CSR activities and employees' responsible behavior. They found out that employees show this socially responsible behavior only within the company, thus there is an insignificant correlation between them.

Companies' stakeholders, including customers, employees, suppliers, local communities, investors, trade unions, policymakers, and regulators, increasingly demand better sustainability performance and disclosures from companies, greater accountability and transparency for their impacts on society and the environment (Accountancy Europe, 2023). Incorporating sustainability considerations into strategic decisions, operations, value chains, and company culture is the pragmatic approach to secure the business' future existence.

Porter and Kramer (2002) highlighted a positive correlation between social responsibility and business opportunities from the market perspective opportunities, productivity, human competencies, and improving the competitive context. This is confirmed by Dai et al., (2021), who state that many large corporate customers worldwide increasingly recognize the importance of integrating CSR initiatives into their business strategy to build a sustainable competitive advantage in the marketplace. On the contrary, Kotzian (2024) examined that not meeting public and stakeholders' expectations about the sustainability behavior of a company results in controversies damaging the company's reputation.

Tencati et al., (2004) state advantages for companies, citizens, and government deriving from CSR–social commitment system participation in their paper. The benefits for companies are according to them mainly:

- Increased corporate trust and reputation,
- A better market position in the context of growing demand for ethical goods and services,
- Easier access for companies to financial markets, especially to sustainability-oriented funds,
- Possible fiscal, economic, and administrative stimuli, the government could reward socially responsible companies.

Companies that report ESG matters are more likely to gain a competitive advantage, exploit commercial and business opportunities, improve their ESG performance, and eventually create long-term value for stakeholders. Better ESG performance can help companies win market share, develop new products and services, increase company value, secure profitability, and attract investors, top talented employees, and new customers.

Companies that are excellent at ESG have a better awareness of business risks, take steps to mitigate them, and are more resilient to market uncertainty. These companies have the potential to create new business models and products, opening up opportunities to enter new markets.

2.3. Results of the Questionnaire Survey

As part of the research, the importance that young people, university students, give to socially responsible businesses, was investigated. The research has focused on their perception of sustainability and which CSR attributes they consider most important.

The survey aimed to find out whether respondents think that there are socially responsible companies in their country. The results are shown in Table 2.

Table 2 Answers to question: In your opinion, are there socially responsible companies in your country?

Country *column perc.*	Slovakia	Czech Republic	Poland	Slovenia	Total
Yes	100/75.76	60/60.00	29/74.36	17/68.00	206/69.59
No	3/2.27	2/2.00	2/5.13	2/8.00	9/3.04
I don't know	29/21.97	38/38.00	8/20.51	6/24.00	81/27.37
Total	132/100	100/100	39/100	25/100	296/100

Source the author

As can be seen from Table 2, up to 69.59 % of the respondents admit that there are socially responsible companies in their country, and only 3.04% think that such companies do not exist in their country. Up to 27.37% of the respondents were not able to answer this question. Up to 75.76% of young Slovaks are convinced that there are companies in Slovakia that behave in a socially responsible way. On the contrary, only 60% of young Czechs are persuaded of this fact.

Although up to 75.76% of respondents from Slovakia stated that there are socially responsible companies in Slovakia, only 56 (56.00%) of them were able to name some of these companies. There are more positive results among young Czech respondents. Out of 60 Czech respondents who admitted that there are socially responsible companies in their country, up to 42 of them (70.00%) were able to name some of these companies. In Poland, 23 respondents (79.31%) named some socially responsible companies, and in Slovenia only 9 respondents (52.94%) were able to name socially responsible companies. At this place, it is important to point out that not every respondent was able to name 5 socially responsible companies. Five socially responsible companies were named by 30 respondents from Slovakia, 20 respondents from the Czech Republic, 12 respondents from Poland, and 3 respondents from Slovenia. Most respondents mentioned only one or two socially responsible companies.

In Slovakia, the most mentioned companies (Figure 1) were Lidl (25 respondents), IKEA (25 respondents), and Tesco (12 respondents). The conclusion of the research is that the young generation perceives supermarkets, banks, and insurance companies, as well as mobile operators, as socially responsible companies. Other companies mentioned by the Slovak respondents were Henkel, Metro, Slovenské elektrárne, dm drogerie markt, Softec, Uniqa, Kyndryl, Deloitte, Volkswagen, Anasoft, Bezobalovo, etc. Interestingly, even small local companies were mentioned by the respondents.

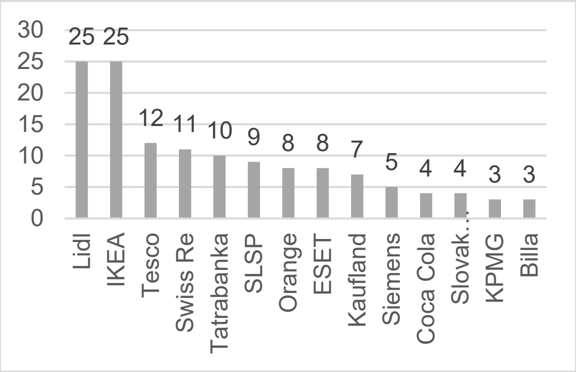

Figure 1 Socially responsible companies according to Slovak respondents
Source: the author

In the Czech Republic, the most mentioned companies (Figure 2) were ČEZ (12), Škoda (11), and Lidl (8). Other companies mentioned by respondents were Dermacol, Česká spořitelna, Deloitte, EY, Marlenka, Plzeňský Prazdroj, Vodafone, McDonalds, Innogy, Nestlé, Odragas, E.on, LG electronics, etc.

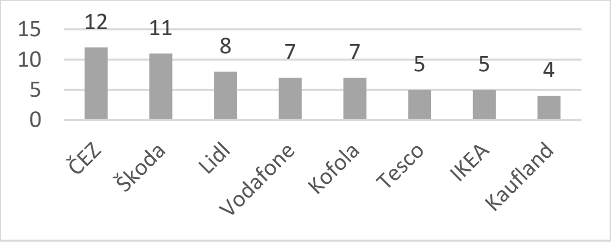

Figure 2 Socially responsible companies according to Czech respondents
Source: the author

The most mentioned companies by Slovenian respondents were KRKA, Gorenje, Impol, Lumar, Afrodita, Talum, Emmi, Hofer, Moga, TAB, Micro&Polo, Spar, Lidl, etc.

According to Polish respondents, the socially responsible companies are PGE, Orlen, CCC, Toyota, Google, PKP, Vans, Patagonia, Inglot, Roleski, Nestlé, Philip Morris, Danone, ABB, Biedronka, Tymbark, Starbucks, Colgate, Adidas, Nike, Mondi, KGHM, TDJ, DBI Plastics, Synthos, Santander Bank, Bank PKO BP, Toyota, Rolski, FM Logistic, CCC, Fundacja Polsat, Tymbark, Raben, Chespa, Maspex Wadowice, etc. Polish respondents reported very many different companies. Some of them were repeated within the responses, but most were different.

This confirmed the fact that respondents in all four countries perceive the socially responsible behavior of companies. Thus, the conclusion is that the young generation in all four countries analyzed does not perceive only large multinational companies as socially responsible, as many small local companies were also mentioned in respondents' answers.

In the next part of the survey, the respondents were asked to select up to 5 attributes they consider to be the most important in the actions of responsible companies. They could select from these attributes:

- Protecting the health and safety of employees,
- Fight against corruption and bribes,
- Business ethics,
- Suitable working conditions, the balance of personal and working time of employees,
- Diversity, inclusion, and equal opportunities,
- Respect for human rights,
- Impact on the local community and philanthropy, supporting the region where the company operates,
- Reducing carbon emissions,
- Use of alternative energy sources,
- Recycling, waste reduction,
- Open company communication towards customers,
- Staff development and training, up-skilling,
- Good relations with suppliers and customers,
- The company offers ecological products, services for the socially or medically disadvantaged,
- Support for science and research, cooperation with schools.

