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Content

Relationships between Macroeconomic Variables and the Stock Price Returns: Case for USA and Eurozone

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Abstract
This research aim examines the relationship in between the macroeconomic variables and the equity markets.
There had been interest rates, money aggregates, consumer sentiment, CPI, PPI, industrial production and stock indices across Eurozone and USA used in between 5/2011 and 2/2021. Based on this research, US stock index had not been the output of macroeconomic regressors, it was actually the opposite. As a method, vector error correction model (VECM) for the long-term cointegration among variables, as well as short-term vector autoregressive (VAR) stochastic models were used. The Eurozone has been heavily dependent on the consumer sentiment and inflation. Influence of Covid-19 pandemic and post-crisis behaviour of stock will be included in the next paper.

Keywords
VECM, VAR, eViews, cointegration, macroeconomic variables, interest rates, stock price returns.

JEL Classification
C01, C32

1 Introduction

This paper examines the impact of the macroeconomic variables on the particular stock markets returns. The current approach is that monetary variables influence the real economy. This research aim is to analyse the relationship the macroeconomic variables and the equity markets and their relationship to the stock markets in USA and Eurozone. Time period of the case study is between 5/2011 and 2/2021.

The contribution of this paper is at identification of the long-term relevance and significance of particular national indicators on the selected international stock markets. That makes the difference visible between traditional market economy and once planned economies. Any evidence supporting economic theories at investment decision-making process would be beneficial not only for academic researchers, but investors too.

2 Literature Review

Since the 1970s, there have been written many academic papers with the focus on seek for monetary variables and analyzing their impact on the mostly developed countries (Haitsma, Unalmis and Haan, 2016; Fausch and Sionius, 2017; Feldman, 2017 and Kulhanek and Matuszek, 2006).

Haitsma and Unalmis and Haan (2016) confirmed the impact of ECB monetary policy on the stock returns in the European union. Similar results were identified by Fausch and Sigonius (2017) on the German stock market. Balafas and Florackis and Kostakis (2018) also examined monetary policy and

stock markets. Additionally, all three papers found the opposite relationship during the Great Recession as the lack of market and investors' confidence. Kulhanek and Matuszek (2006) tested long-term influence of the MS on the stock returns in the Central Europe and concluded that it is weakening during time. Feldman (2017) ran Monte Carlo simulations on the interest rates and their impact on the stock returns in emerging markets. Chatziantoniou and Duffy and Filis (2012) also confirmed the relationship between monetary variables and stock returns in the European union, as well as in the USA.

Stock markets reflect the big picture of real economy. Even Donald Trump often observed the US equity markets and claimed the credit for their resilient growths as his own presidential fiscal success "to make America great again". On the other side, in the rest of the world it is mostly central banks that had received the big monetary decision-making power in the third millennium.

Macroeconomical factors are usually those representing a severe part of the stock variance, especially the monetary policy´ tools and money variables play usually the vital importance. The research is in consequence with Branzovsky (2018) and Branzovsky (2019).

3 Methodology and Data

The first step, before distinguishing VAR and VEC models, is called a specification of the stationarity (trends) of the variables. Time series stationarity is a characteristic typical for a low volatility around the mean value and no trend representing an autocorrelation. Stationarity is usually apparent already from the chart, followed by correlogram and unit root tests. In this paper it is processed by Augmented Dickey-Fuller (ADF) test and by Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test. Stationarisation of time series not in levels is usually processed by natural logarithmisation and by first or higher-order differentiation, or by both. Non-stationary time series may be endangered by the spurious regression, and so stationary variables are a must assumption for VAR models. Besides of that, a long-run model called Vector Error Correction Model (VECM) that furthermore solves an issue of the model with cointegration, does not require stationarity of the data.

3.1 VAR model

Standard vector autoregressive (VAR) is an econometric model used for analysing, simulating and predicting linear interdependencies among multiple time series. Each of them plays is treated symmetrically once as an exogenous, and once as endogenous variable. VAR as a multi-equational model is due to possible cointegration among regressors considered as the short-run model.

A p-order VAR model, described as a VAR(p) is a set of k variables and their p time-lagged values. The specific model for endogenous variable explained by its own time lags and one another variable could be as follows:

$$y_t = \mathrm{A}_1 y_{t-1} + \cdots + \mathrm{A}_\mathrm{p} y_{t-p} + \mathrm{B} x_t + \varepsilon_t \quad (1)$$

where are k observed endogenous variables, A are the parameters of endogenous variables parameters and their time lagged values, B are the exogenous variables parameters and possibly their own time lagged values and are normally distributed standard errors and p is the maximum time lag. The optimum maximum time of lags to be used may be found out by t-tests, F-test and mainly by information criteria.

Granger causality is a predictive concept for stochastic linear measuring whether lagged value of a stationary variable X does or not improve an explanation of another stationary variable Y – to see what variability of Y is explained by its time lags and then to see if additional lagged values of X may improve their relationship.

Cholesky´s Impulse-Response analysis is a verification method to identify the inner-behaviour among the variables in the VAR model over the time period.

Cholesky´s Variance decomposition works sort of as a dynamic coefficient of determination. This step is necessary for variable´ variance based on own shocks and cross-variables shocks. Apparently, their

own shocks are the most important of the error variances, but other ones will also be transmitted into VAR model.

Residual tests of distribution, homoscedasticity and autocorrelation are to be run. For more details about VAR models see Branzovsky (2018).

3.2 VEC model

Until cointegration has started being studied back in the 1980s, most of econometric financial models had had significant explanatory power due to the spurious regression as most of financial variables keep drifting together side by side. The reality of integrated (non-stationary) financial time series led Engle and Granger (1987) to say that the combination of such series may be still linear. If these cointegrating relationships are identified, time series are called to be cointegrated and the long-run linear relationship may be estimated in the cointegrating equation of VEC model through OLS. Cointegration has changed the way how econometrists had been thinking once for good. As Cuthbertson et al. (1993, p. 129) mention it makes economic models based on theories to be economically correct saying whether variables within the model are actually influencing / cointegrating each other.

VEC model is effective with the variables that are non-stationary in levels, but are integrated of higher orders, but all of the same order, the highest one I(max(x1, x2, ...)). In that case the test of cointegration is proceeded, and if time series identified to be cointegrated, there may be a long-run relationship among those meaning that any potential short-term shock will oscilate around and converge to the long-run equilibrium.

$$\Delta y_t = \prod(y_{t-1} + X_{t-1}) + \sum_{i=1}^{p-1} \Gamma_i \, (\Delta y_{t-i} + \Delta X_{t-i}) + \varepsilon_t \tag{2}$$

where are the differences of non-stationary endogenous variables, are non-stationary deterministic variables and are normally distributed standard errors while p is the maximum time lag. VECM is gathered of adjustment coefficient of cointegrating vector and its parameters based on lagged raw time series, then of short-run coefficients linked to the lagged differenced variables, error and finally by a possible intercept.

$$\prod = \sum_{i=1}^{p} A_i - I \qquad\qquad \Gamma_i = -\sum_{j=i+1}^{p} A_j \tag{3}$$

where is a matrix of coefficients that is a result of multiplication of two k x r matrices α and under the scenarios r < k and is stationary in levels, where r represents the reduced cointegration rank while β cointegrating vector. The coefficient matrix and reduced rank are tested by the Johansen method from an unrestricted VAR model.

When specifying the deterministic trend, it is natural that just as time series may have means and trends, the cointegrating equations may have intercepts and deterministic trends as well. Regarding to that, there are two types of columns – cointegrating column and outside column depending on whether the deterministic variables do or do not appear inside the cointegrating relations.

As trends are typical for financial time series, only deterministic trends cases with linear trends (case 3 and 4) of five Johansen´s were considered.

Case 3 for linear trend of the level data only:

$$H_1(r): \prod y_{t-1} + \mathrm{B}x_t = \alpha \, (\beta' y_{t-1} + \rho_0) + \alpha_\perp \gamma_0 \tag{4}$$

Case 4 for linear trends of both the level data and the cointegrating equations:

$$H^*(r): \prod y_{t-1} + \mathrm{B}x_t = \alpha \, (\beta' y_{t-1} + \rho_0 + \rho_1 t) + \alpha_\perp \gamma_0 \tag{5}$$

Where represents the deterministic term outside of the cointegrating relation (rank).

This problematic is solved by two obvious tests. The Engle-Granger cointegration test is used for VEC models with one cointegrating equation model while Johansen test is suitable even for those with several equations. Regarding to the number of cointegrating relations and their statistical significance, there are two types of test statistics: trace statistics and maximum eigenvalues statistics. Estimation of cointegrating relations r in their first columns is proceeded in the order as follows r = 0, 1, ... , k – 1 until the rejection of the null hypothesis. The second columns involve the estimates of the ordered eigenvalues of the matrix. Trace statistics for testing the null hypothesis of r cointegrating ranks is calculated as below:

$$LR_{tr}(r|k) = -T\sum_{i=r+1}^{k}\ln(1-\widehat{\lambda_i}) \quad (6)$$

where represents i-th largest eigenvalue of the matrix. The maximum eigenvalues statistic for testing alternative hypothesis of r+1 cointegrating relations is as follows:

$$LR_{tr}(r|r+1) = -T\ln\left(1-\widehat{\lambda_{r+1}}\right) = LR_{tr}(r|k) - LR_{tr}(r+1|k) \quad (7)$$

Estimation of the cointegrating vector β coefficients and its adjustment coefficients follows. Identification of the cointegrating vector is based on the normalisation.

4 Data

The authors analysed monthly data from May 2011 to February 2021. This is 118 observations across both regions – Eurozone and USA. The data was collected at St. Louis Federal Reserve System's database.

The endogenous variables are the regional stock market indices even though some regressors could be better explained variables. S&P 500 stock price index was analysed on behalf of the US equity market (SPX), and DAX 30 stock index as the valid representant of the Eurozone (DAX). Both stock indices were taken to the value in the end of each particular month.

As for independent power-explaining regressors these have been used: discount rates (US/EMU_IR), M1 money aggregates (US/EMU_M), consumer sentiment (US/EMU_CS), industrial production level (US/EMU_IP) and producers' price index (US/EMU_PPI). No dummy variables have been used at this research paper as there have not been that many of those. Based on the mainstream economic theories, money supply, consumer sentiment, industrial production ought to be positively impacting the stock returns, whilst interest rates negatively. Effect of inflation level is not clearly defined as there have been studies standing for both impacts, non-negative as well as negative.

For VAR model, all observed variables must have been stationary at *I(1)* and hence not only naturally logarithmed, but differenced at first levels too. These stationary variables US/EMU_X with no unit roots were labelled as DL_US/EMU_X.

5 Results

ADF and KPSS tests were run in order to address the issue with stationarity at 10% significance level[1]. All variables have been trendy, non-stationary with a unit root, *I(1)* at statistical confidence 90+ % based on ADF and KPSS.

For VEC model, the raw non-stationary time series were used, after being natural-logarithmed into L_X, except of the interest rates that were only transformed into quarterly rates. For VAR models, all variables were modified into the first differentiations of naturally logarithms (DL_X) as for VAR the time series are required to be stationarity of the first order *I(1)*. See short-run VAR models initially, and then let be verified the potential cointegration among regressors.

1 This paper works with * at 10%, ** at 5% and *** at 1% statistical significance level.

The **lag order** for models was selected based on several information criterions, e.g. Akaike, Schwarz and Hannah-Quinn information criteria (the most preferred one with the lowest coefficient), LR statistic test at 10% significance level etc. As tested by above mentioned ICs, the best-fitted models have been those with two lags.

The **Granger causality** show that whilst in Eurozone consumer sentiment and monetary variables (money supply, discount rate) do influence the German equities, that is not the case in the USA where no regressors have had the explanatory power to predict the US equities. Oppositely, it may be seen that consumer sentiment is actually the output of what's happening to the equities, in both markets. The same result is for industrial production (real economy) being impacted by stock markets at first line.

*DL_EMU_CS**, DL_EMU_M**, D_EMU_IR* do Granger cause DL_DAX.*
*DL_DAX does Granger cause DL_EMU_CS*** and DL_EMU_IP***.*

No variables do Granger cause DL_SPX.
*DL_SPX does Granger cause DL_US_CS***, DL_US_IP***, DL_US_M***, and DL_EMU_PPI***.*

Estimation of the **VAR** parameters was run via OLS method. All parameters were rounded to two decimals. If not statistically significant, the particular variables were omitted and VAR model was re-tested for if not better. Intercepts were kept in the VAR models if significant but their relevance in models depend on the economical interpretation.

$$\boldsymbol{DL\_SPX_t} = 0.01^{***} - 0.28\ DL\_SPX_{t-1}^{***} - 0.12\ DL\_SPX_{t-2} + 1.88\ DL\_US\_PPI_t^{***} - 0.34\ DL\_US\_PPI_{t-1} + 0.06\ D\_US\_IR_t^{***} - 0.06\ D\_US\_IR_{t-1}^{***}$$

adj. R^2 = 21 %

$$\boldsymbol{DL\_DAX_t} = -0.34\ DL\_DAX_{t-1}^{***} - 0.34\ DL\_DAX_{t-2}^{***} + 17.59\ DL\_EMU\_CS_t^{***} - 5.03\ DL\_EMU\_CS_{t-1}^{*} + 0.91\ DL\_EMU\_M_t + 1.46\ DL\_EMU\_M_t^{**} + 4.62\ DL\_EMU\_PPI_t^{***} + 0.57\ DL\_EMU\_PPI_{t-1} - 0.12\ D\_EMU\_IR_t^{*} - 0.22\ D\_EMU\_IR_{t-1}^{***} - 0.01\ D\_US\_IR_t - 0.08\ D\_US\_IR_{t-1}^{***}$$

adj. R^2 = 48 %

Both national short-run models with two lags VAR(2) have been **statistically verified**. Regarding to unrestricted VARs **residual econometric verification**, there have been some residual autocorrelations found out in the models based on LM and Portmanteau Autocorrelation tests at *** significance. On the other hand, correlation matrix has additionally identified no high correlation among the variables.

Running residual heteroscedasticity White tests with/without cross terms estimated the p-values lower than 10% significance level meaning rather rejecting null hypothesis of homoscedasticity – VAR models are considered as being heteroscedastic[2].

VARs' residuals have come from the normal distribution[3].

Regarding to the Cholesky´s **Impulse response** method, the only endogenous variable (German DAX) reacted swiftly to any changes in regressors usually within one following month and mitigating this change smoothly in approximately three next months. Relationships have been generally positive right after any change and negative on any discount rate' (both EMU, USA) hike.

In terms of Cholesky´s **Variance decomposition,** there has been no explanatory power for stock returns. Nevertheless, European consumer sentiment and PPI have been accounted for approximately 35 % of the stocks' variance within one to two months.

[2] Heteroscedasticity may have negatively influenced the accuracy of the OLS estimated parameters, but the trends ought to be still alright.

Explanatory power of the US variables has been very limited and the influence of the US fed fund rates changes on Eurozone a bit exaggerate too. US markets have been lightly influenced by fed fund rates and inflation there only. Consumer sentiment has been mostly explained by all the regressors including stock returns. That represents the state when consumers only observe the wellbeing of the economy and make their risk attitude ex-post. Nevertheless, consumer sentiment is vital in Eurozone in defining the profitability of the European stock markets.

As the raw data are non-stationary, performing of **Johansen cointegration test** is to be performed, as well as testing the long-term model. Involving the endogenous macroeconomic variables, the Johansen cointegration test and deterministic trend case 3 with linear trend among data while just intercept expected in the cointegrating equation, revealed one to two cointegrating equations at 10% significance level. Based on ICs, the lag order for VECM is 2 coming from the unrestricted VAR models.

VECM long-term equilibriums have not been identified as adjustment coefficients γ_1 were not statistically significant as there must had been some other dynamic fluctuations in-between series. In this case the reader can be indifferent between usage of VEC and VAR models. Short-run part of VECM revealed that stock returns are influenced by its own lagged values***, consumer sentiment*** and one-lagged interest rates (both US and Eurozone).

The only statistically significant VEC model ** at 10% significant level in the long-term was identified in the US market. The whole adjusted coefficients of determination R^2 were 49 % (EMU) and 22 % (US). Regarding to Eurozone, the strongest influence had been consumer sentiment and PPI, in the US market slightly by PPI too. Consumer sentiment in the Eurozone had had the dependent variable with the adjusted coefficient of determination R^2 set as 83 %, and 25 % for the US market. Fed fund rates had been the only regressors having an impact to the US equities. Of those generally explained variables the industrial production and money aggregates were the top ones in its identification.

6 Conclusion

US equities have not been that much influenced by macroeconomic variables there like their overseas neighbours. Based on this research, there is only limited chance for investors to gain in the US stock markets when predicting as the logic there is opposite – it is the stock market that drives all other variables.

Eurozone has been heavily dependent on the consumer sentiment and inflation that were both vice versa dependent on the well-being of the Eurozone economy in back. Changes in the US monetary policy had not that great impact on DAX index as thought.

This research paper tested long-run and short-run relationships between macroeconomic variables and stock returns in the Eurozone and USA. Long-run relationship was found out in the US market that is little unpredictable. Tests were run on monthly data from May 2011 to February 2021. Additionally to Branzovsky (2018)′ and Branzovsky (2019)′ similar researches run on several countries from the Great Recession, monetary variables had been once again somewhat exaggerated indeed, compared to the relevant real economy' indicators.

For both countries' short-term VAR models with two lags (two-month delay), all displayed heteroscedasticity and autocorrelation of their residuals. Impulse responses of dependent variables on the explanatory shocks revealed that stock indices had been negatively influenced by their own two-month lagged values and interest rates.

Based on this study outcomes, European stocks are data-driven whilst US data are stock-driven.

For the upcoming research authors refer adding several other countries in order to increase the extent of covertness globally that could be compared. Additionally, with the current pandemic issues the time scale could be distinguished into period ahead of the Covid-19 crises and ex-post with potential prediction for the stocks.