The most important attributes of socially responsible behavior among all respondents (Figure 3) were 'Protecting the health and safety of employees' (70.95% of all respondents), 'Respect for human rights' (64.86%), and 'Suitable working conditions, the balance of personal and working time of employees' (58.45%).

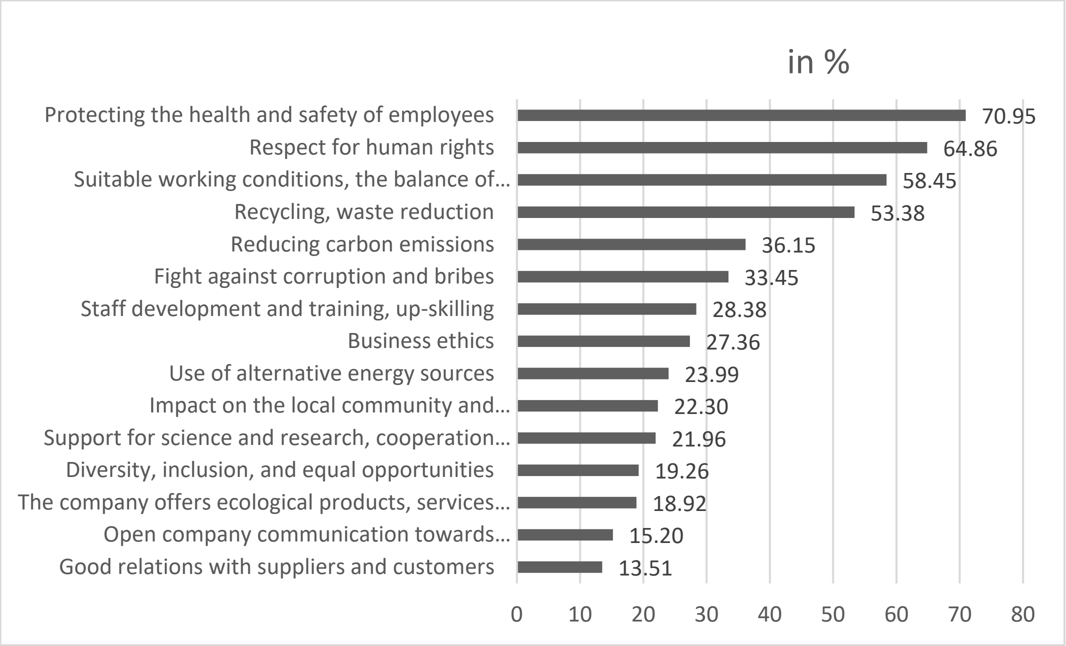

Figure 3 The most important attributes of socially responsible companies (overall results)
Source: the author

In Slovakia, the most stated attributes were 'Protecting the health and safety of employees' (75.7% of respondents), 'Respect for human rights' (32.3%), and 'Recycling, waste reduction' (22.00%). Czech respondents considered 'Protecting the health and safety of employees' (75.00%), 'Respect for human rights' (69.00%), and 'Suitable working conditions, the balance of personal and working time of employees' (59.00%) the most important attributes in the actions of socially responsible companies. In Poland, the most important attributes were 'Respect for human rights' (66.7%), 'Suitable working conditions, the balance of personal and working time of employees' (61.5%), and 'Protecting the health and safety of employees' (61.5%). Similar results to the previous three countries were also observed in Slovenia. The most important attributes of socially responsible behavior of companies were according to Slovenian respondents 'Protecting the health and safety of employees' (84.00%), 'Suitable working conditions, the balance of personal and working time of employees' (72.00%), and 'Respect for human rights' (56.00%).

The least important attributes among all respondents were (Figure 3) 'Good relations with suppliers and customers' (13.51% of all respondents), 'Open company communication towards customers' (15.20%), and the fact that 'The company offers ecological products, services for the socially or medically disadvantaged' (18.92%).

The Slovak respondents considered 'Good relations with suppliers and customers' (11.36% of the Slovak respondents), 'Diversity, inclusion, and equal opportunities' (18.18%), and 'Open company communication towards customers' (18.94%) the least important attributes of CSR. Similar results were obtained by the Czech respondents who considered 'Good relations with suppliers and customers' (11.00%), 'Open company communication towards customers' (15.00%), and 'Diversity, inclusion, and equal opportunities' (16.00%) the least important attributes. In the case of Polish respondents, slightly different results have been observed. According to them, the least sustainable attributes of companies were 'Open company communication towards customers' (10.26%), 'Good relations with suppliers and customers', 'The company offers ecological products, and services for the socially or medically disadvantaged' (17.95% each), and 'Support for science and research, cooperation with schools' (20.51%). The young Slovenian respondents considered 'Open company communication towards customers' (4.00%), 'Support for science and research, cooperation with schools' (12.00%), 'Use of alternative energy sources', and 'Diversity, inclusion, and equal opportunities' (16.00% each) the least important attributes of CSR.

The results showed that the young generation represented by University students considers the social pillar of TBL as the most important. The young people expect their future employers to create good working conditions, protect their health and safety, and offer a balance of personal and working time.

There is a correlation between the country of respondents and the selected most important attributes of socially responsible companies (Table 3). There is a statistically significant correlation at a significance level of 0.1 (p-value = 0.0613). However, the measures of contingency indicate a weak degree of dependence.

Table 3 Assessment of the association between the country of respondents and the attributes of socially responsible companies

Statistic	DF	Value	Prob
Chi-Square	45	60.4844	0.0613
Likelihood Ratio Chi-Square	45	63.0524	0.0389
Phi Coefficient		0.2053	
Contingency Coefficient		0.2011	
Cramer's V		0.1185	

Source: the author

The next part of the analysis has focused on preferences for sustainable attributes of companies depending on gender. The results showed that there is a correlation between the gender of respondents and the selected most important attributes of socially responsible companies (Table 4). The correlation is statistically significant at a significance level of 0.05 (p-value = 0.0393). The measures of contingency also indicate a weak degree of dependence.

Table 4 Assessment of the association between the gender of respondents and the attributes of socially responsible companies

Statistic	DF	Value	Prob
Chi-Square	15	25.8807	0.0393
Likelihood Ratio Chi-Square	15	25.9285	0.0388
Phi Coefficient		0.1343	
Contingency Coefficient		0.1331	
Cramer's V		0.1343	

Source: the author

As seen in Figure 4, the priorities for sustainable attributes of companies were slightly different between women and men, as well as in comparison with the overall results. Women considered 'Protecting the health and safety of employees' (73.54% of female respondents), 'Respect for human rights' (69.84%), and 'Recycling, waste reduction' (61.38%) as the most important attributes of socially responsible behavior of companies. On the other hand, men preferred 'Protecting the health and safety of employees' (66.36% of male respondents), 'Suitable working conditions, the balance of personal and working time of employees' (58.88%), and 'Respect for human rights' (56.07%).