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Application of Hull-White Trinomial Lattice Approach to Valuation of Mortgage Origination Implicit Option

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Abstract

In the moment of a mortgage approval a Czech bank virtually writes an implicit option to a client who either exercises it by signing the Mortgage contract or the option expires worthless. To valuate the described implicit option the paper valuates the underlying mortgage contract as a coupon bond using Hull-White trinomial tree method. Afterwards using the same method, the trinomial tree is constructed for valuation of the implicit option with regards to initial term structure of interest rates faced at the moment of the option writing. Goal of the paper is to describe the Hull-White method and its application to the valuation of the implicit option written at origination of a hypothetical mortgage contract.

Keywords
- Mortgages, Options, Trinomial tree, Term structure

JEL Classification
- C58, C63, D81, G12, G21

1 Introduction

The paper aims to apply standard financial methods to valuate an implicit option written to clients when their mortgage is originated. Origination of the mortgage is defined here as a time between approval of the mortgage with offered interest rate (henceforth *IR*) and signing of the mortgage contract. For the purposes of this paper the *IR* offered to a client consist of cost of funds rate (henceforth *CoF*) and mark-up added by a bank to create profit (business margin), which is fixed across time and banking sector. *CoF* represents, in this paper, CZK fix-to-float interest rate swap rate (henceforth IRS), which is a market rate predominantly used by the Czech banks to reference their costs of funding for any mortgage contract.

The time gap between IR offering (approval) and contract signation creates a risk for the bank. When the contract is finally signed the market *CoF* might be different from the *CoF* at the moment of IR offer. The risk can be propagated into the mortgage's profitability via two channels: cost of funding (increased market funding rate increases *CoF* and so decreases the effective business margin) and opportunity cost (bank could have allocated its capital to today's mortgages with higher rates rather than yesterday's, hence increasing implied cost of capital and decreasing profitability in terms of return on equity). To include this risk to the profitability it must be properly valued.

Relevant literature on mortgage-backed options valuation is scarce. The authors focus either on valuation of a whole mortgage and its derived securities represented by Kau et al. (1987) and Calvo-Garido and Vázquez (2017) or on more technical aspects of valuating the mortgage prepayment and default options such as Hürliman (2011).

As literature directly related to the valuation of the risk described above was not found, the paper aims to fill the gap by describing a possible approach. The risk is valued by a construction of the specific implicit option and valuating it by means of Hull-White trinomial tree approach.

The first section of the paper presents methodology and application of mortgage contract valuation as an underlying asset for the investigated implicit option. A hypothetical mortgage valuation model is constructed by means of Hull-White trinomial tree with focus on term structure of *CoF*. The second section applies a similar approach to model the implicit option underlying asset's paths and the valuation of the implicit option is performed. Concluding section focuses on brief discussion of the results and recommendation for further investigation.

2 Mortgage Contract Valuation

In this section a mortgage contract is valuated as a coupon bond by the means of Hull-White trinomial tree approach with the focus on the term structure of CoF.

2.1 Mortgage Contract Definition

Let a mortgage be defined as a coupon-bearing bond with maturity *M* years and monthly coupon payments equal to standard annuity payments $\tau = \frac{FA \cdot IR/12}{1-(1+IR/12)^{-12M}}$, where *FA* stands for the mortgage contract financed amount and *IR* is the offered interest rate (*CoF* + business margin). The bond is issued by a client to a bank for the initial price *FA*.

Each $0 < X \leq M$ years a bank holding the bond has a right to change the *IR* for the next *X* years – this moment is called the refixation. A bank holding the bond will change the *IR* in a way to keep its full business margin, hence the *IR* will equal to the current *CoF* at the refixation date plus business margin. Since the *IR* changes at the refixations, also the coupon payment τ changes accordingly taking into account the residual maturity of the bond.

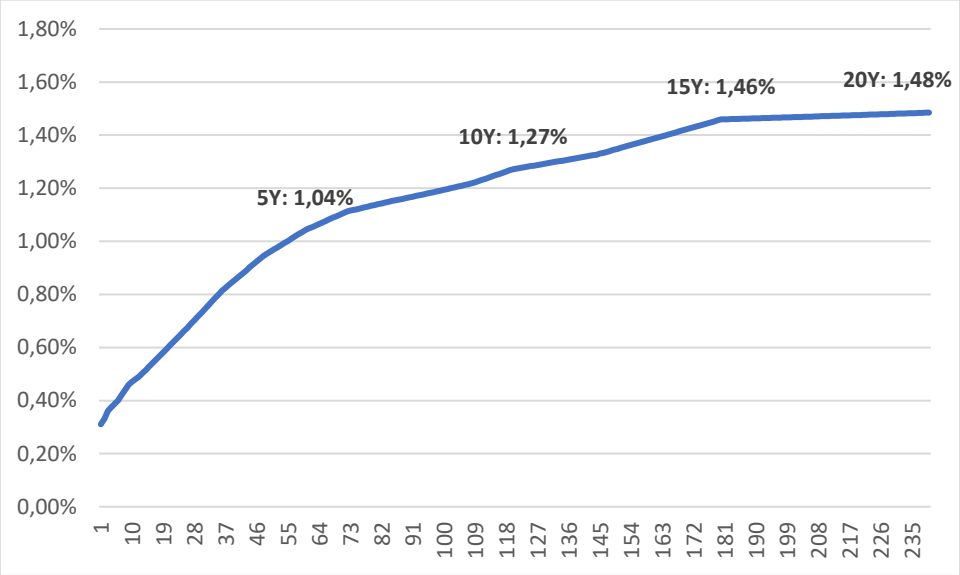
For the purposes of this paper, no prepayment or default options are available for the client (the issuer of the bond). The net present value (*NPV*) of such a contract is calculated as the sum of all discounted cashflows (coupon payments τ).

2.2 Mortgage Refixation *IR* and Term Structure

To correctly value the mortgage contract, the future *IRs* at refixation has to be known. Firstly, the only variable part of the *IR* is the *CoF*. Therefore, further analysis will be performed using this rate and business margin is added only at the end to get the final *IR*.

In the moment of mortgage contract origination, the bank faces the term structure of *CoF*. If the refixation period is 5 years, a bank's cost of funding is referenced to 5-year *CoF*, on the other hand, if the refixation period was 20 years, the cost of funding reference rate would be 20-year *CoF*. Figure (1) shows *CoF* monthly term structure (maturities not available from market were interpolated).

Figure 1. CZK fix-to-float IRS curve (average of 2021/01)



Source: NEWVALUES (2021)

To get the *IR* for the first 5-year refixation period to be offered to a client, a bank will use $5Y\ CoF = 1.04\%$ and will add its business margin. The future *CoF* in the following refixations is unknown and has to be modelled with respect to the current term structure, because it provides information on current market expectations of *CoF* movements in the future.

2.3 The Hull-White Mean-reversion Model

Description and application of the model is based on the Hull and White paper (Hull and White, 1990) in which they explore the approach on how to enhance the Vasicek (1977) model to fit the current term structure of modelled interest rates. One-factor version of their model is

$$\Delta r = (\theta(t) - ar)\Delta t + \sigma \Delta z, \qquad (1)$$

where parameters a and σ are constants. In this model r stands for modeled interest rate, a is a rate of mean-reversion, σ represents the interest rate volatility, Δz is a standard Brownian motion and parameter $\theta(t)$ is a function of time chosen such that the model fits the current term structure.

Desirable $\theta(t)$ can be analytically derived such that

$$\theta(t) = F_t(0,t) + aF(0,t) + \frac{\sigma^2}{2a}(1 - e^{-2at}), \qquad (2)$$

where $F(0,t)$ is the instantaneous forward rate at the time *t* seen from the time 0 and the last term of the equation tends to be very small and can be omitted. Important to note is that the equation implies that on average, r follows the slope of the current term structure (forward rates) curve and if it drifts away, it returns to the curve with rate a.

2.4 The Hull-White Trinomial Tree Construction Methodology

A trinomial tree is a strong tool to model stochastic processes of interest rates. Compared to binomial tree provides additional room to model complex processes such as mean-reversion.

This paper follows Hull-White (1990) trinomial tree construction methodology consisting of two stages.

We assume that the tree's time step is Δt, the rates on the tree R are the continuously compounded Δt-period rates and that the R follows the same stochastic process as modelled rate r.

2.4.1 The First Stage

The first stage of the tree construction is building a tree for variable R^* which is initially zero and follows the process $\Delta R^* = -aR^*\Delta t + \sigma\Delta z$. This process is symmetrical about $R^* = 0$.

Step between the tree's nodes ΔR is set to

$$\Delta R = \sigma\sqrt{3\Delta t}. \tag{3}$$

Let $(i \in Z^+, j \in Z)$ be the node where $t = i\Delta t$ and $R^* = j\Delta R$. Let $p_u, p_m, p_d \in [0,1]$ be the probabilities of upward, straight and downward movement from a tree's node (in other words, these are probabilities of upward, middle and downward branches pointing from the node).

The first and the second moment of ΔR^* in time Δt is $-aR^*\Delta t$ and $\sigma^2\Delta t$ respectively. Hence the p_u, p_m, p_d have to satisfy the following conditions to match the mean and standard deviation

$$\Delta R(p_u - p_d) = -aj\Delta R\Delta t, \tag{4}$$

$$\Delta R^2(p_u + p_d) = \sigma^2\Delta t + a^2j^2\Delta R^2\Delta t^2, \tag{5}$$

$$p_u + p_m + p_d = 1. \tag{6}$$

Using equations (4-6) the solution to the equations system is as follows,

$$p_u = {}^1\!/_6 + {}^1\!/_2\,(a^2j^2\Delta t^2 - aj\Delta t), \tag{7}$$

$$p_m = {}^2\!/_3 - a^2j^2\Delta t^2, \tag{8}$$

$$p_d = {}^1\!/_6 + {}^1\!/_2\,(a^2j^2\Delta t^2 + aj\Delta t). \tag{9}$$

2.4.2 The Second Stage

The aim of the second stage of the tree construction is to convert the R^*-tree into the R-tree by shifting the nodes of the R^*-tree such that the term structure of interest rates is matched. Define $\alpha(t) = R(t) - R^*(t)$ and α_i as $\alpha(i\Delta t)$. Define $Q_{i,j}$ as present value of a security that pays-off €1 if node (i,j) is reached and zero otherwise. Iterative forward induction is used to compute all α_i and $Q_{i,j}$.

The iteration starts when the $Q_{0,0}$ is chosen to be 1 and α_0 is set to initial Δt-period rate r_1 which is known. Then the $Q_{1,1}, Q_{1,0}, Q_{1,-1}$ can be calculated. There is a probability p_u that the node $(1,1)$ is reached and discount rate for the time step is α_0 hence, $Q_{1,1} = p_u e^{-\alpha_0}$. By the same approach we get $Q_{1,0} = p_m e^{-\alpha_0}$ and $Q_{1,-1} = p_d e^{-\alpha_0}$.

When we have all Q's next step is to compute α_1. It is chosen to correspond with the zero-coupon bond maturing in the time $2\Delta t$ with price e^{-2r_2}. Price of the security seen in the node (i,j) is $e^{-(\alpha_i + j\Delta t\Delta R)}$, therefore assuming that $\Delta t = 1$ it is $e^{-(\alpha_1+\Delta R)}$ for the node $(1,1)$, $e^{-(\alpha_1)}$ for the node $(1,0)$ and $e^{-(\alpha_1-\Delta R)}$ for the node $(1,-1)$. The probability weighted sum of prices gives the security price as seen from the initial node $(0,0)$ which should be the same as price of the known zero-coupon bond $Q_{1,1}e^{-(\alpha_1+\Delta R)} + Q_{1,0}e^{-(\alpha_1)} + Q_{1,-1}e^{-(\alpha_1-\Delta R)} = e^{-2r_2}$ giving equation $\alpha_1 = \ln\left(\frac{Q_{1,1}e^{-(\alpha_1+\Delta R)} + Q_{1,0}e^{-(\alpha_1)} + Q_{1,-1}e^{-(\alpha_1-\Delta R)}}{e^{-2r_2}}\right)$.

As we have α_1 we can similarly calculate $Q_{2,2}, Q_{2,1}, Q_{2,0}, Q_{2,-1}$ and $Q_{2,-2}$ and subsequently calculate α_2. Described iterative process ends when all nodes have their α's and we are able to produce full tree for R.

2.5 Application to Valuation of a Mortgage Contract

Let there be a mortgage contract with maturity 20 years, refixation period 5 years, financed amount 100 and no option of prepayment or default. In this section let us assume there is no time gap between *IR* offer and contract signation. The bank faces *CoF* forward curve (Table 1) at the moment of mortgage contract origination. Because the refixation period is 5 years, the bank chooses 1.04% as their initial *CoF*. Assuming the business margin of the bank is 1%, the offered (and signed) *IR* for the first fixation period will be 2.04%.

Table 1. Term structure of CoF – Long forward curve

Term	CoF
5Y	1,04%
10Y	1,27%
15Y	1,46%
20Y	1,48%

Source: Author

2.5.1 Hull-White Trinomial Tree Construction

Let σ be equal to 0.001 and a be equal to 0.01. Time step $\Delta t = 5$ because the refixation period is 5 years the ΔR is calculated as 0.3873% and R^* tree is in the Table 2.

Table 2. Tree for R^*

			0.0116
		0.0077	0.0077
	0.0039	0.0039	0.0039
0.0000	0.0000	0.0000	0.0000
	-0.0039	-0.0039	-0.0039
		-0.0077	-0.0077
			-0.0116

Source: Author

Using formulas from the previous section, p_u, p_m, p_d are calculated for each node in the tree, see Table 3.

Table 3. Tree for p_u, p_m, p_d

p_u

			1.0000
		0.1217	1.0000
	0.1429	0.1429	1.0000
0.1667	0.1667	0.1667	1.0000

p_m

			1.0000
		0.6567	1.0000
	0.6642	0.6642	1.0000
0.6667	0.6667	0.6667	1.0000

p_d

			1.0000
		0.2217	1.0000
	0.1929	0.1929	1.0000
0.1667	0.1667	0.1667	1.0000

	0.1929	0.1929	1.0000
		0.2217	1.0000
			1.0000

	0.6642	0.6642	1.0000
		0.6567	1.0000
			1.0000

	0.1429	0.1429	1.0000
		0.1217	1.0000
			1.0000

Source: Author

Note that the probabilities are mirrored across the $j = 0$ path and that all probabilities in the last column equal to 1 because there are no following nodes.

With these prepared, the second stage of the process can be applied iteratively. We set α_0 to 1.04% which corresponds to the point of initial forward curve with the term 5 years. The results for Q and final R are shown in Table 4.

Table 4. Tree for R and Q

Q

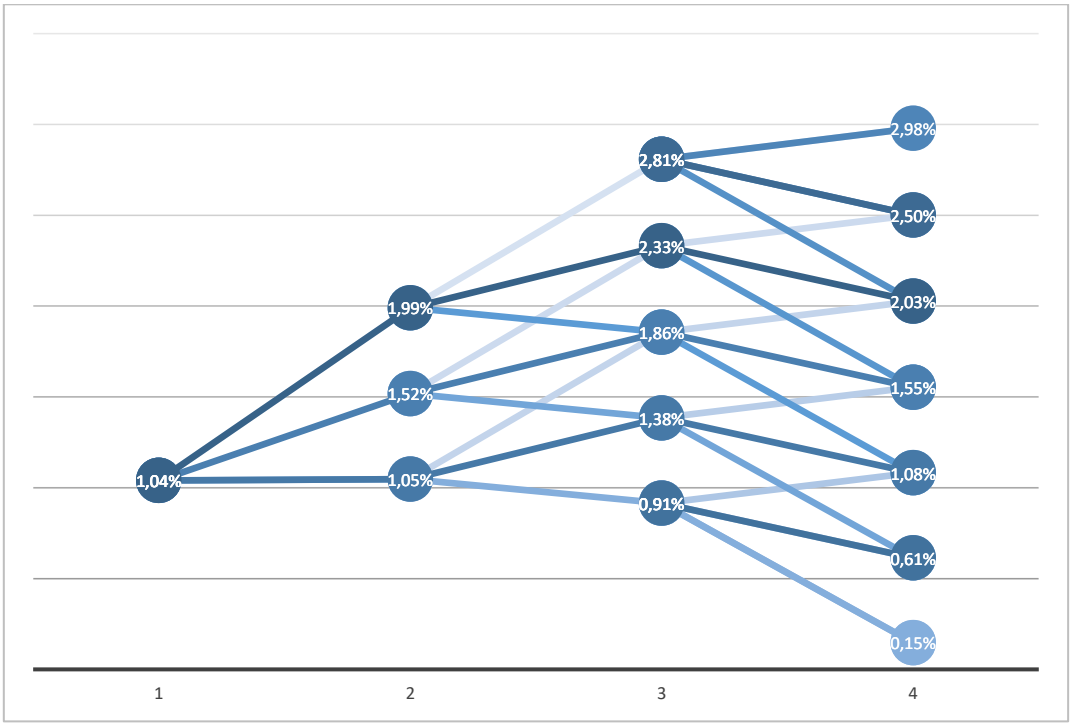
			0.0022
		0.0206	0.0366
	0.1584	0.1935	0.1871
1.0000	0.6337	0.4481	0.3412
	0.1584	0.1972	0.1944
		0.0214	0.0395
			0.0025

R

			0.0298
		0.0281	0.0250
	0.0199	0.0233	0.0203
0.0104	0.0152	0.0186	0.0155
	0.0105	0.0138	0.0108
		0.0091	0.0061
			0.0015

Source: Author

Figure 2. Trinomial tree for R (visualization)



Source: Author

The R's tree (Figure 2) represents the tree of likely paths of *CoF* which are used to produce likely cashflows to calculate the mortgage contract NPV.

2.5.2 Mortgage Contract NPV Calculation

There are 27 paths (number of time steps i_{max} to the power of 3 because each node has 3 branches) which the *CoF* may follow in the future. Each path has its unique probability and sequence of rates shown in the table (5).

Table 5. *CoF* likely paths and their probability

path probability	1st refixation CoF	2nd refixation CoF	3rd refixation CoF	4th refixation CoF
0.0029	0.0104	0.0199	0.0281	0.0298
0.0156	0.0104	0.0199	0.0281	0.025
0.0053	0.0104	0.0199	0.0281	0.0203
0.0158	0.0104	0.0199	0.0233	0.025
0.0735	0.0104	0.0199	0.0233	0.0203
0.0214	0.0104	0.0199	0.0233	0.0155
0.0054	0.0104	0.0199	0.0186	0.0203
0.0214	0.0104	0.0199	0.0186	0.0155
0.0054	0.0104	0.0199	0.0186	0.0108
0.0159	0.0104	0.0152	0.0233	0.025
0.0738	0.0104	0.0152	0.0233	0.0203
0.0214	0.0104	0.0152	0.0233	0.0155
0.0741	0.0104	0.0152	0.0186	0.0203
0.2963	0.0104	0.0152	0.0186	0.0155
0.0741	0.0104	0.0152	0.0186	0.0108
0.0214	0.0104	0.0152	0.0138	0.0155
0.0738	0.0104	0.0152	0.0138	0.0108
0.0159	0.0104	0.0152	0.0138	0.0061
0.0054	0.0104	0.0105	0.0186	0.0203
0.0214	0.0104	0.0105	0.0186	0.0155
0.0054	0.0104	0.0105	0.0186	0.0108
0.0214	0.0104	0.0105	0.0138	0.0155
0.0735	0.0104	0.0105	0.0138	0.0108
0.0158	0.0104	0.0105	0.0138	0.0061
0.0053	0.0104	0.0105	0.0091	0.0108
0.0156	0.0104	0.0105	0.0091	0.0061
0.0029	0.0104	0.0105	0.0091	0.0015

Source: Author

Note that sum of all probabilities for all paths equals to 1 and probabilities are symmetrical around the middle path. This is expected behavior since the continuous stochastic process behind discrete tree should follow the normal distribution.

Next step is to add the business margin 0.01 to the *CoF* paths to get the *IR*. Annuity payments for all paths during all refixation periods are then calculated to get the likely cashflows of the mortgage contract. The obtained cashflows from all likely paths are discounted by the forward curve shown in the Figure 1. Finally, the all-path sums of the discounted cashflows are weighted by the probabilities for each path to get the expected NPV. The NPV of the described mortgage contract equals to 109.0613.

3 Valuation of Mortgage Origination Implicit Option

This section uses presented trinomial tree methodology from previous section to model *CoF* paths between the moment of *IR* offer to client and optional sign of the mortgage contract.

3.1 Mortgage Origination Implicit Option Definition

The investigated implicit option is written by a bank to a client in the moment of *IR* offer for the mortgage contract (mortgage approval). The implicit option gives a right to a client to sell a bond to a bank, hence it is a PUT option. The option expires in 30 days and is of the American type because a client can exercise the option by signing the mortgage contract (selling a bond) any time between the option writing and its expiration.

The described option value is determined by the value of the underlying mortgage contract which is directly determined by the *IR* offered and finally *IR* is determined by the *CoF*. Other parameters such as mortgage contract maturity or refixation period also determines the mortgage contract value, however it is very unlikely that client preferences on these parameters change in 30 days, therefore we only consider possible movements in the *CoF* when valuing the origination option. It follows that the option value is the function of *CoF* and time.

The strike price of the option is the value of the mortgage contract (NPV) at the moment of the option writing (*IR* offer) facing the current forward curve (term structure). Therefore, the option is always at-the-money (ATM) in the moment of writing.

3.2 The Option Trinomial Tree Description

Between the option writing and expiration, the CoF_0 (determining the mortgage contract value) can move upwards, downwards or can stay the same. This leads directly to a conclusion that a trinomial tree approach can be a solid method to model the situation.

As the option expires in 30 days, the only fundamental clue of where the CoF_0 might move is the term structure (short forward curve) faced in the moment of writing. The observed forward curve terms at this short end are usually 1W, 2W and 1M. Therefore, the rate for 3W term is interpolated simplistically as $r_{3W} = (r_{2W} + r_{1M})/2$.

Hence the 4 period Hull-White trinomial tree can be constructed with $\Delta t = 1/52$ to model likely paths of *CoF* between the option writing and expiration. As explained in the section 2.4.1 the first point of the forward curve is always the same as resulting *R* in the node $(0,0)$ and as the option is written ATM the r_{1W} (first point of the forward curve) has to be subtracted from the whole tree to get 0 in the node $(0,0)$ and increments in other nodes. Every increment in each node is then node by node added to the initial CoF_0 and based on this the mortgage contract NPV for each node is calculated.

It is important to note that the increments must not only be added to CoF_0 but to the whole term structure used to model different refixation period cashflows of the mortgage contract. In this paper the term structure (forward curve) can make only parallel shifts, the slope of the curve is not changed in the process.

3.3 The Option Valuation Method

Let E be the strike price of the option which is a price at which the option holder can sell the underlying asset at any time until expiration at time *T*. Let $P_{i,j}$ denote the NPV of the underlying mortgage contract (bond) at the tree's node (i, j). Let $p_u, p_m, p_d \in [0,1]$ be the probabilities of upward, straight and downward movement from a tree's node.

Expiration time $t = T$ is special in a sense that at this moment the option must be either exercised with profit $E - P_{T,j}$ or expires worthless. Hence the value of the option at expiration can be derived as,

$$V_{T,j} = max\left(E - P_{T,j}\,, 0\right). \tag{10}$$

Goal of the trinomial method is to find the value of the option at $t = 0$ and this is achieved by recurring weighting of the option values by probability and discounting by discount rate. We know the possible

option values in expiration $V_{T,j}$ from (5) and financial modelling theory states that for European option we can find any $V_{i,j}$ with recurrence equation

$$V_{i,j} = \mathrm{e}^{-\rho\Delta t}\left(p_u V_{i+1,j+1} + p_m V_{i+1,j} + p_d V_{i+1,j-1}\right);\ j \in \pm[0,i];\ i \in [1, T-1], \qquad (11)$$

where ρ denotes a risk-free interest rate representing an opportunity cost of holding the option. The equation (7) for American type option

$$V_{i,j} = max\left(max\left(E - P_{T,j}, 0\right), \mathrm{e}^{-\rho\Delta t}\left(p_u V_{i+1,j+1} + p_m V_{i+1,j} + p_d V_{i+1,j-1}\right)\right), \qquad (12)$$

takes into account that the option can be exercised in any time until expiration and the holder is in each node pondering whether to exercise immediately or to wait until the next period.

3.4 Application to Valuation of the Mortgage Origination Implicit Option

Let the underlying mortgage contract has the characteristics described in the section 2.5. For reminder, the forward curve necessary to value the underlying mortgage contract is as follows: 1.04%, 1.27%, 1.46% and 1.48% for 5, 10, 15 and 20 years respectively.

3.4.1 Hull-White Short-rates Tree Construction

The short end of the forward curve faced in the moment of the option origination is in the Table 6 as follows: 0.27%, 0.29% and 0.31% for 1, 2 and 4 weeks term respectively. The 3 weeks term has to be interpolated with simple average to get 0.30%.

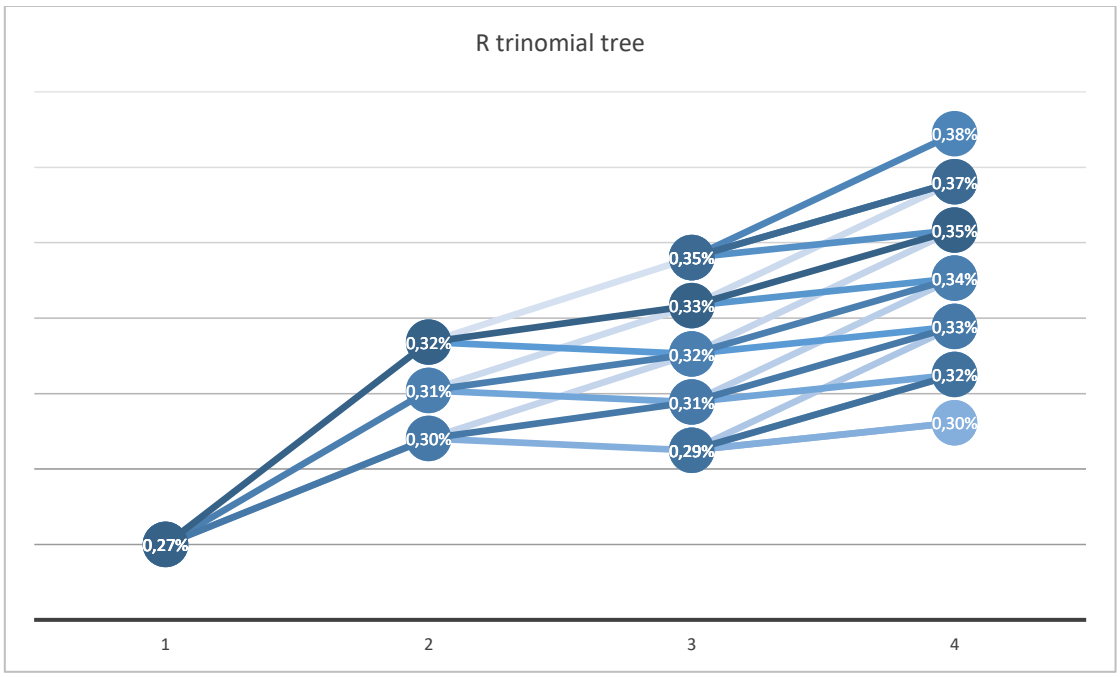
Table 6. Short rates term structure

Term	*r*
1W	0,27%
2W	0,29%
3W	0,30%
1M	0,31%

Source: Author

Let σ be equal to 0.00001, a be equal to 0.0001 and $\Delta t = 1/52$ (one week time step). Hull-White trinomial tree approach described in section 2.4 leads to the R tree in the Figure 3.

Figure 3. Trinomial tree for short rates (visualization)



Source: Author

Another important output are the probabilities p_u, p_m, p_d for each node which will be used in the final step of the option valuation.

To continue with the valuation incremental tree is computed by subtracting $R_{0,0}$ value, which is 0.27%, from all node *R*s.

3.4.2 The Option NPV Tree Computation

In the next step the long forward curve is parallelly shifted by the incremental tree to get likely paths of the long *CoF* in the next 30 days (table 7).

Table 7. *CoF* term structure adjusted for incremental tree

$5Y\ CoF$

			0.0115
		0.0112	0.0114
	0.0109	0.0110	0.0112
0.0104	0.0108	0.0109	0.0111
	0.0107	0.0108	0.011
		0.0106	0.0109
			0.0107

$10Y\ CoF$

			0.0138
		0.0135	0.0137
	0.0132	0.0133	0.0135
0.0127	0.0131	0.0132	0.0134
	0.0130	0.0131	0.0133
		0.0129	0.0132
			0.0130

$15Y\ CoF$

			0.0157
		0.0154	0.0156
	0.0151	0.0152	0.0154
0.0146	0.0150	0.0151	0.0153
	0.0149	0.0150	0.0152
		0.0148	0.0151
			0.0149

$20Y\ CoF$

			0.0159
		0.0156	0.0158
	0.0153	0.0154	0.0156
0.0148	0.0152	0.0153	0.0155
	0.0151	0.0152	0.0154
		0.0150	0.0153
			0.0151

Source: Author

Further the mortgage contract NPVs for each node of the option tree are computed based on the procedure described in the section 2.5. getting values in the Table 8.

Table 8. The option NPV tree

			108.9350
		108.9720	108.9493
	108.9978	108.9866	108.9637
109.0613	109.0126	109.0014	108.9782
	109.0277	109.0163	108.9929
		109.0314	109.0077
			109.0227

Source: Author

Note that NPV in the node $(0,0)$ equals the expected NPV of the mortgage contract from the section 2.5. The first fixation *IR* of modelled mortgage in each node equals to offered *IR.*

3.4.3 The Option Valuation

At this point we have everything we need to value the origination option: strike price, probabilities for each node and the underlying mortgage contract NPV likely paths in the next 30 days.

Table 9. The option discounted values V

			0.1263
		0.1120	0.1120
	0.0975	0.0976	0.0976
0.0830	0.0830	0.0830	0.0831
	0.0683	0.0683	0.0684
		0.0535	0.0535
			0.0385

Source: Author

Using the equation (10) and (12) we get the expected option values in the table (9) and the expected present value of the mortgage origination implicit option is 0.083 which corresponds with the price CZK 830 for each one million of financed amount of a mortgage contract. This is the value of the risk undergone by a bank when providing 30 days to a client to sign the mortgage contract.

4 Conclusions

In this paper, Hull-White (1990) model of short rates and corresponding trinomial tree method was described. Furthermore, the method was applied to valuate firstly the mortgage contract and secondly the mortgage origination implicit option, which is written to a client by a bank in the moment of the mortgage contract interest rate offer. The main advantage of the Hull-White approach is its ability to take into account initial term structure if interest rates faced at the moment of valuated security issue which provides fundamental information on likely future movement of spot interest rates. The application on hypothetical mortgage contract originated on the Czech market at the beginning of the year 2021 produced reasonable result.

Further improvements are many, firstly the modelled mortgage contract lacked crucial features such as premature payments possibility or debt default possibility that can be modelled as so-called prepayment and default options. Another feature of the mortgage contract not accounted for here, is gradual drawing, distinctive mainly for mortgages backed by property in construction. Again, such feature can be valuated by a specific option. Incorporating the value of these features to the mortgage contract valuation would have material effect on the result of this paper. Secondly the crucial parameters σ and a are merely stated in this paper, however a proper econometric model should be constructed to provide estimation of these parameters based on historical behavior of interest rates term structure.

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Hierarchy of Dynamic Capabilities

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Abstract
Researchers agree that dynamic capabilities (DC) have a hierarchical structure but there is no consensus with regard to DC levels and multidimensionality. The inconsistency in the numbering of individual levels seems to be particularly confusing. Although the authors cite the most popular hierarchy concepts, no common DC hierarchy has been adopted so far. The purpose of the article is to gather and compare the most important existing concepts and combine them to propose one consistent hierarchy of dynamic capabilities. This work also aims to propose a unified, universal nomenclature for individual levels in this hierarchy. A literature review using the snowball approach was used as the research method. As a result of the analysis, a coherent DC hierarchy was obtained. This should significantly facilitate not only future research in this field, but also implementation of research results in practice.

Keywords
Dynamic capabilities, Hierarchy, Higher-order dynamic capabilities, Dynamic capabilities levels.

JEL Classification
D21, L10

1 Introduction

Currently, the environmental conditions are constantly changing. This caused changes in the activities of enterprises, because companies must take into account this variability. In management theory, the response to constant changes in the business environment is dynamic capabilities view - one of the most influential schools in contemporary management theory (Mitręga, 2019).

The dynamic capabilities approach is focusing on opportunities, on new resources and on value creation. DC are engaged in sensing new opportunities (and threats), seizing them and transforming the organization as these opportunities or threats arise (Teece, 2007). As dynamic capabilities are change-focused, it is important how organizations develop and integrate new capabilities and resources (Schilke et al., 2018). The value of DC lies in their ability to change the resource base through creation, integration, recombination and resource release (Eisenhardt and Martin, 2000). According to DC theory, some companies can better than others alter their resource base by adding, deleting, or reconfiguring, these resources or competences (Danneels, 2008). Furthermore, dynamic capabilities develop through learning, either deliberate learning or learning-by-doing, or both (Zollo and Winter, 2002). Resources, good strategy and dynamic capabilities can be the fundamental sources of competitive advantage.

Although this field of research is relatively young, the interest of the scientific community is huge and the number of publications is growing exponentially. A significant number of articles are published in high-ranking journals that set the main trends in research. Researchers are responding surprisingly quickly to the identified DC research gaps. For example, not so long ago, huge shortcomings in empirical research were pointed out, while currently the number of such studies is significant and is constantly growing. Researchers also regularly order the previous achievements in literature reviews (e. g. Barreto, 2010; Laaksonen and Peltoniemi, 2016; Schilke et al., 2018).

However, there is one area that has not yet been properly ordered. This is the hierarchy of dynamic capabilities. There is a consensus that they have a hierarchical structure but no common DC hierarchy

has been adopted so far. Authors often cite the most popular hierarchy concepts (Collis, 1994; Hine et al., 2014; Winter, 2003), but the inconsistency in the number of levels and the numbering of individual levels is very confusing.

The main purpose of this paper is to propose one consistent DC hierarchy, combining the most important existing concepts, and to prepare a unified, universal nomenclature for individual levels in this hierarchy. Due to the main goal, it is also assumed to prepare a tabular summary of the main concepts, which in the future should help to avoid misunderstandings. So the indirect goal of this study is to significantly facilitate future research on particular dynamic capabilities levels and the links between them.

The literature review using the snowball approach was chosen as the research method. Both the most frequently cited in the literature DC hierarchies concepts and the comments on them in literature reviews were analysed. On this basis, an attempt was made to explain the emerging misunderstandings and organize the subject.

2 Literature Review

The dynamic capability perspective is strongly related to the resource-based view of the firm (RBV) (Barney, 1991; Wernerfelt, 1984) as it originally focused primarily on modifying the company's asset base. Resource-based theory concentrate on the chief resources and capabilities of the organization, especially those where the organization has a competitive advantage, as the principal source of successful strategic management (Lynch, 2015). In the time when business environment is constantly changing, not only resources are important for running a business, but also the capability to adapt to change.

Works of Collis (1994), Teece et al. (1997), Eisenhardt and Martin (2000) lie at the core of this dynamically developing research field. Although initially the perspective of dynamic capabilities met with criticism due to the confusion around the construct, much effort has been made to build coherent and consistent interpretation of DC.

For instance Di Stefano, Peteraf and Verona (2014) note that the two seminal DC papers: Teece et al. (1997) and Eisenhardt and Martin (2000), offer different understandings of the construct's core elements and this resulted in two inconsistent separate research streams in DC perspective, but they also claim that it is possible to combine divergent understandings into a coherent whole and try to find a solution to this problem.