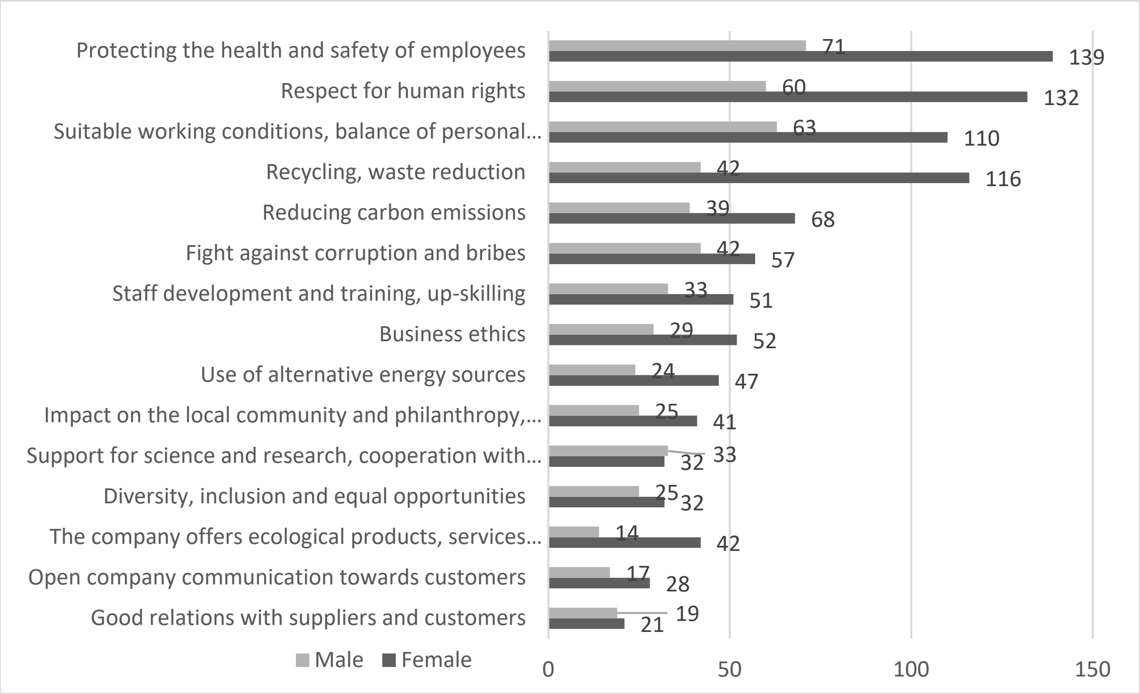

Figure 4 The most important attributes of socially responsible companies according to gender (overall results)
Source: the author

The next part of the survey has focused on investigating which CSR areas the companies should prioritize their engagement in. The respondents should select up to three areas from the following:

- Support for socially or medically disadvantaged population groups,
- Protecting the environment, mitigating the impacts of climate change,
- Supporting the education of the younger generation,
- Supporting sport and leisure activities for children and young people,
- Fight against corruption and bribes,
- Promoting digital literacy with an emphasis on children and youth,
- Humanitarian and development aid abroad.

The results showed (Figure 5) that the young generation expects companies to be more engaged in 'Protecting the environment and mitigating the impacts of climate change' (72.30% of all respondents), in 'Supporting the education of the younger generation' (55.41%), and in 'Supporting socially or medically disadvantaged population groups' (42.57%). Similar results were obtained when examining respondents' views depending on their country of origin. Only in Poland, the second most preferable area of corporate responsibility was the 'Fight against corruption and bribes'.

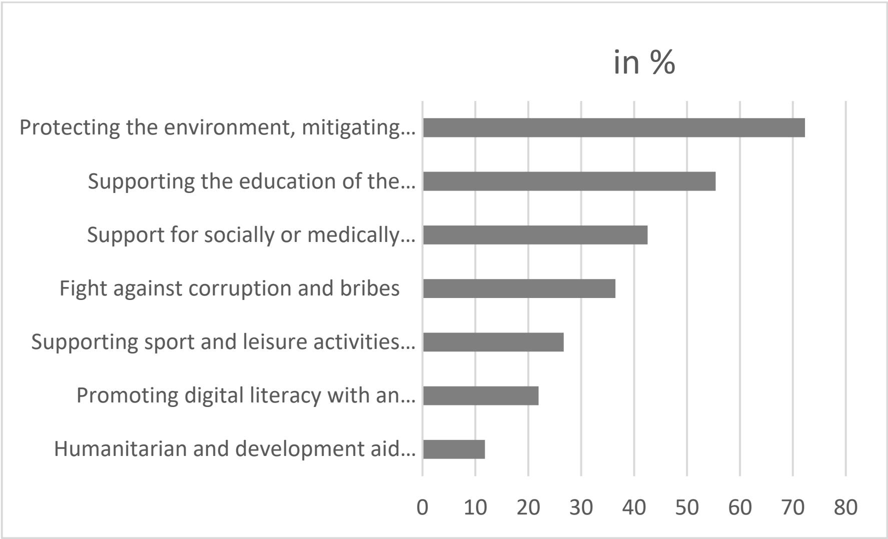

Figure 5 Areas related to CSR where companies should be the most engaged (overall results)
Source: the author

Table 5 presents the results of the analysis of respondents' answers to the question of whether 'they would prefer to buy a product or service from a company that behaves in a socially responsible way, even if they had to pay a little more'.

Table 5 Answers to the question: Would you prefer to buy a product or service from a company that behaves in a socially responsible way, even if you had to pay a little more?

Country *column percentages*	Slovakia	Czech Republic	Poland	Slovenia	Total
Definitely yes	25/18.94%	13/13.00%	9/23.08%	8/32.00%	55/18.59%
Rather yes	80/60.61%	61/61.00%	23/58.97%	15/60.00%	179/60.47%
Rather no	12/9.09%	15/15.00%	2/5.13%	2/8.00%	31/10.47%
Definitely no	6/4.54 %	4/4.00%	0	0	10/3.38%
I don't know	9/6.82%	7/7.00%	5/12.82%	0	21/7.09%
Total	132	100	39	25	296

Source: the author

The results presented in Table 5 prove that the young generation in all countries analyzed would buy more expensive products or services from a company that behaves in a socially responsible manner. This is considered to be a very positive fact. 'Yes' or 'Rather yes' have been stated by up to 79.06% of all respondents, namely up to 79.55% of respondents from Slovakia, 74.00% of respondents from the Czech Republic, 82.05% of respondents from Poland, and 92.00% of respondents from Slovenia.

In the final survey question, respondents were asked whether they thought companies should report information relating to their socially responsible behavior (Table 6).

Table 6 Answers to the question: Should companies report information regarding their socially responsible behavior?

Country *column percentages*	Slovakia	Czech Republic	Poland	Slovenia	Total
Yes	114/86.40%	85/85.00%	36/92.30%	23/92.00%	258/87.16%
No	5/3.80%	5/5.00%	1/2.60%	1/4.00%	12/4.06%
I don't know	13/9.80%	10/10.00%	2/5.10%	1/4.00%	26/8.78%
Total	132/100%	100/100%	39/100%	25/100%	296/100%

Source: the author

Up to 87.16% of respondents think that companies should present sustainability information. This information is important not only for their business partners, investors, and banks but also for customers, and the community in which the company operates. Information about how a company treats the environment and society, as well as what its management priorities are, builds a company's image and makes it competitive. By demonstrating its social commitment, responsibility, and sustainability in behavior, the company can gain the social recognition it needs to be successful.

Conclusion

ESG reporting will play an increasingly important role in companies' activities. Sustainable business and reporting on environmental, social, and governance information are required not only by governments and public authorities to transform the European Union into a modern, resource-efficient, and competitive economy with no net emissions of greenhouse gases by 2050, to protect, conserve, and enhance the EU natural capital and protect the health and well-being of EU citizens from environment-related risks and impacts, but are also required by investors, customers, employers, and other stakeholders as well. ESG reporting helps companies win market share, secure profitability, increase company value, and attract investors, new customers, and responsible employees. The sustainable business of companies can positively form the company's image and make it more competitive in the marketplace.

It is expected that after transposing the CSRD into the national law of EU member states, the ESG reporting will be more transparent, comparable, and understandable, the presented information will be relevant, and verifiable, and will faithfully represent the impact of the company on the environment, society, and employees.