In turn, according to Schilke et al. (2018), although the dynamic capabilities are not defined with a single definition, the concept is understood quite unambiguously. Among the many definitions of DC, the three most frequently cited deserve special attention: Teece et al. (1997), Eisenhardt and Martin (2000), and Helfat et al. (2007). They are complementary and build on one another. Moreover, the main remaining definitions are very much in line with these three (Table 1). This is the first, but not the only, step to build a coherent theory.

Table 1. The concepts of dynamic capabilities

Definition of DC	**Source**
(…) the socially complex routines that determine the efficiency with which firms physically transform inputs into outputs.	Collis (1994, p. 145)
(…) the firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments.	Teece et al. (1997, p. 516)
The firm's processes that use resources - specifically the processes to integrate, reconfigure, gain and release resources - to match and even create market change.	Eisenhardt and Martin, (2000, p. 1107)
(…) the capacity of an organization to purposefully create, extend, or modify its resource base.	Helfat et al. (2007, p. 91)

(…) the capacity (1) to sense and shape opportunities and threats, (2) to seize opportunities, and (3) to maintain competitiveness through enhancing, combining, protecting, and, when necessary, reconfiguring the business enterprise's intangible and tangible assets"	Teece (2007, p. 1319)
(…) the firm's potential to systematically solve problems, formed by its propensity to sense opportunities and threats, to make timely and market-oriented decisions, and to change its resource base.	Barreto (2010, p. 271).
(…) a set of current or potential activities that utilize the firm's productive resources to make and/or deliver products and services.	Teece (2014, p. 328)
(…) the abilities to reconfigure a firm's resources and routines in the manner envisioned and deemed appropriate by its principal decision-maker(s).	Zahra et al. (2006, p. 918)

Source: Own elaboration

The relationships between main concepts has been explained in many high quality publications (e.g. Helfat and Peteraf, 2003; Karna et al., 2015; Peteraf et al., 2013; Schilke et al., 2018; Teece, 2007).

Another extremely important element in building a coherent DC theory is the regular ordering of the previous research achievements in literature reviews. The review and synthesis of literature can move the research forward (Helfat and Martin, 2015). These types of reviews were published mainly around 2010, at the initial stage of theory development (e. g. Ambrosini and Bowman, 2009; Arend and Bromiley, 2009; Barreto, 2010; Di Stefano et al., 2010; Easterby-Smith et al., 2009; Helfat and Peteraf, 2009). Nowadays effective attempts are still being made to order knowledge about DC (Laaksonen and Peltoniemi, 2016; Schilke et al., 2018), but due to the huge amount of research, these are rather thematic literature reviews for instance on dynamic managerial capabilities (Helfat and Martin, 2015), dynamic capabilities in public organizations (Piening, 2013) or dynamic capabilities and sustainability (Buzzao and Rizzi, 2021).

DC roots are in the field of strategy, but now we can observe the development of this approach in many other management research fields for instance: marketing (e. g. Fang and Zou, 2009; Mitręga, 2019), human resources management (e. g. Chatterji and Patro, 2014; Hsu and Wang, 2012), entrepreneurship (e. g. Arend, 2014; MacLean et al., 2015), innovation management (e. g. Ellonen et al., 2009; Lee and Kelley, 2008) or knowledge management (e. g. Cepeda and Vera, 2007; Denford, 2013).

Furthermore the dynamic capabilities framework is currently being improved by integrating relevant ideas from other contemporary theories (Schilke et al., 2018), for instance institutional theory (e. g. Gupta et al., 2020), psychological theory of the firm (e. g. Hodgkinson and Healey, 2011), evolutionary economics (e. g. Vergne and Durand, 2011), transaction costs theory (e. g. Argyres and Zenger, 2012) or organizational learning literature (e. g. Easterby-Smith and Prieto, 2008).

While so far such great effort has been made to broaden and structure knowledge of DC, one research field seems to be neglected – hierarchy of dynamic capabilities. Researchers agree that DC have a hierarchical structure (e. g. Ambrosini et al., 2009; Collis, 1994; Hine et al., 2014; Schilke, 2014; Winter, 2003), but there is no consensus with regard to DC levels and multidimensionality. The inconsistency in the numbering of individual levels seems to be particularly confusing. Although the authors cite the most popular hierarchy proposals (Collis, 1994; Hine et al., 2014; Winter, 2003), no single common concept has yet been developed.

It might be suggested that the reason for this may be the fact, that the topic is not interesting enough, however it is easier to understand DC in the context of DC hierarchy (Teece, 2018). There is a consensus that individual DC levels vary significantly and that higher levels affect lower levels. therefore, the ordering of dynamic capabilities hierarchy should be the basis of DC theory building.

3 Methodology

Since the purpose of this article is to identify, analyse and order the main concepts of the DC hierarchy, it was decided, that the literature review method will be used. Initially it was assumed that it would be a systematic review, but it soon became apparent that this was not the appropriate method. Attempts have been made to search databases using keywords, but it turned out that not only the number of received records was small, but also the vast majority of articles found were not sufficiently related to the topic in question. Moreover, due to the large variety of nomenclature of individual levels in the DC hierarchy, there was a risk of omitting important publications when using such a method. It was due to the fact that the amount of literature on the topic is small and the researchers use inconsistent terminology.

As a result, it was decided to conduct literature review using a snowballing approach. Literature reviews on DC were taken into account. Several important articles on the DC hierarchy were also identified (e. g. Hine et al., 2014; Verreynne et al., 2016). On the basis of these publications, it was determined which authors were the precursors of the dynamic capabilities hierarchy. The articles indicated by the authors of the analysed publications were taken into account. Thanks to this approach, it was possible to gather information on the origin, main concepts of hierarchy, and emerging misunderstandings.

The causes of confusion resulting from the existence of several different hierarchy concepts were identified. The earliest DC hierarchies were then compared with each other and with the later concepts proposed on their basis. The collected materials were analysed to find a consistent DC hierarchy, combining earlier concepts. Much attention has been paid to the naming of individual hierarchy levels. The unified, universal appellations was proposed. Because the purpose of the work was not to introduce new nomenclature, but to reconcile existing ones, the proposed terminology was created on the basis of existing classifications, and the use of individual terms was logically justified.

4 Results

4.1 Hierarchy of dynamic capabilities in literature

Researchers agree that dynamic capabilities have hierarchical structure (e. g. Ambrosini et al., 2009; Collis, 1994; Schilke, 2014; Verreynne et al., 2016), although there is no consensus on DC levels and multidimensionality. In order to get to the roots of the hierarchical approach to dynamic capabilities a literature review was carried out using the snowball method. DC literature reviews and publications focused on the dynamic capabilities hierarchy, published in reputable scientific journals, were taken into account. The authors claim that the precursors of the hierarchy of dynamic abilities are Collis (1994) and Winter (2003) (Ambrosini and Bowman, 2009; Schilke et al., 2018; Verreynne et al., 2016) and they list some other important papers.

Collis analyzed in his article DC with regard to the competitive advantage. He proposed to divide the capabilities into categories: first category – capabilities to perform the basic company activities such as logistics or marketing campaigns, second category – capabilities for dynamic improvement of the company's operations such as process or product innovations and responding to market trends, third category, very similar to the second one - capabilities also closely related to dynamic improvement but rather metaphysical, which enable companies to recognize the value of their resources and develop novel strategies faster than competitors and higher-order categories (fourth, fifth and so on) – capabilities of "learning to learn". In response to the actions of competitors, company capabilities can be always superseded by a better, higher-order capabilities. But competitors can do the same and so on, and so on. In this way Collis built a hierarchy of DC with an unlimited number of levels, although that was not his main goal. The concept of Collis is interesting, but it should be rather treated as an n-dimensional mathematical model, that reduces to few dimensions in business practice. It is emphasized by the author himself, who claims, that starting from a certain level - higher-order dynamic capabilities do not necessarily exist.

Teece et al. (1997, p. 516) divide capabilities into two classes: ordinary capabilities and dynamic capabilities – the firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments.

Winter (2003, p. 991) defined zero-level capabilities as ordinary capabilities that allow a company for short-term "make a living", when DC as those that extend, modify or create zero-level capabilities. For him, first-order dynamic capabilities are those that work to extend, modify or create the usual capabilities by routinizing the response to familiar types of change. They are highly patterned and routine in many aspects. New product development is a prototypical example of such capabilities. But competitors can be always more flexible and use higher-order dynamic capabilities.

Danneels (2008) is sometimes listed among the precursors of DC hierarchy. However, due to the fact that his article focuses on competences, not capabilities, and that his work creates more confusion with regard to terminology (Schilke et al., 2018), this article was not considered for analysis.

Teece, in his later works (2007, 2018), also divides a layer of dynamic capabilities. He distinguishes two classes of DC: microfoundations and higher-order capabilities. According to him microfoundations (second-order dynamic capabilities) are responsible for the adjustment and recombination of a company's existing ordinary capabilities and the development of new ones, for instance new product development or expansion into new sales regions. In turn, higher-order capabilities are the base of sensing likely avenues for the future, devising business models to seize opportunities, and determining the best configuration of the company for the future.

Some attempts have been made to organize the concepts of DC hierarchy (e. g. Hine et al., 2014; Schilke, 2014) and the proposed solutions should be appreciated. The publication of Hine et al. (2014) is particularly interesting. Examples of DC hierarchy proposals are presented in Table 2.

Table 2. The concepts of dynamic capabilities hierarchy

Collis (1994, p. 144-145)	**Winter (2003)**	**Teece (2007, 2018, p. 40-41)**	**Schilke (2014b, p. 368)**	**Hine et al. (2014, p. 1314-1315)**
and so on	*Higher-order capabilities* capabilities to be more flexible	*Higher-order dynamic capabilities* capabilities by which management, senses likely avenues for the future, devises business models to seize new or changed opportunities, and determines the best configuration for the organization based on its existing form and the new plans for the future.	*Second-order dynamic capabilities* routines that reconfigure first-order dynamic capabilities	(*Higher-order*) *dynamic learning capabilities* capabilities focused on creativity and experimentation to create new capabilities and change the way current capabilities are used
Fifth category of … better capabilities (than lower) to "learning to learn to learn"				
Fourth category of... better capabilities (than lower) to "learning to learn"				
Third category of … closely related to dynamic improvements, comprises the more metaphysical strategic insights	*First-order dynamic capabilities* those that work to extend, modify or create the usual capabilities by	*Microfoundations* (*second-order dynamic capabilities*) capabilities which involve the adjustment and recombination of a firm's existing	*First-order dynamic capabilities* routines that reconfigure the organizational resource base	(*Lower-order*) *dynamic functional capabilities* change-focused capabilities, that uses less-patterned routines and more

Second category of capabilities shares the common theme of dynamic improvement to the activities of the firm	routinizing the response to familiar types of change	ordinary capabilities as well as the development of new ones		specialized resources
First category of capabilities those that reflect an ability to perform the basic functional activities of the firm	*Zero-level capabilities* capabilities that permit a firm to "make a living" in the short term, "how we earn a living now" capabilities	*Ordinary capabilities* operational and other ordinary capabilities, the routine activities, administration, and basic governance	*Substantive capabilities* capabilities which refer to the routines that enable firms to deploy their resources in order to earn a living in the present	*First-order ordinary capabilities* non-change focused, focused on everyday subsistence tasks of the firm using current resources capabilities

Source: Own elaboration

As can be seen from the prepared comparison (Table 2), on the lowest level are ordinary capabilities. They are not dynamic capabilities, but including them in the hierarchy orders the dependencies between various types of capabilities. Therefore, this level is taken as the zero level. In this category there are ordinary, operational capabilities, which are non-change focused capabilities, fundamental to day-to-day working of the firm. They can also be called static or lower-order (Collis, 1994), zero-level (Winter, 2003) or substantive (Schilke, 2014; Zahra et al., 2006) capabilities.

On the next level there are dynamic functional capabilities, which are change-focused capabilities created by learning mechanisms. They can be called first-order DC (Schilke, 2014; Winter, 2003), lower-order DC (Verreynne et al., 2016) or microfoundations (Teece, 2007, 2018). Typical examples of such capabilities are the change of product or the production process.

On the highest level of the hierarchy there are higher-order dynamic capabilities, which can be also called second-order dynamic capabilities (Schilke, 2014), dynamic learning capabilities (Hine et al., 2014) or higher-order capabilities (Winter, 2003). They are change-focused creative abilities to reconfiguration, renewal and re-creation of resources and creation of radically innovative or new routines. They are defined as the organization ability to go beyond the current strategic orientation, to look at resources creatively, to use them in an unconventional way.

The three categories of capabilities concern the ability to static (ordinary capabilities), dynamic (functional DC) or creative (higher-order DC) activity of company Collis (1994).

4.2 Reasons for confusion about the DC hierarchy

There are several reasons for many misunderstandings about the DC hierarchy. First, it should be made clear that we are talking about a hierarchy of dynamic capabilities, not about a hierarchy of capabilities. While in publications about capabilities, ordinary capabilities are placed at the first level of the hierarchy (e. g. Collis, 1994), in the hierarchy of dynamic capabilities we can find zero-level, which means that the ordinary capabilities on this level are not DC (e. g. Winter, 2003).

Secondly, inconsistent terminology, mainly numerical ones (which results, also from the above) causes divergent interpretations. Therefore, the comparisons of the concepts of hierarchy proposed by the researchers can be based on erroneous assumptions.

Third, the number of levels in the hierarchy is not always the same. While there are usually three levels, then Collis (1994) writes about an indefinite number of levels. His hierarchy also does not directly reflect the levels in other DC hierarchies.

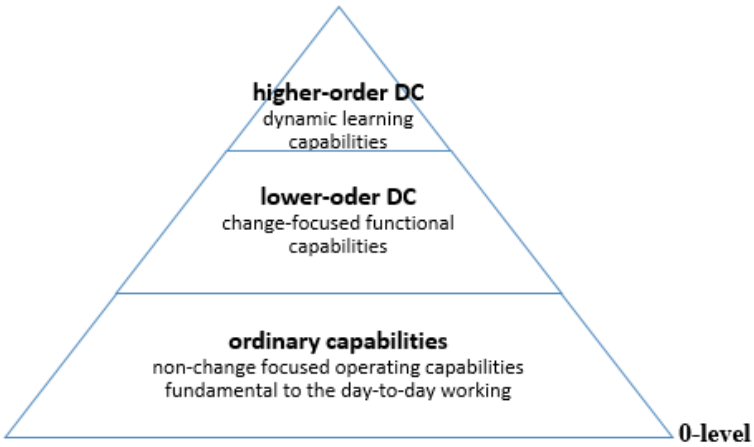
Fourth, when DC hierarchy is described based on some specific economic theory, the assumptions and conclusions made are often not universal. Therefore, the general framework of the hierarchy should be very general, not detailed. Thanks to this, the proposed structure will be widely used.

4.3 Hierarchy of dynamic capabilities

It should be noted, based on the above considerations, that there are some differences in the studies of various authors, but there are also many similarities in the different DC hierarchy concepts. The authors distinguish two main types of capabilities: ordinary and dynamic, and DC are usually further divided into two categories. So, as can be seen in Table 2, the hierarchy of dynamic capabilities usually consists of three levels. Collis concept only seemingly stands out significantly. As the author himself writes, the second and third categories of capabilities are very similar, difficult to distinguish. In the prepared comparison, they were both treated as the middle level. All other categories relate to learning, continuous learning skills and as such have been classified collectively as the highest level of dynamic learning capabilities.

Some authors use numeric names, but the numerical nomenclature is not consistent. In order to avoid confusion it is suggested to use the names of the levels without numeric terms. Therefore, the other two levels are named on the basis of the nomenclature used in the previous classifications, omitting the numerical names (bold font in Table 2). So it seems reasonable to name the other two levels lower-order DC and higher-order DC. Lower-order DC are dynamic functional capabilities and higher-order DC are dynamic learning capabilities. The top level has not been named "dynamic learning capabilities" as this would suggest that there are other higher-order dynamic capabilities. Thus, the dynamic capabilities hierarchy is as in Figure 1.

Figure 1. Hierarchy of dynamic capabilities



Source: Own elaboration based on Hine et al. (2014), Verreynne et al. (2016)

The above proposition is largely based on the work of Hine et al. (2014), whose contribution to the development of a consistent hierarchy of dynamic capabilities should be appreciated.

The question is whether the above hierarchy should not be called a hierarchy of capabilities rather than DC hierarchy. At the lowest level there are ordinary capabilities which are not DC, therefore this level is considered here as the zero-level. On the other hand, we consider this hierarchy from a point of DC view - hence its name. However, it is necessary to place operational capabilities in hierarchy, as this well illustrates the influence of the capabilities from a higher level to a lower level capabilities. Higher-order DC affect lower-order DC and lower order DC affect ordinary capabilities.

5 Conclusion

As there is disagreement over the hierarchy of dynamic capabilities in terms of the number of levels and their names, so far there has been a lot of confusion. On the other hand, although the hierarchies proposed till now differ, however they also share many similarities. So, it is possible to combine divergent understandings into a coherent whole. Analysed DC hierarchy concepts are complementary and build on one another. Nevertheless, particularly inconsistent terminology, mainly numerical ones, has contributed to many inaccuracies in previous studies. That's why efforts have been made to order the existing concepts.

As a result of the conducted analysis, the consistent DC hierarchy, combining the most important existing concepts was proposed. The nomenclature has been unified and simplified. In addition, a tabular summary of the main concepts was prepared. It should allow for the avoidance of misunderstandings in the future. It should be assumed that the proposed hierarchy constitutes a certain universal framework that can be filled with additional content, depending on the researcher's point of view.

The study has some limitations. First of all, the author's attention was focused just on DC hierarchy. In the future research the relationship between particular levels should be investigated. It is also the need to study higher-order dynamic capabilities.

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Aspects of infrastructure supporting innovative businesses in the Moravian-Silesian Region and the Silesian Voivodeship

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Abstract
Constant and dramatic changes characterize the modern market and competitive environment, generally associated with the need to prosecute every current scientific knowledge, the security of its applicability, and rapid technology shifts. One way to maintain a market position in these conditions and create a stable environment for survival is innovation, often establishing new start-ups based on a revolutionary idea.
The launch of these new and unstable companies is a perplexing query; basically, the infrastructure supporting innovation businesses should help with this period. As there is no precise definition of this infrastructure, this paper aims to draw its characteristics in similar borderline regions: the Moravian-Silesian Region in the Czech Republic and the Silesian Voivodeship in Poland, which will, to a certain extent, make it possible to capture international differences. This paper aims to discover the associations between the scope of individual organizations and cooperation with other organizations in the infrastructure supporting the innovative business through correlation analysis.

Keywords
Infrastructure supporting innovative business, incubator, accelerator, innovative parks.

JEL Classification
M16, O31

1 Introduction

The contemporary business environment goes through dramatic changes, frequently linked to current scientific knowledge, applicability, and rapid technology shifts. The COVID 19 pandemic also plays an important role here when companies, even those perceived as innovative, are forced to adapt to the new environment and the market. Multiple classes of innovative companies commit to transferring the results of research and development into their business functioning. Švejda (2007) convinces that innovative business connects with the forecast of high-level knowledge into the market movements, enabling to obtain an added dimension to higher-quality products and a price more agreeable than suggested by rivals. Innovative entrepreneurship sorts cover small and medium-sized companies, widely known as start-ups or spin-offs with insufficient capital level but assuming high profits after succeeding through initial steps.

Moreover, Pomerol (2018) emphasizes that innovative firms started to grow after the economic crisis, and the most notable progress transpired between 2006-2010. In this respect, the outcome of the current situation may be similar. Therefore, organizations operating within the framework of the infrastructure supporting innovative businesses are also growing.

It appears that the fundamentals of infrastructure supporting innovation companies concerning comparable economic and cultural developments are equal in the Czech Republic and Poland especially in the border regions of the Moravian-Silesian Region and the Silesian Voivodeship. Observation of both regions enables collecting knowledge on possible diversity in infrastructure supporting innovative businesses and provides potential cooperation. The paper aims to outline the specificities of

infrastructures supporting innovative entrepreneurship in chosen regions (the Moravian-Silesian Region and the Silesian Voivodeship) of the Czech Republic and Poland. At the same time, the author performed a correlation analysis to determine the relations between the scope of individual organizations and cooperation with other organizations in the infrastructure supporting innovative business, using Spearman's rank correlation coefficient.

2 Literature Review

The launch of start-up is a complex problem; principally, the infrastructure supporting innovation businesses should support actions with this period. Okoń-Horodyńska (2000) points out, that the system of the infrastructure supporting innovative businesses includes a set of elements that have active character, i.e., shaping them after reaching the level critical gain strength for self-propelling development. All aspects of the infrastructure refer to the social layer indicated by resources intellectual capital. They conclusively determine the outcomes of engaged transformational undertakings.

The role and functions of the infrastructure supporting innovative businesses can be considered on two levels (Balzat and Hanusch, 2003). The first one, which appears to be critical, arises from the context of infrastructure functioning in a given country - it determines the status and mission of institutions in the national innovation system and the approach of a given country to supporting entrepreneurship. The second layer is definite types of entities and their specific services.

Defining the role, tasks, and services of infrastructure is a vast issue. The very definition is comprehensive, making it impossible to indicate its position and assign functions to specific types of entities. The European Commission also brings awareness to the discrepancy in definitions throughout the Union: "Due to the definitional challenges, it is difficult to estimate the number of business incubators and business accelerators" (European Comission, 2019). Authors (Besussi, 2006; Blażlak, 2010) show the image of infrastructure as organizations that contribute to the improvement of entrepreneurship. At this level of generalization, it is a typical role for both surveyed countries.

The additional obstacle is that the innovative business infrastructure is not attached to state structures in the analysed countries and, therefore, defines their individual activities independently (Ministerstwo Rozwoju, 2019). The entity, mainly depending on the access to resources (whether capital or human) and also ownership defines a specific range of services provided, which include services related to renting the necessary space, consulting and coaching (at all levels), interconnection of companies with the environment, in some cases also direct funding assistance. The thinking for the national and regional level of infrastructure function shows two highlights of its organizations. First, each country and region has a different set of types of institutions that have evolved in a specific context and have their own story. The current state depends on historical conditions. Secondly, institutions supporting innovative businesses are part of a larger complex, part of the system, different in each country and region with action depending on the environment in which they operate, the place they occupy in the system, and on how they are related to each other as well as to other elements of the system.

Referring to the functions performed by infrastructure, five main functions can be indicated:

- the function supporting the transfer of knowledge,
- the incubation function,
- the advisory function,
- the integration function,
- the information and promotion function.

Authors (Roundy, 2021; Mian et al., 2021) also indicate several critical accomplishment determinants: the role of infrastructure results from clearly defined strategies for developing innovation and research directions at the government level. The essential factor is the level of cooperation with science, administration, the market, and one another.

There are incubators (business), accelerators, and science and technology parks in the Czech Republic. In the scope of support, these institutions' types do not vary from the variety of activities of Polish innovation centers.

Matusiak (2015) describes Business Incubator as a separate entity based on real estate, implementing a business incubation program, with an offer and services supporting newly established and young micro and small and medium-sized enterprises. The primary purpose of the business incubator is to help the newly established company reach maturity and function independently on the market. The incubator's activity is focused on supporting the development of newly established companies, job creation, and local development. According to the European Commission (2019) definition, a business incubator has designated a place where many newly established organizations are concentrated (functioning for no more than three years) in a relatively limited space. On the other hand, the creators of accelerators are private initiatives promoted by referrals to successful entrepreneurs accompanied by venture capital funds.

According to Veber et al. (2016), Science and Technology Parks assists or negotiates contacts between new knowledge producers and the business sector to expedite the emergence and development of innovative enterprises. The term "Science and Technology Park" has been used in the Czech Republic since 1990 for all kinds of parks.

In the literature on the subject, we can also come across a more general Innovation Center concept. It means a center that provides clients with unique information, consulting, and training services of a pro-innovative nature. The addressees of comprehensive pro-innovative services are most often already operating enterprises or technological start-ups.

3 Methodology and Data

Empirical surveys provide the mapping of infrastructure supporting innovative businesses on a selected sample of 22 organizations representing the infrastructure supporting innovative companies in the Moravian-Silesian Region (CZ) and the Silesian Voivodeship (PL). The analysis is based on the prepared questionnaire, which contained a total of 20 questions. The management of selected organizations took part in a questionnaire month-lasting survey. Primary research was conducted in 2019, but additional questions regarding co-operation were asked to the same organizations during January 2021. The author focuses on three areas: obtaining essential information concerning organizations supporting entrepreneurship in the Moravian-Silesian Region and the Silesian Voivodeship, implementing programs supporting the development of clients' business activities, and level of collaboration with other similar organizations during the pandemic in the main areas of activity of the organization. The answers to the questions in this last part were structured into a Lickert rating scale, with 1 indicating a deficient level of cooperation, 5 a very high level. A correlation analysis was performed using Spearman's rank correlation coefficient (significance level of 5 %) to determine the relationships between the scope of individual organizations and cooperation with other organizations falling under the infrastructure supporting innovative entrepreneurship in the field of market mapping, the financial part of the projects, advisory network, exchange of experience, technology transfer, promotion, and resources.

Of the thirteen addressed organizations in the Moravian-Silesian Region, data from only 11 organizations were evaluated because of the incompleteness of the answers. In Silesian Voivodeship were addressed 17 organizations, but only 11 organizations answered the questions. The rate of return of the questionnaire is 73 %. Concerning the organization's type of owner, the organizations were owned:

- 48 % by a private business entity,
- 29 % by a university,
- 23 % by a public institution.

The research sample consisted of:

- 20 % innovation centers,
- 48 % incubators,
- 32 % science and technology parks.

4 Empirical Results

Organizations falling under the infrastructure supporting innovative businesses in Moravian-Silesian Region are owned mainly by a private owner (4 organizations). A public organization holds three organizations, three are controlled by a combined ownership (public institution, university, private company), and a university occupies simply one organization. Concerning the variety of services offered by analyzed organizations, there is no exact interpretation of a bid characterizing the organization representing the particular type of infrastructure. Organizations in the Silesian Voivodship are also owned chiefly by a public institution (6 organizations); in 4 organizations appeared a combined owner. Also, just one organization is owned strictly by a private business unit. The analysis also provided a list of services offered by regions, see Table 1.

Table 2. Frequency and share of individual services provided in international comparison

Offer	*Frequency_CZ*	*Frequency_PL*	*Share_CZ*	*Share_PL*	*Rank_CZ*	*Rank_PL*
Space renting	8	11	13 %	31%	1.	1.
Coaching	7	8	12 %	23 %	2.	2.
Finance	6	6	10 %	11 %	3.	3.
Market partnership	8	3	13 %	9 %	1.	4.
HR	6	2	10 %	6 %	3.	5.
Laboratories using	5	2	8 %	6 %	4.	5.
Intellectual property protection	5	1	8 %	3 %	4.	6.
Law services	2	1	3 %	3 %	6.	6.
Administration	4	0	7 %	0 %	5.	7.
Founding	5	0	8 %	0 %	4.	7.
Others	4	11	7 %	31 %	5.	1.

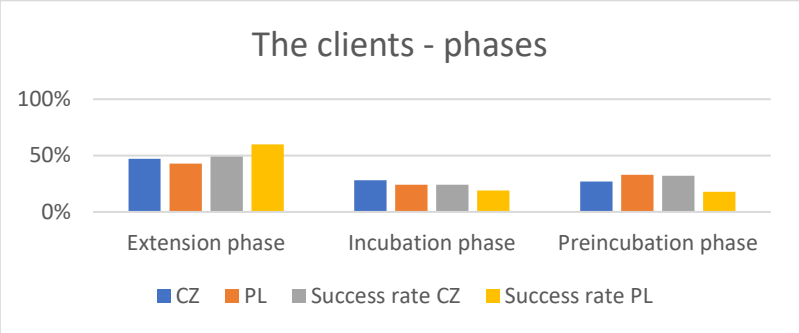
Source: Own research (2019)

In terms of client structure using provided services, in the Moravian-Silesian Region, it creates companies with the character of private business units (86 %), obeyed by companies with students' engagement (10 %), and firms employing researchers, the so-called spin-off firms (5 %). In the Silesian Voivodeship, the most influential group creates private business units (83 %), followed by companies where the students work (12 %) and on the third position by companies in which researchers operate, so-called spin-off companies (4 %). Another aspect examined was the occupancy of individual organizations in both selected regions. The average annual occupancy rate by institutions in the Moravian-Silesian Region is 59 %. On the contrary, in the Silesian Voivodeship it is 81 %.

The largest group of clients in the Moravian-Silesian Region were in the extension phase (47 %), followed by companies searching for help in the incubation phase (28 %), and finally in the preincubation stage (27 %) with a 32 % success rate. For replenishment, 24 % of companies completed the incubation phase, and 49 % of companies in the extension period. The situation is slightly different in the Silesian Voivodeship. Again, the most numerous group of the clients demanded assistance in the

extension stage (43 %), followed by the preincubation phase (33 %), and these in the incubation phase (24 %) of analysed organizations. In terms of successful closing the program, the success rate was 18 % in the preincubation stage, 19 % in the incubation phase, and finally 60 % in the extension phase, see Figure 1.

Figure 2. The clients - phases



Source: own research (2019)

Based on previous research and the literature, a list of seven individual areas was created for cooperation with other organizations falling under the infrastructure supporting innovative businesses. A correlation analysis was performed using Spearman's rank correlation coefficient to determine the dependence on the subject of activity, see Table 2. Grey rectangles indicate very strong positive correlation.

The very strong correlation was recorded in the case of specialization in market partnership services. The more critical the organization considers this activity, the more often and intensively it cooperates with other organizations supporting infrastructure supporting innovative entrepreneurship, especially in the areas of joint market mapping, networking, exchange of experience and best practice, collaborative technology transfer. A completely different situation uncovered by the analysis is the fact that the activity of organizations in the field of financial services correlates very strongly with cooperation in this field, which can be explained by the fact that companies providing such services usually focus on one type of activity, and therefore their cooperation is typically limited to this particular area. A robust correlation is also captured in organizations preferring consulting services related to law, administration, and intellectual property (i.e., to some extent, documentation). In this case, the willingness to cooperate is growing, especially in joint management of projects financed from external sources, creating an advisory network, or the exchange of experience.

Table 2. Dependence of inter-entity cooperation on the nature of provided services

	Shared market mapping	***Shared projects - external sources***	***Advisory network***	***Exchange of experience***	***Shared technology transfer***	***Shared promotion***	***Cooperation on resources***
Space renting	0,233**	0,372**	0.459**	0,143**	0,196**	0,574**	0,302**
Coaching	0,461**	0,236**	0,571**	0,589**	0,249**	0,501**	0,101**
Finance	0,123**	0,019**	0,167**	0,202**	0,119**	0,304**	0,851**
Market	0,842**	0,241**	0,861**	0,871**	0,357**	0,837**	0,132**

Laboratories	0,328**	0,387**	0,132**	0,451**	0,102**	0,107**	0,340**
Intellectual property	0,342**	0,845**	0,451**	0,542**	0,071**	0,477**	0,216**
Law	0,398**	0,439**	0,869**	0,430**	0,141**	0,224**	0,138**
Administration	0,249**	0,537**	0,429**	0,709**	0,355**	0,236**	0,485**
Funding	0,390**	0,241**	0,251**	0,365**	0,097**	0,142**	0,860**

Source: Own research

*** Correlation significant at the level of 0.05*

5 Conclusion

The analysis confirmed no clearly defined interpretation of individual organizations operating within the infrastructure supporting innovative business in both selected countries, the Czech Republic and Poland, neither at the state level nor at the local government level. This fact causes each organization to define its focus and services offered at its discretion. For this reason, exists no visible diversity in activity between science and technology parks, a business incubator, and innovation centers concerning the services provided in the sample from the Moravian-Silesian Region or equal in Silesian Voivodeship.

It was determined that similar services are offered to clients by all infrastructure types (science and technology parks, a business incubator, innovation center). It only depends on the directors and executive teams of the individual organizations, who consider the services provided to be essential, on which they want to focus.

At the same time, the analysis showed that the average annual occupancy in individual organizations in the Polish analysed region is significantly higher than in the Czech region. New innovative companies here prefer to use experts' help in individual steps to increase their chances of success. This situation could also be caused by the fact that parts of incubators in Poland are established at universities, such as academic business incubators.

Equally, the correlation analysis showed that cooperation with other entities belonging to the infrastructure supporting innovative entrepreneurship depends on the subject of the operation of a particular entity, where collaboration most often occurs in the case of companies providing market partnership services. A specific group is organizations advising in connection with the documentation necessary for starting a business. It is cooperation, especially in the border area of these two very similar regions, that could lead to mutual learning from examples of good practice and contribute to an inevitable unification of concepts within the European Union, where start-ups often seek financial assistance from their resources.

This cooperation can become essential in times of crisis (caused by a pandemic) when innovation will be one of the steps to survive, while companies will rely on the help of experts who can reduce the risk of failure. Of course, the research was limited by a smaller amount of data obtained from subjects and the impossibility of dividing subjects according to individual criteria. Therefore, it would be appropriate for the organizations to belong to the infrastructure under investigation to define each type of

organization's specific scope. In the future, comparisons should be made in cross-border regions, defining centers that would be helpful for Czech and Polish companies, focusing on acceleration programs that could help companies in innovation activities.

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PERCEPTION AND VALIDATION OF FAKE NEWS, CASE STUDY: FACULTY OF ECONOMICS STUDENTS

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Abstract
Number of Fake News is alarmous and increase every year. The internet allows the possibility of Fake News making and sharing. So, it is important to focus on perception and validation of these messages. Students of Economic Faculty of VSB – Technical University of Ostrava were chosen like interest group. The research is based on questionnaire research. The questionnaires were distributed via webpages because of Covid-19 pandemic. Relationship between gender and education of people about Fake News in age of interest group and relationship between gender and education about Fake News in older age than interest group is tested in the paper. The paper is focused on validation Fake News sources and their using by interest group.

Keywords
Fake News, validation of Fake News, questionnaire research, case study – economic students

JEL Classification
I21, C89

1 Introduction

Fake News and their impact to the society is big. With using the Internet is sharing this type of news really easy and quick. The number of the readers of this news it can be very high because of it. So, the consequence of the Fake News can be overwhelming. In these days, it can be so horrible that it can influence the financial markets or states functions. So, it is necessary to recognize the Fake News. For these reasons are created webpages and other data sources for validation of the news. The problem is that the number of users is lower than readers of the news. It can have many reasons. One of the key reasons is unknowing the validation sources. Other reason, which cannot be quick solved like the previous, e.g. provide to the readers validation data sources, is the trusting the information because the information is shared by someone who the reader thrust.

People with most internet skills are young people study regarding digital skills by Eurostat (Database – Eurostat, 2021). So, study is focused on perception and validation of the Fake News by young people. In this case, students between 18 and 25 years from Faculty of Economics of VSB – Technical University of Ostrava are chosen like interest group. The interest group contains both genders. 81 students are included – 37 man and 44 women. The study is provided by qualitative research, namely questionnaire research. February and March 2021 were chosen like testing period. Covid-19 pandemic do not allow the traditional concept of the questionnaires. So, the questionnaires were distributed online via Google Forms. The questionnaire contains 30 questions regarding Fake News. 2 hypotheses were found out from the answers: relationship between gender and education of people about Fake News in age of interest group and relationship between gender and education about Fake News in older age than

interest group. Pearson's Chi-square Test, Cramer Coefficient, Mann-Whitney Test, and other statistic methods are used then.

Fake news is key problematic in these days, mainly fake news regarding Covid-19 pandemic and other international topics. So, the authors of the paper will be focused on this problematic in their future work.

2 Literature Review

Fake News and their perception by society is devoted big attention (Nutil, 2018; Alvarová, 2017; Gregor and Vejvodová, 2018 and Táborský, 2020). The main shareability is now through the Internet (Nutil, 2018 and Alvarová, 2017). So, for the study focused on fake news it is necessary do the research with people with the digital skills. The most digital skills have the young generation by Eurostat (Database - Eurostat, 2021).