The research proved that the young generation perceives the socially responsible behavior of companies. Respondents from all four countries were able to name companies that behave responsibly towards the environment and society.

According to the research, 'Protecting the health and safety of employees', 'Respect for human rights', 'Suitable working conditions, the balance of personal and working time of employees', and 'Recycling, waste reduction' belong to attributes which more than 50.00% of respondents consider to be the most important in sustainable behavior of companies. The results showed that the young generation prefers social aspects of CSR related to employees over those related to the company's behavior towards business partners or customers.

The questionnaire results confirmed that more than 50.00% of the young respondents think that companies should be more involved in 'Protecting the environment, mitigating the impacts of climate change' and 'Supporting the education of the younger generation'. We positively assess that the young generation (79.06% of all respondents) is willing to pay extra for products or services offered by a socially responsible company that focuses on protecting the environment and establishing suitable working conditions for its employees. Up to 87.16% of all respondents approved that companies should report sustainability information. Companies are required to report not only on their financial performance but also on their social and environmental performance. By applying the CSRD and ESRSs, companies are expected to report not only sustainable information but also to truly act responsibly towards the environment, employees, the community, and society.

Demonstrating responsible behavior, and presenting ESG requirements can affect creating a good company image and increasing its competitiveness.

Declarations

Availability of data and materials

The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

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Business process redesign as a basic aspect of digital business transformation

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Abstract

Background: It is widely accepted that the digital transformation of business is increasingly attracting the attention of researchers from the academic circles as well as professionals from the business community. The main consequence of this lies in the daily development of new and improvement of existing digital technologies. The outcomes of such events on the market are reflected in all aspects of companies' operations. For this reason, they are constantly looking for various improvements to their business, which most often include the implementation of new technology. Mere implementation of a new technology without any other changes very often leads to failure. The core of this failure can be found and attributed to inadequately identified, analysed, documented and established business processes. Business process management (BPM) and redesign as its integral part are actually an indispensable segment of a successful process of digital business transformation. Therefore, the digital transformation of business should not be viewed exclusively from a technological perspective, but also from a process viewpoint.

Purpose: With the aim of shedding additional light on the connection between business process management and digital business transformation, the paper aims to identify and explain the importance of business process redesign.

Study design/methodology/approach: For the purposes of this paper, a systematic literature review was conducted.

Findings/conclusions: The result of the conducted research indicates that a process approach to the digital transformation of business can contribute to significantly different, more successful results.

Limitations/future research: Limitations refer to the number of databases searched during this systematic literature review. Subsequent research could include additional sources that would include additional works that can contribute to a better research result.

Keywords

digital transformation; digital technologies; business process management; BPM; business process

Introduction

The fourth industrial revolution or Industry 4.0 can be characterized as the era of digitization and information (Kostakis & Kargas, 2021). It was very quickly realized that the initial goals of Industry 4.0 would be exceeded and that its impact would be reflected on all companies and society as a whole. Entering the fourth industrial revolution marked the need for companies to change their strategies and practices in order to cope with the information storm and rapid changes in the market, in order to achieve competitive advantage and survival (Kostakis & Kargas, 2021). Guided by recognized potentials, stated changes, needs and intentions as well as the goal to evolve towards the digital age, companies are starting their own transformation known as digital transformation with the aim of achieving competitive advantage and emphasizing diversity (Fernández-Rovira & Álvarez Valdés, 2021; Skhiri & Duverne, 2020). Digital business transformation is becoming the goal of every company (Karekla et al., 2021). Li, (2020) describes digital transformation as a modern way of overcoming obstacles caused by digital changes. Although studies on digital transformation have existed for about 10 years, only in recent years have they aroused greater scientific interest (Ivančić et al., 2019). Regardless of the fact that they represent a more recent concept, Graphs 1 and 2 testify to the interest of scientists in the analysis of this topic. A search of the index databases "Scopus" and "Web of Science" by entering the keywords "Digital transformation" resulted in a total of 19,121 hits that contain a defined keyword in the title or abstract. The decline that can be observed for the year 2022 on both graphs can be attributed to the fact that at the time of writing this paper, not even half of the year 2022 had passed. Observing the trend of the number of works in previous years, it is expected that the number of published works will continue to grow this year compared to the previous one. Both graphs point to 2016 as the year of the start of a significant increase in interest in the topic of digital transformation.

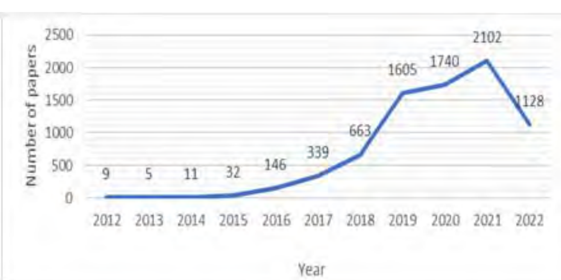

Figure 1 Number of papers "Web of Science" - "Digital transformation"
Source: the authors' contribution

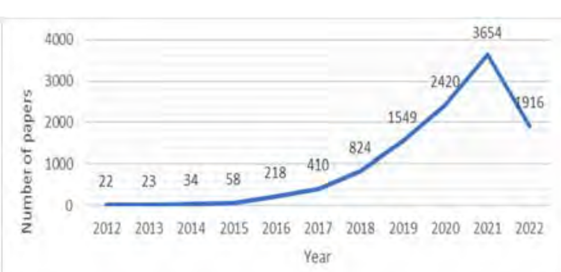

Figure 2 Number of papers "Scopus" - "Digital transformation"
Source: the authors' contribution

A large number of works, however, did not lead to the selection of one generally accepted and most precise definition of this phenomenon. One of the main reasons for this lies in the fact that there is no universal approach for the realization of the transformation process (Kondarevych et al., 2020). Each company has its own approach and follows a different path on its digital journey (Karekla et al., 2021). However, assertion, which has been confirmed by many authors through their works, concerns the role of business processes and business process management in the digital transformation of business. Based on the conducted research, Fischer et al., (2020) state that their analyzed companies used business process management in order to achieve a positive impact on costs, service quality and the customer himself. Also, Ochara et al., (2018) mention business process modeling, which is part of business process management, as a key basis for digital transformation. In their book, Dumas et al. (2013) defined business process management as the science and art of observing the way work is carried out in the organization, with the aim of ensuring consistent outputs and exploiting potential opportunities for improvement. Unlike digital transformation, which is a more recent topic, various sources suggest that business process management has captured the attention of stakeholders as early as the 1990s. Bogea Gomes et al. (2019) observe that most innovations are driven by processes rather than technologies. Brkic et al., (2020) states that technologies are one of the drivers of business changes. As the search results of the previously mentioned index databases confirm, the interest of researchers in this topic has existed for more than two decades longer than the interest in digital transformation. Figure 3 shows that the importance of business processes does not decrease and that they represent an indispensable area during the implementation of undertakings such as digital transformation.

Figure 3 Number of papers - "Business process management"
Source: the authors' contribution

The structure of this paper is organized as follows: after the introduction, Section 1 describes the methodological procedure used. Section 2 summarizes the results of the conducted research while the last section of this paper provides a conclusion.

1. Methodology

The methodology used during the research process was focused on research question: place of business process redesign as a basic aspect of digital business transformation.

The way in which the systematic review process was carried out consists of eight steps, namely (Kitchenham, 2004, Xiao & Watson, 2019):

1. Formulation of the research problem;
2. Development and validation of the review process;
3. Literature search;
4. Reviews for inclusion of the study in the work;
5. Quality assessment;
6. Data extraction;
7. Analysing and synthesizing data;
8. Reporting on findings.

Figure 4 shows the mentioned process.

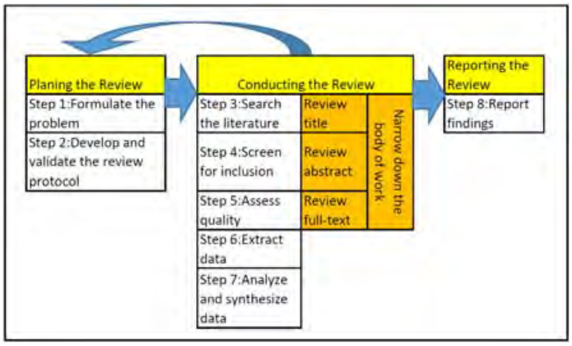

Figure 4 The process of systematic literature review
Source: Xiao & Watson, 2019

The first step involves formulating research questions. Research questions are based on digital transformation and business process management (BPM). Due to the wide scope of the given topic, it was necessary to narrow the point of view and introduce additional restrictions. The question that is defined by observing this domain is: place of business process redesign as a basic aspect of digital business transformation.

The second step involves developing and validating the review process. As mentioned in the first step, due to the wide domain of observation, it was necessary to introduce certain additional keywords. Those are "redesign" and "digital technologies". Thus, the observed domain of works is narrowed.

The third and fourth steps include literature search and review for inclusion in the paper. The channels used to find relevant literature are electronic databases. The electronic databases on which the literature search was performed are "Web of Science" and "Scopus". In order for the work to contain the essence that follows contemporary events, the time period of literature observation is limited to the previous seven years. "Digital transformation", "business process management", "BPM", "digital technology" and "redesign" are the key words that were used when searching the databases. Table 1 shows the final combination of key words used in the search for the primary studies.

Table 1 Final search string and total number of hits

Final Search string	Number of hits		
	WoS	Scopus	Total
Digital transformation AND Business process management	84	95	179
Digital transformation AND BPM	51	52	103
Digital transformation AND redesign	35	61	96
Digital technology AND redesign	19	96	115
Digital transformation AND business proces AND redesign	3	10	13
Total	192	314	506

Source: the authors' contribution

Papers that did not provide a concrete hint in their title that they were conducive to research were excluded from further consideration. The date when the search was carried out is April 2022, while the date of finding the works is also April 2022. After the search, no additional restrictions were introduced. After reading the abstracts of the selected papers, it was concluded that 112 papers will be included in the paper. The next step was to find and eliminate duplicates. After completing this step, there are 92 papers that will be considered by the authors. Papers have been taken from all potential areas that are conducive to the research domain.

When performing the first iteration, only those papers were taken into account that, based on their title, based on the authors' decision and assessment, are suitable for inclusion in the research, i.e. can provide useful information for research. The next step was iteration through the abstracts of the selected papers. The electronic bases mentioned above were used for the given iterations. The period for which the works were observed is from 2015 to 2022. A search of the Web of Science index database using defined keywords resulted in a total of 192 hits. The number of works that were suitable for inclusion in the work (in the first iteration) is 50. The same procedure was repeated on the second index database - Scopus, where we hit 314 potential works, of which the number of those that were suitable amounted to 62. The total number of papers that were accepted during the first iteration was 112. Then we proceeded to eliminate duplicates. By eliminating duplicates, 92 papers were obtained.

The fifth step includes quality assessment. A detailed reading of the selected works further reduced the number of publications included in the final list of works. In order for the paper to be a relevant reference for a given research, it had to contain an answer to research question. Papers that did not contain any information suitable for research were excluded from further analysis. A qualitative analysis was then performed. Reading the papers resulted in a total of 32 papers that are relevant and included in the paper. The reasons for removing the remaining works were:

1. ongoing research - 2;
2. incomplete work - 3;
3. out of context - 10;
4. not in English - 3;
5. other - 42.

The sixth step is data extraction. A narrative review was performed to extract data. Thus, there was a lower degree of rigor when it comes to the criteria for inclusion in the work. Also, textual narrative synthesis was performed. When extracting data from the works, the data were entered in a separate table, key observations, and notes. The extraction was performed in such a way that the relevant data on the topic was taken.

The seventh step involves analysing and synthesizing the data. Analysing was done for each paper separately, and by synthesizing them, an attempt was made to create a broader picture that would answer the research questions. Figure 5 shows the method of conducting search and evaluation of works.

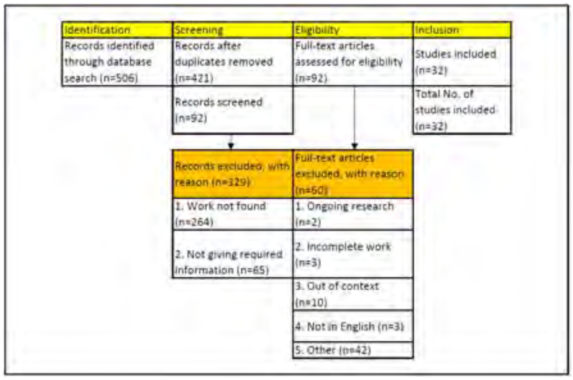

Figure 5 Literature search and evaluation for inclusion in the work
Source: Xiao & Watson, 2019

2. Research results

2.1. Business process redesign as part of business process management

The changes taking place in the global market affect changes within organizations, and they must adapt to new conditions as quickly as possible in order to advance in the market. One of the ways that enables them to follow global trends is to change their business processes (Stjepić et al., 2020). Van Looy, (2018) states that adaptation to changes in the form of business process redesign began in the 1990s and continues to this day. Business processes are series of activities (Baiere et al., 2020) aimed at completing set tasks and achieving defined goals. A number of authors state that they represent the core of the company and influence the attractiveness of products and services. Moreover, they define tasks and jobs, which means that they shape the roles of all employees and thus influence the ability of organizations to adapt to new situations and meet growing demands (Dumas et al., 2013).

Due to the importance of business processes, monitoring and managing them effectively are crucial for the company's success (Stjepić et al., 2020). Business process management (BPM) began in the early 1990s when organizations realized the value of IT investments is gained through complementary changes in business processes and work practices that, in turn, have enhanced quality, product offerings, and service delivery (Baiyere et al., 2020). Dumas et al. (2013) state that the ultimate purpose of the business process management initiative is to ensure positive outcomes and maximum value for clients through the selected business processes that are the subject of management. A BPM initiative usually includes the steps shown in Figure 6.

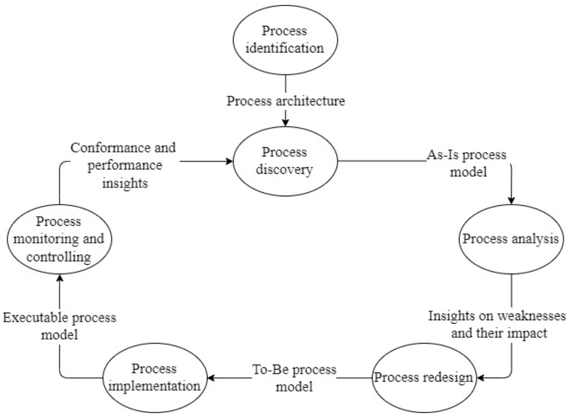

Figure 6 BPM lifecycle
Source: Dumas et al., 2013

2.2. The road to digital transformation

Ismail et al. (2017) ask the right question in their work, which is "Is digital transformation, as a topic, a novelty?". Indeed, if we go back, people have always been looking for changes while doing their jobs. The reason for this does not lie in the desire for changes, but in the pursuit of improvement, i.e. more efficient, effective and better performance of work. The roots of digital transformation can be found in business transformation, a topic on which the first papers appeared in the 1990s.