One of the quickest ways how to find out the facts about the society problematic is through questionnaire research (Řezanková, 2017). So, the questionnaire research and consequently statistic research is used obviously (Hendl, 2009). In the research both of them are used. Questionnaire research is provided via webpage because of Covid-19 pandemic.

3 Methodology and Data

To test the independence of quantities (Hendl, 2009), Pearson's chi-square test of independence ($\chi 2$) is used, based on Formula 1:

$$(1) \qquad \chi 2 = \sum_{i=1}^{n} \frac{(O_i - E_i)^2}{E_i}$$

where: n represents the range of the analyzed set, O_i represents the observed frequency and E_i represents the expected frequency.

In the case of the independence test, the null hypothesis (H_0) is determined: the analyzed quantities are independent, and the alternative hypothesis (H_1) is determined: the analyzed quantities are dependent. The significance level is set at 5%. To use Pearson's chi-square test of independence, it is necessary to follow the learned conditions, for example, that at least 80% of the expected frequencies are greater than 5.

If a thread is found between the analyzed quantities, it is appropriate to determine its intensity. To determine the degree of dependence, the Cramer's coefficient (V) is used (Hendl, 2009), based on Formula 2:

$$(2) \qquad V = \sqrt{\frac{\chi 2}{n \cdot (m-1)}}$$

where m = min (r1, r2).

The Cramer's coefficient takes values from the interval 0 and 1, and the closer it is to the number 1, the greater the degree of dependence between the analyzed quantities.

Mann-Whitney U test (Mann and Whitney, 1947) is nonparametric test of the null hypothesis that, for randomly selected values X and Y from two populations, the probability of X being greater than Y is equal to the probability of Y being greater than X. Visible like Formula 3.

$$(3) \qquad U = \sum_{i=1}^{n} \sum_{j=1}^{m} S(X_i, Y_j)$$

where S(Xi,Yj) = 1 when Y < X, 0 when Y > X, ½ when Y = X.

Data for the analysis of the impact of Fake news on students of the VSB - Technical University of Ostrava were obtained from an online questionnaire survey using the Google Forms application. In total, data were received from 79 students.

4 Empirical Results

H_0: There is no statistically significant difference between men and women in agreement with the statement "I think my peers are well educated in Fake News."

H_1: There is a statistically significant difference between men and women in agreement with the statement "I think my peers are well educated in Fake News."

Table 3. Gender opinion on question: "I think my peers are well educated in Fake News."

	Man	***Woman***
Disagrees	7	4
Rather disagrees	10	10
Rather agrees	15	27
Agrees	5	2

Source: authors

Table 2. Mann-Whitney U test Result

Mann-Whitney U	***P-value***
694	0,288

Source: authors

The value of the Mann-Whitney test is 694 and the p-value is 0.288. Given that the p-value is greater than the specified level of significance (5%), we do not reject the null hypothesis. The test result can be formulated as follows: At a significance level of 5%, no statistically significant difference was found between men and women in the question "I believe that my peers are sufficiently educated in the field of Fake news".

H_0: There is no statistically significant difference between men and women in the degree of agreement with the statement "I believe that older people are sufficiently educated in the field of Fake news."

H_1: There is a statistically significant difference between men and women in the degree of agreement with the statement "I believe that older people are sufficiently educated in the field of Fake news."

Table 3. Gender opinion on question: "I believe that older people are sufficiently educated in the field of Fake news."

	Man	***Woman***
Disagrees	12	21
Rather disagrees	12	17
Rather agrees	12	3
Agrees	1	2

Source: authors

Table 4. Mann-Whitney U test Result

Mann-Whitney U	***P-value***
643	0,114

Source: authors

The value of the Mann Whitney test is 643 and the p-value is 0.114. Given that the p-value is greater than the specified level of significance (5%), we do not reject the null hypothesis. The test result can be formulated as follows: At a significance level of 5%, no statistically significant difference was found between men and women in the question "I believe that older people are sufficiently educated in the field of Fake news between men and women".

Table 5. Gender opinion on question: "Do you know validation Fake News webpages?"

	Yes	***No***
Man	14	23
Woman	6	36

Source: authors

All expected frequencies are greater than 5 (minimum value is 9.25), and therefore the assumptions of Pearson's chi-square test of independence are met.

H_0: Awareness of Fake news verification sites does not depend on the gender of the respondents,

H_1: Awareness of Fake news verification sites depends on the gender of the respondents.

Table 6. Pearson's chi-square test of independence result

Value	***P-value***
6,051	0,014

Source: authors

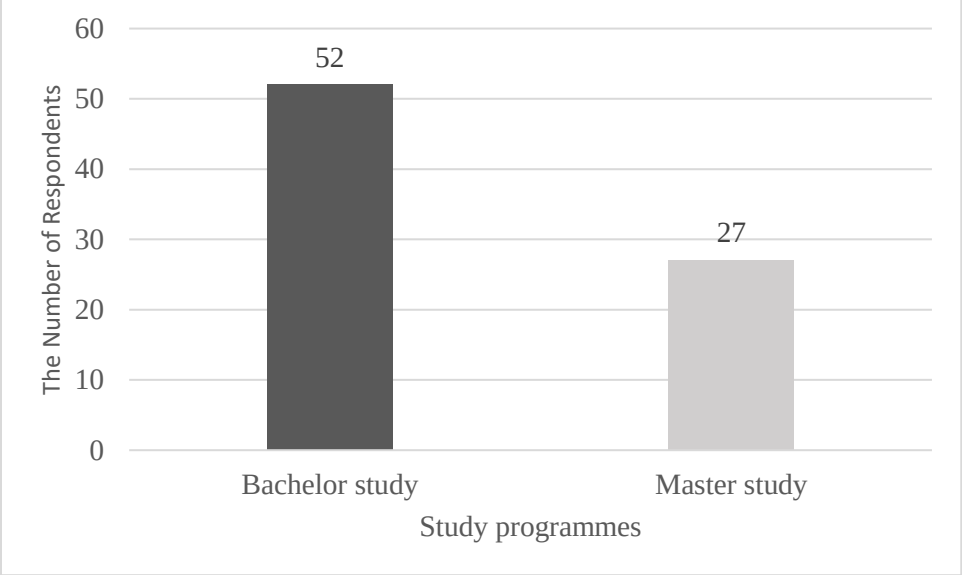
The value of Pearson's chi-square test of independence is 6.051 and the p-value is 0.014. Given that the p-value is less than the specified level of significance (5%), we reject the null hypothesis. The test result can be formulated as follows: At a significance level of 5%, it was found that the awareness of the Fake news verification site depends on the gender of the respondents. The value of the Cramerv test reached 0.275, which represents a weak dependence.

Table 7. Gender opinion on question: "If you know the validation Fake News webpages, did you use it?"

	Yes	***No***
Man	3	11
Woman	2	4

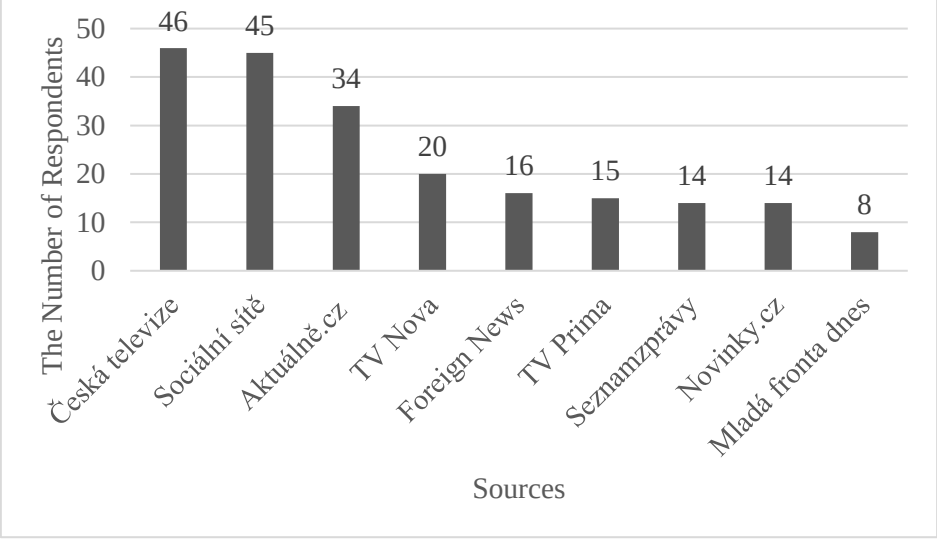
Source: authors

Figure 1. Number of students contained in the research in bachelor and master study



Source: authors

Figure 2. The most common sources from which students draw information



Source: authors

If a student believed in any Fake News, he either did not change any behaviour based on it, or began to verify more information and look for more sources, or changed his mind about the spread of fake news.

5 Conclusion

The paper is focused on Fake News problematic and the perception and validity of it. Mainly focused on young people, because they have the most digital skills and most fake news are shared by the Internet. Students from Faculty of Economics of VSB – Technical University of Ostrava are chosen like interest

group. Research is based on qualitative research, namely questionnaire research. Because of Covid-19 pandemic the questionnaires are distributed via Internet. 2 main hypotheses were found out from the answers: relationship between gender and education of people about Fake News in age of interest group and relationship between gender and education about Fake News in older age than interest group.

At a significance level of 5%, no statistically significant difference was found between men and women in the question of education of people about Fake News in age of interest group. At a significance level of 5%, no statistically significant difference was found between men and women in the question about Fake News in older age than interest group. At a significance level o 5% is statistically significant difference between gender and perception of validation Fake News webpages.

Because of actual topic, the authors will be continued with the research in their future works.

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E-recruitment: Merits and Demerits

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Abstract

Research Background: As a result of the current unprecedented global changes due to COVID-19, many organizations were obliged to face the reality, i.e., to keep a social distance and therefore to adopt new ways for the recruitment of new candidates, so that they survive the current challenges.

Purpose of the article: The aim of this article is to review recent publications, to analyse them and to provide an insight on the advances made in the recruitment process, and its merits and demerits on HRM.

Methods: This article provides a comprehensive review of quantitative, qualitative and theoretical studies published in journals and distinguishes articles that fall within the search criteria.
Findings and value added: Human resources management in most companies put an effort on the digital transformation of their recruitment processes in order to survive and grow. These findings won't only benefit academicians but also managers and potential researchers, because they will be able to acknowledge the various aspects about e-recruitment.

Keywords
Human Resources Management (HRM), e-recruitment, digitalization.

JEL Classification
M12, O15, O33, Y3.

1 Introduction

The Covid-19 pandemic forced many organizations to collectively swap the physical for the digital world in a matter of months. As retailers learn to operate without stores, business travellers without airplanes, and workers without offices, much of what started out as a temporary expedient is likely to become permanent. Thus, businesses are now spending less on office space and travel and more on cloud computing, collaboration software and logistics. In many ways, digitization is simply the next chapter of a process under way for a century.

In this regard, challenges brought from today's complex environment has led to changes in human resource management - HRM. Whereas HR managers needed to adapt to these new changes risen by the pandemic crisis and get used to work online with employees, to manage digital processes and to deal with employee's dismissal, in addition to carry out retention and selection procedures online (Gulua, 2020). Though, the situation has been inverted to create a more strategic process thanks to which organizations can build their brands and become more attractive to potential candidates (Urbancová et al., 2015).

Currently, online recruitment and social networking sites are experiencing considerable growth (Gigauri et al., 2020). Thus, they are becoming an important alternative to the traditional recruitment of employees through job boards, such as in the Czech Republic, Prace.cz and Jobs.cz (Bohmova and Pavlicek, 2015). Kemp (2020) stated that 4.5 billion of people use the internet and 3.8 are active social media users. For this reason, companies have to stretch their recruitment efforts across online space

using more digital tools and methods in order to attract new talents who spend their time in the digital space (Gigauri et al., 2020).

The aim of this paper is to review recent publications, to analyse them and to provide an insight on e-recruitment concept and the advances made in recruitment technologies. Furthermore, the author examines its merits and demerits. This article is written as a follow-up study to the research paper "The digitalization of HR processes: success factors and consequences", where the author suggested for future research, e-recruitment should be discussed.

The second part of this paper provides a theoretical background on e-recruitment and examines digital and AI-enabled recruiting technology and tools. The third part describes the methodology used in this paper. The fourth part illustrates the results obtained from the analysis of publications. And finally, the conclusion provides a summary on the topic.

2 Literature Review

Hada and Gairola (2015) define e-recruitment as the process of using web-based resources for tasks concerned with searching, attracting, assessing, interviewing and hiring new employees. Although e-recruitment is considered as a rather new concept for most of organizations, first articles seemed to appear in the middle of 80s (Fred and Kinange, 2018). However, it took a decade till the concept was covered by empirical and systematic research in human resource related journals. Whereas the sudden rise was attributed to the increase of use of internet in organizations (Fred and Kinange, 2018).

Traditionally, the recruiters used to seek for new candidates through newspaper advertisements, purchasing databases from external resources, or asking specialized hiring agencies to headhunt the appropriate candidates (Bohmova and Pavlicek, 2015). Lately, e-recruitment is a growing trend, it takes place online while using tools that enable the reception of applications, the search for professionals, a quick triage and provision of feedback to applicants (Brandao et al., 2019). Thus, the main objective of e-recruitment is to capture attention of the highly skilled and competent workers with suitable profiles for the job announced. Brandao et al. (2019) claim that e-recruitment process starts by announcing a job in the digital space, preparing a form to be filled up online and making it accessible for potential applicants, and developing digital database where the applications will be stored. They added that e-recruitment may imply the use of specialized selection tests such as personality tests, reacting immediately online, assembling tools that enable the elimination of applications unsuitable for the job.

Chang and Chin (2018) stated that individuals frequently search for a firm's information by visiting its website. For this reason, developing an attractive website can be an effective method to induce individuals' visits. In this regard, Direen et al. (2007) showed that customized websites content can significantly influence job seekers' attraction to the organization. Hence, studies on the visual design of e-commerce have shown that an effectively designed website enhances emotional appeal and accordingly the results in shaping more positive attitudes and approaching behaviours in users.

However, nowadays social networking sites (SNS) present a novel way to actively seek out potential candidates through direct contact (Howardson and Behrend, 2014). Likewise, social media rely on mobile and web-based technologies to create highly interactive platforms through which individuals and communities share, co-create, discuss and modify user-generated content (Din et al., 2015). Din et al. (2015) enhanced that SNS play a vital role in the recruitment process, for this reason, companies need to use its full potential to accomplish their purposes. Nagendra (2014) conducted a research on SNS and determined that all the basic HR functions including recruitment can be effectively managed by social medias.

Bohmova and Pavlicek (2015) indicated that the ratio of hiring decisions is influenced by screening SNS profiles, where one fifth of the employers claimed that SNS encouraged them to hire the candidate and more than 45% of employers stated that screening the candidates' SNS profile resulted in not hiring them. Moreover, Golovko & Schumann (2019) found a positive correlation between Facebook posts and recruitment success and showed that recruiting information or other work-related news on Facebook

influence the successful realisation of the overall recruitment process. Thus, the researchers suggested that HR managers should be proactively and permanently employed on Facebook while simultaneously using traditional channels. However, Stoughton et al. (2019) pointed out that screening applicants through SNS can be considered as invasion of their privacy and consequently causing negative feelings towards the company and workplace. Also, Bohmova and Pavlicek (2015) mentioned the following reasons – Table 1, for hiring or rejecting candidates due to SNS screening.

Table 1. Reasons for hiring or rejecting candidates due to SNS screening

Hire	Reject
Gave a positive impression about their personality and organizational fit	Lied about their qualifications
Profile supported their professional qualifications	Posted negative comments about their previous employer
Profile showed a creative candidate	Posted inappropriate photos
Candidate had good references posted by others	Demonstrated poor communication skills
Showed solid communication skills	Posted inappropriate comments

Source: Bohmova and Pavlicek (2015, pp. 25), modified.

2.1 Digital Recruitment

Gigauri et al. (2020) identified three stages of evolve in digital recruitment, i.e., digital recruitment 1.0, digital recruitment 2.0 and digital recruitment 3.0. Black and Van Esch (2020) expressed that digital recruitment 1.0 was established in the mid to late of 90s and included the digital transform of information regarding job positions and candidate information, which allowed organizations to reach out a large number of potential employees through corporate websites, and likewise, potential employees could look for and screen thousands of jobs easily through the internet to obtain the most suitable.

Digital recruitment 2.0 emerged ten years later after the start of digital recruitment 1.0 and was driven by two key developments. The first development occurred as a result of the digital aggregation of all the jobs throughout numerous job boards so that candidates could find all open positions at one place, and also organizations were able to offer their jobs at different platforms through which applicants could reach them freely (Black and Van Esch, 2020). The second development was related to the introduction of digital professional and social networking sites (Black and Van Esch, 2020). Hence, one of the earliest most successful professional SNS is LinkedIn. Whereas LinkedIn allows people to form professional networks and communities of interest, exchange information and endorse people in their networks as well as receive endorsements from people in their network (Black and Van Esch, 2020). In this regard, Bohmova and Pavlicek (2015) claimed that HR professionals use to determine additional information about the candidates from the following SNS: Facebook 76%, Twitter 53% and LinkedIn 48%.

Digital recruitment 3.0 has started to become fully-fledged from 2010 to 2015. According to Kaplan and Haenlein (2018), the main element behind it, was the introduction of artificial intelligence – AI. Presently, companies are beginning to transform their recruiting activities through AI as computers can already execute tasks, solve problems, and reach decisions that were only a privilege of human intelligence (Gigauri et al., 2020). Thus, both employers and candidates will be influenced by AI-enabled recruiting process, which includes job postings, searching for candidates, conducting job interviews, and finally evaluating the applicants (Wright and Atkinson, 2019).