In general, the term "transformation" became a term for various practices and organizational outcomes in the 1990s. Business transformation is a term that has been used for many years, but defining it is not easy due to the large number of different definitions. One of the definitions given by McKeown and Philip (2003) defined the term "Business Transformation" as a comprehensive concept that includes a series of competitive strategies that organizations adopt in order to bring about significant improvements in business performance. In addition to the use of information technologies, quality management and organizational development, these strategies also include business process re-engineering, which has evolved over time into redesign of business processes as a step of business process management.

Just as the academic community agreed that the digital transformation of business consists of a large number of aspects, so researchers 20 years ago and more saw that business transformation is not a simple undertaking. Various aspects contribute to the creation of complex relationship between operational needs, capabilities, business processes, and organizations involved (Lakemond et al., 2021). Based on the available literature, Muzyka et al. (1995) divided the initial view of transformation, which was defined as a change in organizational logic as a consequence of fundamental behavioural changes, into 4 types of transformation:

1. Re-engineering - improving overall organizational efficiency while not wholly solving the issue of better workforce engagement;
2. Restructuring - improving efficiency through right sizing (often downsizing), product portfolio pruning;
3. Renewing - achieving better efficiency, effectiveness and innovation through building new capabilities, introducing new business units and redefining the strategy;
4. Regeneration - improvement of existing processes and consideration of existing opportunities.

It was mentioned earlier that in the 1990s, transformations were related to the area of strategy, which included, among other things, information technologies. Enterprises were increasingly dependent on information and means of communication and manipulation of these resources (McKeown & Philip, 2003). Information technologies have become crucial for a large number of companies because the competitive advantage of companies derives from the ability to efficiently generate, maintain and use knowledge about both internal and external aspects of business. Because companies were gaining competitive advantage through the effective generation, use, and maintenance of knowledge about their internal and external environments, information technology has become a critical point for most organizations. Furthermore, technology has been identified as a major dimension contributing to organizational business transformation (Ismail et al., 2017). The significant role attributed to information and communication technologies in the transformation process stems from the recognition of their speed of development and expansion.

Focusing on technological change during business transformation, Ismail et al. (2017) called technology-enabled transformation. The domain of information systems expands the original concept of business transformation by pointing to potential information technologies and their role in IT-enabled transformations (Venkatraman 1994). This type of transformation is basically perceived as a change caused by a change in information technologies, whereby the impact of information technologies must be reflected on at least 3 of the 7 identified dimensions (Ismail et al., 2017):

1. Processes;
2. New organizations;
3. Relations;
4. User experience;
5. Markets;
6. Customers;
7. Disruption.

Since information technologies formed the basis of transformation, many authors defined the rules and criteria of transformation in accordance with the possibilities of existing information technologies (Ismail et al., 2017).

2.3. Digital transformation

The literature offers different interpretations of digital transformation. Today, technological changes, which form the basis of the previously explained type of transformation, can be seen either as a source of digital threat or as a source of digital opportunities that drive digital transformation (Wessel et al., 2021). Kreuzer et al., (2022) state that the ability to recognize the possibilities of digital technologies is necessary in today's digital world. Therefore, digital transformation is increasingly becoming a central issue for businesses worldwide (Thamjaroenporn & Achalakul, 2021). The characteristics of this era include the rapid development of a large number of new technologies (Liu et al., 2020). The key technologies that are disrupting the market and opening up new opportunities to transform strategies and operations in ways we could not even imagine a few years ago are: cloud computing (Wessel et al., 2021), Internet of Things - IoT, Big Data, Artificial Intelligence - AI (Favoretto et al., 2022; Gurbaxani & Dunkle, 2019; Karekla et al., 2021; Khin & Ho, 2019; Li, 2020; Pînzaru et al., 2019), blockchain and robotics (Karekla et al., 2021). The use of individual digital technologies does not mean the digital transformation of the organization (Kondarevych et al., 2020), but also, the process of digital business transformation does not require the implementation of all the mentioned technologies, but only those that the company estimates can contribute to achieving the greatest benefit. Therefore, companies must possess vision, ability, knowledge, skills, then must show serious commitment and at the same time courage when making certain risky decisions (Pînzaru et al., 2019).

Digital transformation in itself represents a complex area of research that arises from a large number of different aspects of observation. Existing research points to some of them, such as the digital transformation of society, industry and economy. The introductory part of the paper offered, among other things, 2 figures (Figure 1 and 2) that clearly suggest that a search of academic publications using the keyword "Digital transformation" offers thousands of papers that explore this concept from different perspectives. Ismail et al. (2017) grouped and offered some of the possible perspectives shown in Figure 7.

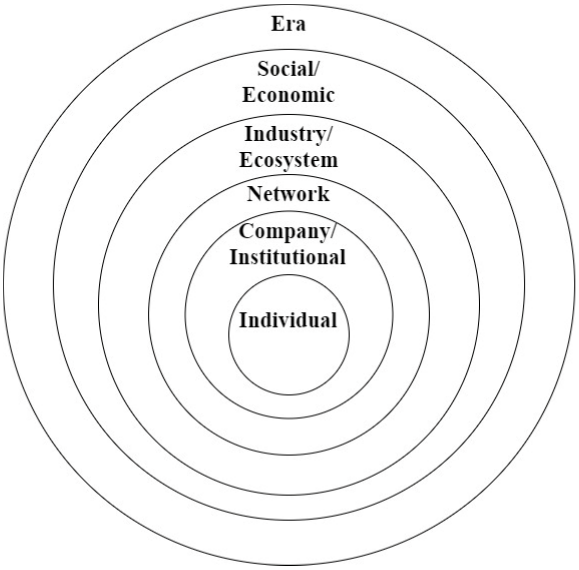

Figure 7 Digital transformation perspectives in the literature
Source: Ismail et al., 2017

According to different perspectives of observation, authors offer different definitions. Most theorizing in the field of digital transformation is driven by the idea of using digital technologies to improve business results (Wessel et al., 2021). However, although digital transformation relies on digital technologies, it represents a much broader concept that includes the analysis and reengineering of business processes, changing strategies, organizational structures, changes in the way of managing the organization, stimulating employees, changes in the required knowledge and skills of employees etc., in order to adapt to the evolving digital business context (Favoretto et al., 2022; Gurbaxani & Dunkle, 2019). Wessel et al. (2021) offer a more detailed definition that also highlights the use of digital technologies in order to improve business outputs, key business processes and task automation. On the other hand, Saarikko et al. (2020) define digital transformation as a socio-cultural process of adapting firms to new organizational forms and skill sets that are relevant and necessary for survival in the digital age. Observing digital transformation as a socio-cultural process rather than a technical feat does not mean that technology is treated as unimportant, but that they consider organizational culture and ideas rather than technological savvy to be the drivers of transformation. Ivančić et al. (2019) united the two previously mentioned views in defining the concept of digital business transformation, defining it as a continuous process of climbing the scale of digital maturity using digital and other technologies together with organizational practices to create a digital culture.

The broad definition given by Liu et al. (2011) suggests that it represents the integration of digital technologies and business processes. Kaufman & Horton (2015), Schuchmann & Seufert (2015) and Hess et al. (2016) provide a different and more comprehensive view of the digital transformation. They indicate that the use of digital technologies affects on three organizational dimensions: externally, digital technologies influence the improvement of user experience and the establishment of better connections with them; internally, digital technologies contribute to changing the behaviour of employees, the existing ways of doing work and the way of making decisions. A change in the organizational structure can also be counted here; and finally holistic, where the entire organization is affected which often leads to completely new business models.

In their papers, the authors agreed that the business process management is an important step in realizing the digital transformation of business. As mentioned earlier, business process redesign is one of the business process management steps that emerged from business process re-engineering. Continuous optimization of business processes has become an important factor for many companies to achieve success, competitive advantage and satisfy customer needs (Fehrer et al., 2022). In business process management (BPM), business process redesign (BPR) deals with improving business processes to solve previously identified process-related problems (Dumas et al., 2013). Ismail et al. (2017) defined different levels of digital transformation, which he displayed graphically, depending on the complexity of the transformation (Figure 8). According to this understanding, digital transformation implies only revolutionary levels of transformation that are of a higher level of complexity and impact, i.e. suggests that its degree of complexity exceeds that of previous IT-enabled transformations. Figure 8 shows that the lowest level of digital transformation is the redesign of business processes followed by business network redesign, business scope redefinition, customer experience transformation and business model transformation. Business model transformation represents the highest level of digital business transformation.

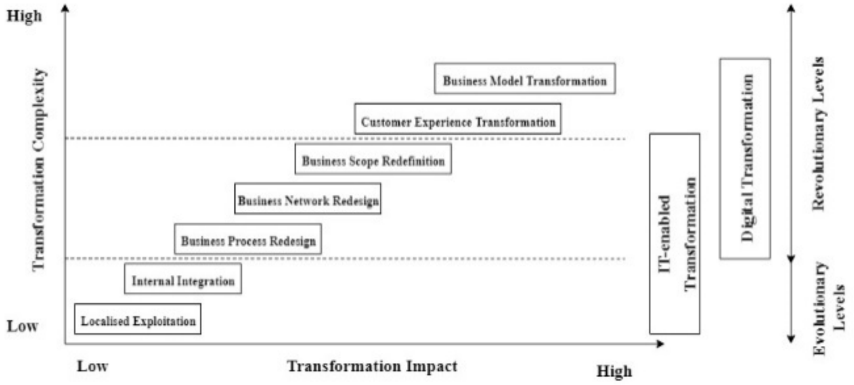

Figure 8 Digital transformation perspectives in the literature
Source: Ismail et al., 2017

In support of the claim about the complexity of the digital transformation of business, as well as the thesis that the implementation of digital and other technologies represents only one step of a much broader process, we can also cite the case study conducted by Ivančić et al. (2019), by which they identified 7 dimensions of digital transformation,:

1. Strategy – a shared digital vision is considered an important factor in successful digital transformation. Although each company defines its own strategy

according to its own needs, goals and stage of the digital transformation process, two common things of all strategic approaches have been observed: 1) defining the role of the Chief Digital Officer (CDO) who is in charge of digital transformation projects and efforts and 2) strong leadership support;

2. People – people have always played a huge role in the work and success of the company. For this reason, in the so-called digital culture, organizations use different approaches to find and acquire employees with digital skills. New hires with digital skills are capable of working on a wide variety of projects and in any team. Also, organizations strive to establish and encourage a culture of knowledge sharing between workplaces. A culture of sharing knowledge without fear that someone else will take credit for a certain contribution enables additional benefits for the company;
3. Organization – a digital transformation project cannot be successfully implemented without the involvement of a large number of different organizational units. Therefore, the digital transformation unit must cooperate with the rest of the company and cannot function independently of others i.e. digital transformation, in addition to the members of the digital transformation unit, requires the inclusion of employees from other departments;
4. Customers – the quality of service provision is one of the aspects that must be analysed and, if necessary, improved through the implementation of digital business transformation. (Re)designed products and services should provide a better user experience, improve the quality of service and create new value for the purchase, taking into account the different characteristics of the market and being guided by the needs of customers;
5. Ecosystem – digital transformation projects include the most diverse aspects and goals of the company's operations. One of the main goals is to create a business atmosphere in which clients are perceived as partners. In this way, consumers are involved in the work of the company and its business processes. In addition, but no less significant, it also represents the creation of connections with the academic community in order to gather knowledge, innovation and human resources;
6. Technology – the implementation of new digital technology requires considering the possibility of connection with existing traditional information technologies. Therefore, digital technologies can be classified as primary and secondary. Primary digital technologies include cloud computing, big data, mobile technologies and the Internet of Things, while secondary digital technologies include wearable devices, artificial intelligence, robotics, etc. Organizations can choose from a set of a large number of modern technologies, depending on the area of digitization. In addition to the adoption of digital technologies, the companies that participated in the case study conducted by Ivančić et al. (2019) emphasized the need and importance of a quality Enterprise Resource Planning (ERP) system;
7. Innovation – generating new ideas and making contributions that will enable the identification and elimination of certain weaknesses in business should be strongly encouraged by management.

Conclusion

Despite the importance of the trend of digital transformation of business, it covers a very wide area of research, and still in many parts is not sufficiently understood and researched. The growing interest in this topic, both among researchers from the academic community and people from the economy, brings new knowledge and discoveries every day.

The general conclusion can be that digital transformation is a more complex type of business transformation empower by technology, which, in addition to addressing the strategic roles of new digital technologies and capabilities for successful digital innovation (Yoo et al. 2010), must also consider other activities in order to successfully implement the digital transformation of business. One of those steps represents business process management and redesign as one of its steps. In business process management, business process redesign deals with improving business processes to solve previously identified process-related problems (Dumas et al., 2013). Due to its importance, Ismail et al. (2017) presented the redesign of business processes in his work as one of the levels of digital business transformation. Successful implementation of business process redesign facilitates the desire to achieve superior performance and sustainable competitive advantage.

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> Ljubojević, T.K., & Dimitrijević, N.N. (1994).

The DOI number or URL of a full text version should be added if it exists.
Here is a list of the most common reference types:

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> Author, A. A., Author, B. B., & Author, C. C. (Year). Title of article. *Title of Periodical, volume number* (issue number), pages.

➲ **Journal article, one author, paginated by issue.**

Journals paginated by issue begin with page 1 in every issue, so that the issue number is indicated in parentheses after the
volume. The parentheses and issue numbers are not italicized, e.g.

> Seliverstova, Y. (2021). Workforce diversity management: A systematic literature review. *Strategic Management*, *26*(2), 3–11. https://doi.org/10.5937/StraMan2102003S

➲ **Journal article, one author, paginated by volume.**

Journals paginated by volume begin with page 1 in issue 1, and continue page numbering in issue 2 where issue 1 ended, e.g.

> Perić, O. (2006). Bridging the gap: Complex adaptive knowledge management. *Strategic Management, 14*, 654–668.

- **Journal article, two authors, paginated by issue.**

  Dakić, S., & Mijić, K. (2020). Regression analysis of the impact of internal factors on return on assets: A case of meat processing enterprises in Serbia. *Strategic Management*, *25*(1), 29–34. https://doi.org/10.5937/StraMan2001029D

- **Journal article, two authors, paginated by volume.**

  Ljubojević, K., & Dimitrijević, M. (2007). Choosing your CRM strategy. *Strategic Management, 15*, 333-349.

- **Journal article, three to six authors, paginated by issue.**

  Marić, S., Uzelac, O., & Strugar-Jelača, M. (2019). Ownership structure as a measure of corporate performance. *Strategic Management*, *24*(4), 28–37. https://doi.org/10.5937/StraMan1904028M

- **Journal article, three to six authors, paginated by volume.**

  Boškov, T., Ljubojević, K., & Tanasijević, V. (2005). A new approach to CRM. *Strategic Management, 13*, 300-310.

- **Journal article, more than six authors, paginated by issue.**

  Ljubojević, K., Dimitrijević, M., Mirković, D., Tanasijević, V., Perić, O., Jovanov, N., et al. (2005). Putting the user at the center of software testing activity. *Management Information Systems, 3*(1), 99-106.