2.2 AI- Enabled Recruitment

According to Black and Van Esch (2020), AI-enabled recruitment tools have been mostly employed across four sets of activities, i.e., outreach, screening, assessment and coordination. During the outreach stage, organizations try to reach to potential candidates and get job opportunities in front of them, so that they're prompted to apply. Once the potential candidates submit their CVs or fill in the digital form, the daunting task of the employer is to screen these documents. As mentioned by Black and Van Esch (2020), screening is no small task, while most organizations receive from 20 to 200 CVs a day. Candidates, who pass the screening task, are further assessed and evaluated if they are appropriate for the job position. Thus, this stage may implicate more than one round of assessment. However, the main objective is to identify the best candidates for the job offer. Black and Van Esch (2020) state that only 38% of organizations use AI-enabled recruitment. Even though AI technology in recruitment has reached a phase when it is more effective and efficient than human beings are, its practical use by executives is delayed (Gigauri et al., 2020). However, potential candidates may have a negative attitude towards AI-enabled recruitment technologies because human interaction is missing, and processes are automated (Van Esch et al., 2019). According to Van Esch et al. (2019), the introduction of AI recruitment technology can interrupt the functionality of HR professionals. Thus, some organizations may want to replace employees in order to save costs, except candidates require an interaction with human beings during the recruitment and selection process. Whereas AI enables consultation, interviewing, and negotiation to be performed through Chatbot (Gigauri et al., 2020).

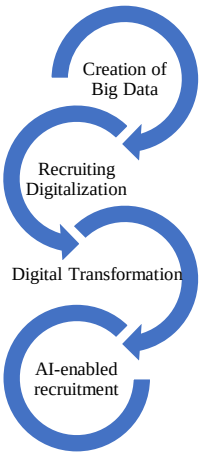
According to Campbell et al. (2020), many organizations have started to use AI in recruitment, for instance, Pandologic and HireScore use AI to scrape data from Facebook, LinkedIn, Twitter, et cetera. L'Oréal used AI to remove gender bias phrasing with a resulting even separation between male and female candidates, which the organization had never achieved before (Black and Van Esch, 2020).

2.3 The Process of Modern Technologies in Recruitment

According to Gigauri et al. (2020), the use of digital technologies and AI-enabled technologies is possible at any stage of the recruitment process. Nevertheless, some processes become completely automated, i.e., they are implemented without an interference of human beings. Also, the most interactive HR processes, such as: accessing candidates at the data collection stage and interviewing candidates, can be conducted through Chatbots (Gigauri et al., 2020). Whereas AI is used in the analysis of interview results.

Furthermore, the introduction of modern technologies in the recruitment process – Figure 1, involves the creation of big data, digitization, digital transformation, and the use of AI (Gigauri et al., 2020). The creation of big data denotes to the digitization of information related to recruitment, guaranteeing their availability, forming digital databases. This stage is a necessity for all other stages. Digitalization is understood as the integration of analytics, social and cloud technologies in different areas of HRM to deliver better productivity, redefined HR processes, work-life balance and decision-making processes and results (Kharroubi, 2021). Digital transformation is the process of using digital technologies to analyse digital information. It refers to the use of Codebots to run repetitive processes, to the automation, and to the software use in recruitment processes (Gigauri et al., 2020). AI-enabled recruitment is the highest level of digital transformation. It refers to automation of the whole cycle of digital systems in all stages of the recruitment process through artificial intelligence, without human intervention (Gigauri et al., 2020).

Figure 1. The process of modern technologies in recruitment



Source: Gigauri et al., (2020, pp. 43), modified.

3 Methodology

A systematic review of the literature on digitalization in HRM was carried out through a relevant search of keywords. Specific keywords like *e-recruitment, digital recruitment, online recruitment* were searched, followed by certain criteria. Primarily, to access the relevant articles, the author searched relevant database Web of Science (WoS) and Scopus. However, in order to identify the merits and demerits of e-recruitment, the author had to analyse publications and highlight the relevant information about it.

4 Results

4.1 Merits

There were multiple merits for utilizing e-recruitment distinguished in publications and will be examined in this part of the paper.

Time and cost savings: According to Kim and O'Conner (2009), the main obvious merit of e-recruitment is certainly time and cost savings that it generates. Hence, the duration of the recruitment process is cut down thanks to the faster transition of information. Also, because of the digital transformation of processes, applications are sent within seconds because of the internet by addressing it directly to the recruiter's e-mail address or by using a job portal as an intermediary. Besides, the cost of electronic job posting is lower than the printed media, employment agencies, head-hunters and other traditional recruitment means (Malinowski et al., 2005). Whereas the posting of job offers on job boards can be quite expensive.

Reduction of the administration load of work: Another significant merit is the diminishing of the administrative burden of the HR department in organizations. Since some tasks of the e-recruitment can be automated by integrating tools to the organization's information system, and therefore reducing significantly the bureaucratic load of work, which saves time (Malinowski et al., 2005). Depending on the development level of e-recruitment at which an organization stands, the number of automated tasks may vary. Actually, the higher the level the use of technology is, the more activities will be supported and automated by the HR information system - HRIS.

Reach of international knowledge: Thanks to e-recruitment, organizations reach a bigger pool of applicants, as well as the potentially recruited candidates often present better profiles than when using traditional means (Kim & O'Connor, 2009). According to Deillon (2014), a higher proportion of international applicants within the knowledge pool could lead to higher unemployment rates in specific regions.

Reach of passive jobseekers: E-recruitment has also brought a new category of applicants into the recruiting pool, the passive jobseekers. Even if they are not looking actively, they may have concern in finding a job with better work conditions, a higher salary, or maybe another work experience (Deillon, 2014). Furthermore, Deillon (2014) states that the student's category among jobseekers is highly present nowadays, thus, 90% of students actively search for a job online. Which could be explained by the fact that young jobseekers are often computer literate (Dhamija, 2012).

Positive impact of the organizational website: According to Deillon (2014, pp. 13), "recruitment is, in reality, job marketing". Thus, electronic job posting has brought to recruitment activities a new facade, i.e., the importance of the organization's image and the design of the job advertisement. Additionally, the better the image of the organization is, the more job seekers will be drawn to apply. Another factor that determines how efficacious an organization can be when attracting potential candidates is the prominence of the corporate brand (Parry & Tyson, 2008).

Decentralization of HR activities: Another merit about e-recruitment is the decentralization of HR operations (Deillon, 2014). Yet, this requires a sufficient level of development, such as the use of HRIS. In contrary to traditional means of recruitment, where the recruiter has to regularly inform HR executives about progresses made in the recruitment process, currently, with the help of e-recruitment tools, an exchange of information is made an information system.

Sophisticated management tool: Thanks to HRIS, the entire recruitment process is accomplished distantly, where the employer to post vacancies, receive CVs, screen, prioritize, contact candidates and track all activities from the boundaries of a private and extremely functional employer workspace (Singh and Singh, 2015). Jobseekers similarly can track the progress of their application at every stage of the hiring process from their own workspace. While this allows for an enhanced user-experience for both employers and jobseekers.

Allows for confidentiality: Both employers and job seekers can select to sustain their confidentiality. Employers can nominate to search the databases without posting a job in case the vacancy is sensitive, or they can post vacancy while keeping the company name confidential. Similarly, candidates can post their CVs online while keeping their names and present employer's name confidential (Singh and Singh, 2015).

Allows for proactively: The recruiters are in full control of the hiring process within e-recruitment; hence, they can contact candidates directly and does not requiring a middleman to sift through, filter, assess or select the required candidates. By being in the driving seat the employer gains valuable insight into the marketplace and the competitive landscape for the position (Singh and Singh, 2015). Also, they'll be able to ensure a superior match and a better fit for the long term.

Technology shift: The last merit does also support the arguments regarding the significance of integrating digital recruiting tools immediately, in order to move the employer up in the value chain and to serve the strategic objectives of the organization (Deillon, 2014). If integrating more advanced e-recruitment tools is a risk for organizations, so not turning towards technology in recruiting or postponing its integration, means exposing the organization to competitive disadvantages against concurrent and to an uncertain future.

4.2 Demerits

On the other hand, the author has distinguished multiple demerits associated with the utilize of e-recruitment.

Budget constraint: Since many organizations are limited with their investments and financial possibilities, so implementing e-recruitment tools would be an obstacle for most of them (Kim and O'Conner, 2009). Also, the implementation of AI-enabled recruitment systems is costly and complex with various tools (Black and Van Esch, 2020). For this reason, researchers suggest buying tools from external providers, but organizations will need to hire several employees every year or to support developing AI tools by themselves (Wright and Atkinson, 2019).

Abundance of applicants: Meanwhile the internet is available to people all over the world, as a result the employer is more likely to get swamped with CVs from interested candidates, who are not qualified to the job position (Singh and Singh, 2015). Therefore, recruiters spend a great deal of time sorting through CVs to eliminate those who are not qualified for the position.

Inflated resume keywords: Since employers depend on HRIS to locate CVs that include relevant keywords, there is a strong possibility that certain keywords in a vast majority of job applicants' CVs are exaggerated (Singh and Singh, 2015). Therefore, recruiters waste time by addressing those applicants who do not meet the job requirements.

Overestimate candidate: It is challenge for a recruiter to determine whether or not an applicant is the right fit for a job without an interview. A candidate can have all the right credentials on paper but still may not have the right character for the company (Singh and Singh, 2015).

Risks of project failure (especially in case of AI-enabled recruiting tools): Implementing e-recruitment tools requires continuous development and the risks of malfunctioning and technical issues at the beginning are considerable, because the system is usually quite complex (Deillon, 2014). Thus, the implementation process needs time and adjustments, which bring further costs to take into account (Kim & O'Connor, 2009).

Outdated job offers: Sometimes recruiters forget to remove old postings for filled job positions from the organization's website and get swamped with CVs for job positions that are no longer open (Singh and Singh, 2015). This may result due to miscommunication between the HR manager and HR administrators or a glitch in the system. However, recruiters will remain flooded with CVs until the posting is removed.

Cultural change: Bringing e-recruitment tools caused many changes within the organization. According to Deillon (2014), the staff has to be trained to deal with the new methods and possible issues, and a new cultural approach towards the recruitment process has to be presented.

Increased labour force mobility among competitors: Posting about job positions online or on SNS has made work conditions and information relatively more available. This means that individuals can compare work offers to other similar ones. In turn, this led some organizations lose some of their employees and have their competitors hiring them (Deillon, 2014).

Potential discrimination: E-recruitment has also brought another legal and social issues. Thus, e-recruitment may discriminate some categories of applicants. This is particularly true for organizations using selection tools on top of recruiting tools within their HRIS (Deillon, 2014). For example, if an organization practices psychometric tests; minorities in terms of ethnic affiliation, competencies and mental abilities could be rejected because of the limited number of profiles the tests utilized (Dhamija, 2012).

Data security and confidentiality: A common fear arising from online jobseekers is data confidentiality and security while applying online. In order to be absolutely legal, organizations have to certify that the information received from an applicant is strictly confidential (Kim & O'Connor, 2009).

Negligence of personnel interaction: The major demerit organizations encounter when adopting e-recruitment tools is the lack of personal interaction with candidates in the recruitment process. Which

can lead to terminating the applying process by some candidates, because of the frustration they may feel and missing the opportunity to interact with their potential employer (Kim & O'Connor, 2009).

No response of the company: Another popular complaint from jobseekers is that they do not get a response from some organizations where they have submitted their CVs and there is no way for the jobseeker to call, because they have purposely omitted a contact number (Singh and Singh, 2015).

Based on a research made by Bohmova and Pavlicek (2015), the following merits and demerits were distinguished to different means of e-recruitment – Table 2.

Table 2. Comparing merits and demerits for different means of e-recruitment

	Job boards	Facebook	LinkedIn	Twitter	Corporate's website
Kind of jobseekers	Junior and senior management, graduates	Young people and graduates	Specialists, senior and top management	Specialists	Active jobseekers
Merits	Many CV responses, database seeking, almost non-limited advertisement	Existence of digital footprint, increasing visitors of corporate's FB page	CV presentation, references, circle of friends, interest groups	Easy reach of specialists worldwide	Responses of active individuals who are interested in a particular company
Demerits	Price, a large number of irreverent responses	Uncertainty that someone replies, distrust in FB	Activity must be made by HR	Limited number of characters, little use in the Czech Republic	Limited distribution, low response

Source: Bohmova and Pavlicek (2015, pp. 29), modified.

4.3 Discussion

In this paper, the author demonstrated several merits and demerits for e-recruitment. Hence, e-recruitment has a major merit as the life of recruitment advertisement is much longer than paper-based advertisements, and organizations can post complete detailed descriptions about the job positions and can answer to FAQs.

Furthermore, the selection of talents with minimal human interference provides great opportunities for timesaving, accuracy, unbiased analysis, impartial, and fair decision-making (Gigauri et al., 2020). Thus, due to e-recruitment, HR managers would be able to create systems of virtual organizations, attract global talents, process a large amount of information and compare data, create jobs anywhere in the world, and coordinate the work and activities of their employees remotely. Accordingly, the digitization of recruitment processes leads to internal optimization of processes such as work automation, paper minimization, and cost reduction.

Nevertheless, the introduction of digital technologies and AI is specifically effective in global organizations, where the number of jobseekers equals tens of thousands. E.g., Google obtains more than 3,000 CVs a day, which means it may receive across 75,000 CVs in one week from the announcement of the vacancy (Robbins and Coulter, 2014).

However, the adaptation of new technologies does not imply that all organizations are certainly allowed to adopt it, because many may encounter problems with safety standards, staff training, additional staffing, or finding resources.

5 Conclusion

This paper has emphasised the importance of e-recruitment especially in today's inconsistent environment which creates many challenges to organizations but also bargains new opportunities. Although digital technologies and AI are new trends in the recruitment process, it has become more

essential as organizations struggle to meet the requirements of social distancing due to the COVID-19 pandemic.

In this regard, HR executives should devote more attention to adopt AI-enabled recruitment, because it has great potential for reaching wider, distinct, and more qualified candidates and to create comprehensive talent pools (Black and Van Esch, 2020). However, they should encounter the risks and uncertainties associated with its implementation due to the fact that it's a novelty. Generally, digital recruitment process has made a progress from 1.0 to 3.0 to AI-enabled (Gigauri et al., 2020). Whereas the implementation of AI in recruitment is a new concept, nevertheless it will take place in the near future.

In this paper, the author demonstrated various merits and demerits associated with the adoption of e-recruitment, as it is easy, and cost effective as applications can be stored in digital databases, but organizations need to take into consideration privacy concerns among candidates, and plan recruiting activities accordingly.

Finally, this paper can be an initial point for an applicable future research about AI-enabled recruitment in Czech organizations.

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1 Effficiency in the public sector - Comparison of the efficiency of german municipal hospitals over time

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Abstract
This paper deals with the topic of efficiency measurement of municipal hospitals in Baden-Württemberg, Germany. The municipal economy and in particular the assurance of public health services have a very high economic and socio-political importance. Hospitals in particular are under tremendous socio-political pressure; in the current COVID-19 crisis this becomes visible more than ever. This socio-political pressure primarily affects publicly owned hospitals – in contrast to privately owned hospitals. In addition to financial pressures on public hospitals, there are several other factors that affect the efficiency of public hospitals. By analyzing various endogenous input and output factors, this paper aims to do its part to illustrate efficiency in public hospitals in a long-term study from 2012 to 2019. Public hospitals in the state of Baden-Württemberg (11.07 million inhabitants) in Germany are considered. This paper may use Data Envelopment Analysis (DEA) to show changes in the efficiency of public hospitals. As a result, these findings can help to provide a comparison of the efficiency of public hospitals over time and to identify possible causes for an increase or decrease in efficiency.

Keywords:
Health services, hospitals, efficiency, Data Envelopment Analysis model (DEA), Malmquist Index Model

JEL Classification:
H40, I1, I11, I15

1 Introduction

The entire population is affected by the quality and availability of health care. Regardless of age, gender and nationality, everyone is in need of good quality and supply of healthcare services. Thus, health care and health protection of citizens are anchored in the individual constitutions worldwide. However, the sustainability and future feasibility of the health care system are closely linked to research of the supply and demand equilibrium. Here, efficiency and effectiveness of the healthcare system represent a possible strategy to solve the differences or discrepancies between the supply and demand of healthcare in a publicly funded healthcare system. This means that the actual production of health care itself is improved, while the budget needed to finance it and the quality of services remain the same. For political representatives, but also for the public and the entire population, monitoring and evaluating the effectiveness and financial efficiency of the health care system is therefore enormously important in the long term (Gavurova and Kocisova, 2020).

Inefficiency is a pervasive problem in healthcare systems. In fact, the World Health Organization estimates that, on average, 20-40% of total health spending worldwide is wasted (WHO World Health Organization, 2010; Asbu *et al.*, 2020). It is therefore not surprising that this political and economic discussion about the efficiency and quality of the public health care system has been going on for many years, not only in Germany but also at the international level (see exemplary Vrabková and Vaňková, 2015; Kalb, 2010). The German health care system considered here has been the subject of increasing political and economic debate for many years. Almost in alternation, the efficiency of the health care system, the quality of the services offered, and the level of expenditures and costs are discussed (Helmig, 2005; Kuchinke *et al.*, 2004; Kalb, 2010; Augurzky and Schmitz, 2010; Schneider *et al.*, 2020). In the discussion about possible cost-saving potential, of the various groups of service providers such as physicians, pharmacies and hospitals and their respective associations, the focus on the hospital sector appears to make the most sense. Especially since the hospital sector is regularly named first when it comes to potential cost savings and the issue of cost explosion in the healthcare system (Helmig, 2005; Vrabková and Vaňková, 2015). At first sight, this seems understandable,

since spending on inpatient hospital services accounts for the largest share of costs in the German healthcare system in absolute terms. As a result, hospitals are under particularly strong public observation and under a great pressure to justify their corporate policy and financial activities. Publicly owned hospitals are particularly in the spotlight because they are considered to be comparatively inefficient and are also financed from public funds (Helmig, 2005). Public, and thus especially municipal, hospitals are therefore under enormous pressure to reduce costs and at the same time provide better services for patients without reducing their quality (Gavurova and Kocisova, 2020; Androniceanu, 2020). Increasing efficiency has become an area of increasing importance for hospitals in order to cope with growing competitive pressure in the hospital market. At the same time, unpredictable fluctuations in demand can make it difficult for hospitals to operate efficiently (Schneider *et al.*, 2020). The question of the efficiency and, consequently, the sustainability of the health care system now arises, especially in the context of the COVID 19 pandemic, when governments have begun to look for solutions, especially for the financing of the health care system in such a crisis (Gavurova and Kocisova, 2020; Androniceanu, 2020).