- **Journal article, more than six authors, paginated by volume.**

  Strakić, F., Mirković, D., Boškov, T., Ljubojević, K., Tanasijević, V., Dimitrijević, M., et al. (2003). Metadata in data warehouse. *Strategic Management, 11*, 122-132.

- **Magazine article.**

  Strakić, F. (2005, October 15). Remembering users with cookies. *IT Review*, *130*, 20-21.

- **Newsletter article with author.**

  Dimitrijević, M. (2009, September). MySql server, writing library files. *Computing News, 57,* 10-12.

- **Newsletter article without author.**

  VBScript with active server pages. (2009, September). *Computing News,57,* 21-22.

B. BOOKS, BROCHURES, BOOK CHAPTERS, ENCYCLOPEDIA ENTRIES, AND BOOK REVIEWS

Basic format for books

Author, A. A. (Year of publication). *Title of work: Capital letter also for subtitle*. Publisher.

➲ **Book, one author.**

Ljubojević, K. (2005). *Prototyping the interface design*. Faculty of Economics in Subotica.

➲ **Book, one author, new edition**

Dimitrijević, M. (2007). *Customer relationship management* (6th ed.). Faculty of Economics in Subotica.

➲ **Book, two authors.**

Ljubojević, K., Dimitrijević, M. (2007). *The enterprise knowledge portal and its architecture*. Faculty of Economics in Subotica.

➲ **Book, three to six authors.**

Ljubojević, K., Dimitrijević, M., Mirković, D., Tanasijević, V., & Perić, O. (2006). *Importance of software testing*. Faculty of Economics in Subotica.

➲ **Book, more than six authors.**

Mirković, D., Tanasijević, V., Perić, O., Jovanov, N., Boškov, T., Strakić, F., et al. (2007). *Supply chain management*. Faculty of Economics in Subotica.

➲ **Book, no author or editor.**

Web user interface (10th ed.). (2003). Faculty of Economics.

➲ **Group, corporate, or government author.**

Statistical office of the Republic of Serbia. (1978). *Statistical abstract of the Republic of Serbia.* Ministry of community and social services.

➲ **Edited book.**

Dimitrijević, M., & Tanasijević, V. (Eds.). (2004). *Data warehouse architecture*. Faculty of Economics.

➲ **Chapter in an edited book.**

Repa, V. (2019). Deriving Key Performance Indicators from Business Process Model. In M. Pańkowska & K. Sandkuhl (Eds.), *Perspectives in Business Informatics Research. BIR 2019. Lecture Notes in Business Information Processing, vol 365.* (pp. 148–162). Springer. https://doi.org/10.1007/978-3-030-31143-8_11

- **Encyclopedia entry.**

Mirković, D. (2006). History and the world of mathematicians. In *The new mathematics encyclopedia* (Vol. 56, pp. 23-45). Faculty of Economics.

C. UNPUBLISHED WORKS

- **Paper presented at a meeting or a conference.**

Ljubojević, K., Tanasijević, V., Dimitrijević, M. (2003). *Designing a web form without tables*. Paper presented at the annual meeting of the Serbian computer alliance, Beograd.

- **Paper or manuscript.**

Boškov, T., Strakić, F., Ljubojević, K., Dimitrijević, M., & Perić, O. (2007. May). *First steps in visual basic for applications*. Unpublished paper, Faculty of Economics Subotica, Subotica.

- **Doctoral dissertation.**

Strakić, F. (2000). *Managing network services: Managing DNS servers*. Unpublished doctoral dissertation, Faculty of Economics Subotica.

- **Master's thesis.**

Dimitrijević, M. (2003). *Structural modeling: Class and object diagrams*. Unpublished master's thesis, Faculty of Economics Subotica.

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Tanasijević, V. (2003, March). Putting the user at the center of software testing activity. *Strategic Management*, *8* (4). https://www.ef.uns.ac.rs/sm2024

- **Document from an organization**

Faculty of Economics. (2008, March 5). *A new approach to CRM*. https://www.ef.uns.ac.rs/papers/acrm.html

- **Article from an online periodical with DOI assigned.**

Jovanov, N., & Boškov, T. A PHP project test-driven end to end. *Management Information Systems*, 2 (2), 45-54. https://doi.org/10.5937/StraMan213302003S

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According to Mirković (2001, p. 201), "The use of data warehouses may be limited, especially if they contain confidential data".

Mirković (2001, p. 201), found that "the use of data warehouses may be limited". What unexpected impact does this have on the range of availability?

If the author is not named in the introductory phrase, the author's last name, publication year, and the page number in parentheses must be placed at the end of the quotation, e.g.

He stated, "The use of data warehouses may be limited," but he did not fully explain the possible impact (Mirković, 2001, p. 201).

➲ **Summary or paraphrase**

According to Mirković (1991, p. 201), limitations on the use of databases can be external and software-based, or temporary and even discretion-based.

Limitations on the use of databases can be external and software-based, or temporary and even discretion-based (Mirković, 1991, p. 201).

➲ **One author**

Boškov (2005) compared the access range…

In an early study of access range (Boškov, 2005), it was found...

➲ When there are **two authors**, both names are always cited:

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➲ If there are **three or more authors** the abbreviation "et al." (Latin for "and others") is employed in APA in-text citations when referencing works with three or more authors. The format is to include only the first author's last name, followed by "et al.," a comma, and the year of publication. For instance, (Dakic et al., 2024) would be used as an example.

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If the work does not have an author, the source is cited by its title in the introductory phrase, or the first 1-2 words are placed in the parentheses. Book and report titles must be italicized or underlined, while titles of articles and chapters are placed in quotation marks:

A similar survey was conducted on a number of organizations employing database managers (Limiting database access, 2005).

If work (such as a newspaper editorial) has no author, the first few words of the title are cited, followed by the year: (The Objectives of Access Delegation, 2007)

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If the author is an organization or a government agency, the organization must be mentioned in the introductory phrase or in the parenthetical citation the first time the source is cited:

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The overview is limited to towns with 10,000 inhabitants and up (Statistical Office of the Republic of Serbia [SORS], 1978).

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(Bezjak, 1999; Griffith, 2004)

➲ **Two or more works by the same author in the same year**

If two or more sources used in the submission were published by the same author in the same year, the entries in the reference list must be ordered using lower-case letters (a, b, c…) with the year. Lower-case letters will also be used with the year in the in-text citation as well:

Survey results published in Theissen (2004a) show that…

➲ To **credit an author for discovering a work** when you have not read the original:

Bergson’s research (as cited in Mirković & Boškov, 2006)…

Here, Mirković & Boškov (2006) will appear in the reference list, while Bergson will not.

➲ When **citing more than one author**, the authors must be listed alphabetically:

(Britten, 2001; Sturlasson, 2002; Wasserwandt, 1997)

➲ When there is **no publication date**: (Hessenberg, n.d.)

➲ **Page numbers must always be given for quotations**:

(Mirković & Boškov, 2006, p.12)

Mirković & Boškov (2006, p. 12) propose the approach by which “the initial viewpoint…

➲ **Referring to a specific part of a work**:

(Theissen, 2004a, chap. 3) (Keaton, 1997, pp. 85-94)

➲ **Personal communications, including interviews, letters, memos, e-mails, and telephone conversations**, are cited as below. (These are *not* included in the reference list.)

(K. Ljubojević, personal communication, May 5, 2008).

FOOTNOTES AND ENDNOTES

A few footnotes may be necessary when elaborating on an issue raised in the text, adding something that is in indirect connection, or providing supplementary technical information. Footnotes and endnotes are numbered with superscript Arabic numerals at the end of the sentence, like this.1 Endnotes begin on a separate page, after the end of the text. However, *Strategic Management* **does not recommend the use of footnotes or endnotes.**

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