Literature review

In the literature on efficiency in the public sector, the health sector has also received the most attention in recent decades. There are a large number of studies that examine the technical efficiency or cost-effectiveness and the respective influencing factors of healthcare facilities (such as hospitals or even nursing homes) in different countries. However, the absolute majority of the studies are concerning the United States of America (Kalb, 2010; Helmig, 2005). Early studies go back to Banker *et al.*, (1986), Grosskopf and Valdmanis, 1987), Nyman and Bricker (1989) and Valdmanis (1992). These studies use linear programming techniques to evaluate different aspects of the technical efficiency of hospitals and nursing homes in the United States of America. The last four studies also examine the influence of the form of ownership on technical efficiency (Kalb, 2010). In contrast to this Steinmann *et al.*, 2003 focus on the size of health care facilities, for instance in terms of the number of beds in hospitals, and technical efficiency. Considering days of inpatient stay, material costs, academic, nursing and administrative staff as input indicators and medical, paediatric, surgical, gynaecological and intensive care discharges as output indicators, the authors find indications in a sample of 89 Swiss hospitals that the smallest and largest hospitals (in terms of number of beds) are more efficient than medium-sized hospitals (Kalb, 2010). Lenka and Votápková (2014) focus on the cost-effectiveness of 81 general hospitals in the Czech Republic using a non-parametric methodology taking into account various environmental variables, in particular the form of ownership. As a result, they found that a non-profit ownership and the existence of a specialized center have a negative impact on the performance of small and medium-sized hospitals. However, a non-profit ownership is advantageous for efficiency in large hospitals. Karlsberg Schaffer *et al.* (2015) state, and particularly highlight, that evidence of cost-effectiveness is rarely used in local and community health spending plans. The study in the United Kingdom, which was developed from the budget reviews issued there, emphasizes the differences in objectives between health technology assessment (HTA) panels and local health care decision makers, such as politicians. The study of 40 in Slovakia by Gavurova and Kocisova (2020) focuses on researching the efficiency of hospitals in Slovakia and aims to explore a compromise between the production of services and the quality of services in the process of providing healthcare. To complement the older contributions mentioned above, a brief overview of the empirical state of research, particularly in Germany, shows that, surprisingly, there are hardly any studies on efficiency measurement of German hospitals in the last ten years.

2 Research objective and research contribution

The aim of this paper is to follow up on previous studies on the efficiency measurement of hospitals and to at least partially close the research gap of recent years. Using the example of selected hospitals in public or municipal ownership in the German state of Baden-Württemberg, an efficiency measurement of the years 2012 to 2019 will be carried out by means of the Date Envelopment Analysis (DEA). Accordingly, this paper aims to answer the following question: *How has the efficiency of public hospitals changed in recent years?*

Accordingly, with 11.07 million inhabitants, Baden-Württemberg is a very populous and economically strong area, which provides a good basis for the sample selection of this work. Following the efficiency comparison of various hospitals in recent years, a brief prognostic statement on the estimated efficiency level in 2020 will

be made. Due to the massive impact of the Corona pandemic, significant changes in the efficiency of hospitals are to be expected. Since the official data on 2020 are not yet available, an estimated trend is derived by means of a survey of experts.

3 Theoretical approach

The study of the efficiency of municipal enterprises or municipal hospitals is conditioned by several theoretical approaches. On the one hand, the theory of "New Institutional Economics" has emerged from the line of neoclassicism in the last decades and thus finds some approval in modern times. Since the research area of municipal hospitals also deals with the question of the public sector and its position in the respective market economy, the theory of the "welfare state" is also the theory to be considered here in particular. From the point of view that the state is an interventionist state and that it is not about market control as such, but that the economic form of a nation has to be adapted to the respective needs, the state can intervene to improve market outcomes. In particular, it is the task of the state to intervene to correct so-called market failures. Furthermore, the "Public Choice Theory" is also relevant for this research area. This theory is, besides the two previously mentioned, the most recent economic theory and basically applies the neoclassical theory to the existing political processes. This theory, as well, is based on the fundamentals of neoclassical theory, but in each case it also aims to give special consideration to the institutional aspects of the public sector. From a normative point of view, this is done in the development of efficient political decisions (Nowotny, 1999).

4 Research Design

4.1 Data access and data processing

In order to be able to answer the question of how the efficiency of municipal hospitals has changed in the last few years, statistical and quantitative data will be collected at the NUTS 3 level (Nomenclature des Unités territoriales statistiques; these are smaller regions, i.e., cities and counties with approximately 150,000 to 800,000 inhabitants). In this first step, data from the officially published quality reports will be used to find out how the efficiency of some randomly selected municipal hospitals has developed in the period 2012 to 2019 on the basis of selected inputs and outputs. The research method is based on an input-oriented Data Envelopment Analysis (DEA) as well as on the Malmquist model. By looking at several years, a long-term study is created in the following.

In a second step, a quantitative, online-based survey will be conducted with a selected group of experts. For this purpose, the persons responsible for the quality reports at the municipal hospitals were contacted. The hospitals that were already included in the first survey are also included in the sample group for the second survey. The survey is nevertheless anonymous in order to ensure a better response rate. The reason for this is that, in the case of a non-anonymous survey on the efficiency of one's own hospital, people might not respond or might only respond with embellished information.

4.2 DEA-Model

The methods of multiple-criteria decision-making (MCDM) are among the most frequently used methods in health care economics today. The models are based on applied efficiency formation and evaluation. Efficiency is generally achieved when the expenditure/costs of ensuring certain processes (inputs) do not exceed the profits achieved at the end of the process (outputs). They refer to the comparison between the actual and the optimal amounts of inputs and outputs (Vrabková and Vaňková, 2015). By efficiency, in this context, is meant technical efficiency. This is the ability to produce a certain quantity of output with the smallest possible input quantity (Augurzky and Schmitz, 2010; Eichhorn and Towers, 2018). Among the non-parametric approaches, one of the best-known methods proposed for the construction of a best-practice frontier is Data Envelopment Analysis (hereinafter DEA), which was introduced by Charnes, Cooper and Rhodes in 1978 (Charnes *et al.*, 1978; Kalb, 2010; Helmig, 2005; Schneider *et al.*, 2020). With regard to the majority of studies on hospital care and other health services, the DEA method is also used predominantly (Vrabková and Vaňková, 2015; Helmig, 2005).

Input-oriented CCR DEA model: The CCR model (Charnes, Cooper and Rhodes) maximizes the proportion of the assessed unit U_q, expressed as the proportion of weighted sum of inputs and weighted sum of outputs, subject to the conditions that (1) the weights cannot be negative (here a number greater than or equal to zero) and (2) the ratios of efficiency of all other units are less than or equal to 1, i.e. z = 1. Each unit obtains the virtual input by using weights for the inputs $v_i = 1, 2, \dots, m$, and the virtual output by using weighted outputs $u_i = 1, 2, \dots, r$:

- the virtual input (weighted input): $\boldsymbol{v_1 x_{1q} + v_2 x_{2q} + \dots\dots + v_m x_{mq}}$,

- the virtual output (weighted output): $\boldsymbol{u_1 y_{1q} + u_2 y_{2q} + \dots\dots + u_r y_{rq}}$.

The model for the unit U_q can be defined as follows (1):

Maximization $z = \sum_i^r u_i y_{iq}$ (1)

subject to
$\sum_i^r u_i y_{ik} \leq \sum_j^m v_j x_{jk}$ $k = 1, 2, \dots, n,$
$\sum_j^m v_j x_{jq} = 1,$
$u_i \geq 0,$ $i = 1, 2, \dots, r,$
$v_j \geq 0,$ $j = 1, 2, \dots, m.$

Formula 1:Input-oriented CCR model

The DEA model hence identifies a group of optimally operating hospitals that are defined as efficient and assigns them a value of one, i.e. z = 1. For efficient units the efficiency values are less than one but greater than zero, i.e. z < 1 (Vrabková and Vaňková, 2015).

An input orientation seems particularly useful if the focus of the model is on a decision unit that can only influence the output quantity to a limited extent, but can minimize the use of resources. This seems very plausible for the decision-making unit hospital, since a hospital can influence the demand for its health care services only to a limited extent and an increase in demand can be induced only with great difficulty (Helmig, 2005). Thus, this study focuses on the DEA input-oriented CCR model in the empirical study.

4.3 Malmquist Index Model

The Malmquist Productivity Index is another model for multi-criteria decision-making, which can be applied in terms of health care to evaluate the efficiency of hospitals. The Malmquist Index (MI) is an instrument for assessing the efficiency of production units over at least two time periods, which attempts to measure the effects of technological change and of other sources of efficiency improvement (Vrabková and Vaňková, 2015; Jablonský and Dlouhy, 2004). Thus, the DEA based Malmquist Index evaluates the efficiency change over time. It is a temporal DEA model, which evaluates the productivity change of a DMU between two periods and is therefore an example in comparative statistics analysis. It is defined as the product of the terms "catch-up" and "frontier-shift" (Vrabková and Vaňková, 2015; Sánchez, 2018). Figure 1 (see Appendix) shows the technical efficiency change based on the MI.

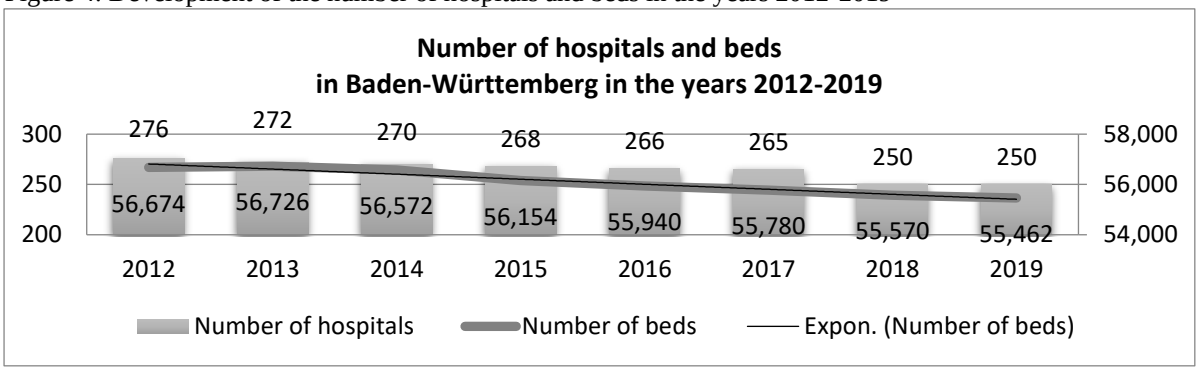
5 Results of the empirical study on the efficiency of municipal hospitals

In order to place the individual results of the municipal hospitals examined in a suitable context, the first step is to take a closer look at data on the overall structure and overall development of all hospitals in the state of Baden-Württemberg. Hospitals in public, private and non-profit ownership are therefore considered in this full survey. In the next step, the efficiency of public and municipal hospitals is examined in detail. This data presentation with two steps therefore provides a more comprehensive picture.

5.1 Full survey of all hospitals in Baden-Württemberg in annual comparison

In the following, the data of all hospitals in Baden-Württemberg and accordingly for a geographic catchment area of around 11.07 million inhabitants are considered for a period from 2012 to 2019. Figure 2 clearly shows that the number of hospitals has fallen by 9.06% and the number of beds by 9.78% in 8 years.

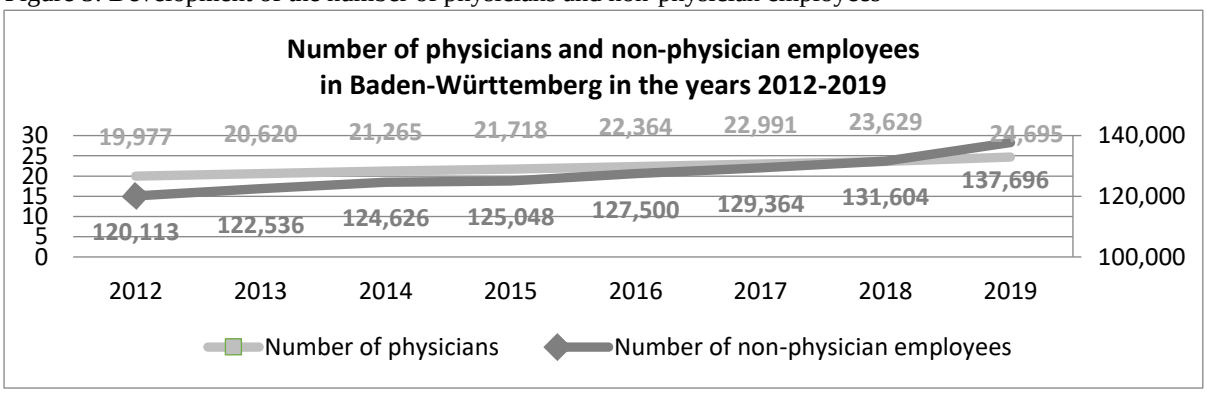
Figure 4: Development of the number of hospitals and beds in the years 2012-2019



Source: Own illustration based on Statistisches Landesamt Baden-Württemberg, 2021.

Accordingly, Figure 3 shows that despite declining hospital locations, the number of physicians and non-physician staff employed at each hospital has increased in recent years. Overall, the number of physicians has increased by 23.61% and the number of non-physician staff by 14.64%.

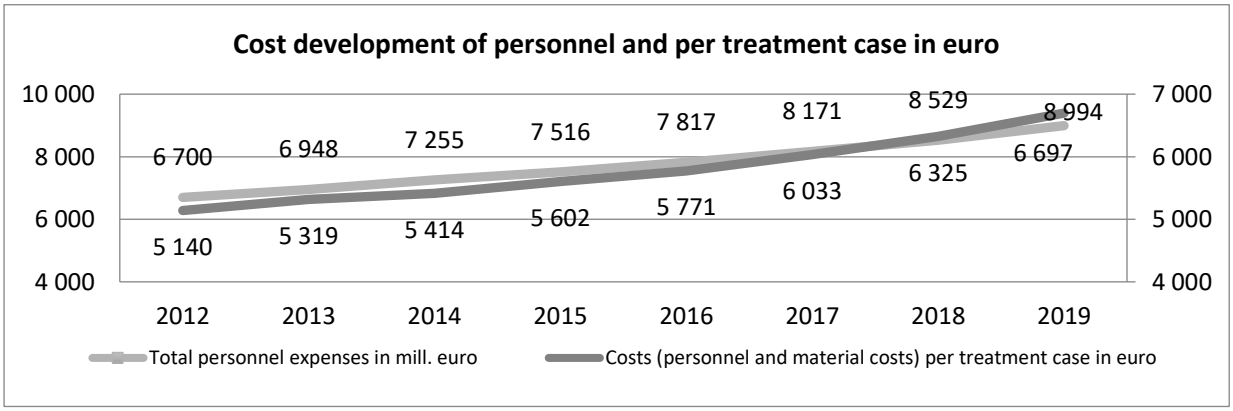
Figure 5: Development of the number of physicians and non-physician employees



Source: Own illustration based on Statistisches Landesamt Baden-Württemberg, 2021.

Other variables to be considered as input factors are personnel costs and costs per treatment case. Figure 4 shows that the costs of personnel and per treatment case are rising steadily year on year. Statewide personnel costs have increased by approximately 34.24% and costs per treatment case have increased by approximately 30.29%

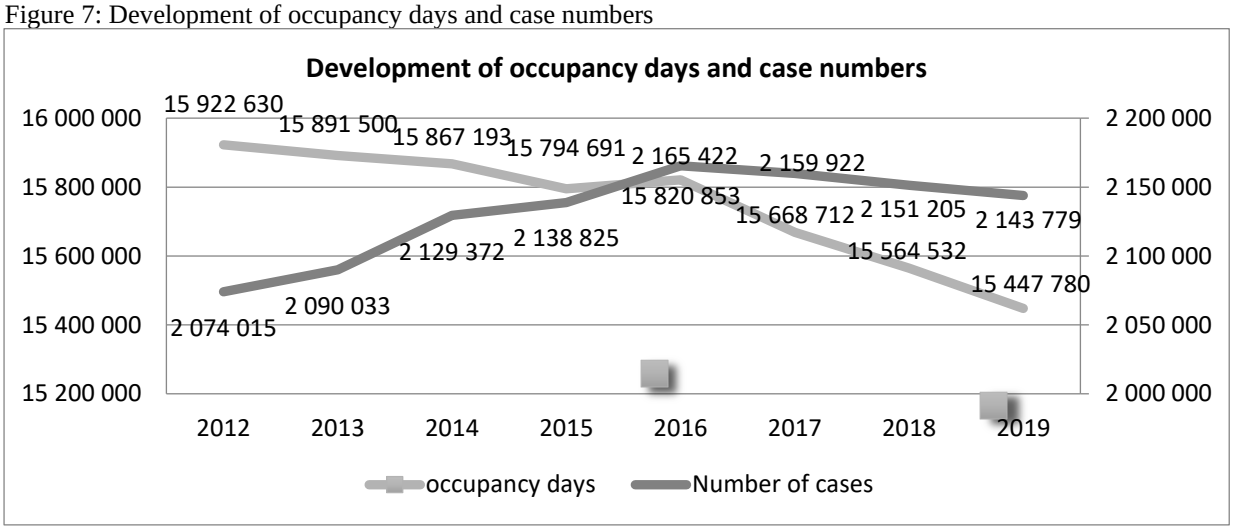
Figure 6: Cost development of personnel and per treatment case



Source: Own illustration based on Statistisches Landesamt Baden-Württemberg, 2021.

If one ultimately looks at the development of output factors such as average days of occupancy and annual average case numbers, the picture is different. Figure 5 shows that while the days of occupancy per hospital are similar; the number of cases is obviously increasing. As a result, more people are being treated in less time in fewer and fewer hospitals over the years. This observation alone leads to a clear statement about a nationwide increase in efficiency in terms of the time taken to treat patients.

Figure 7: Development of occupancy days and case numbers



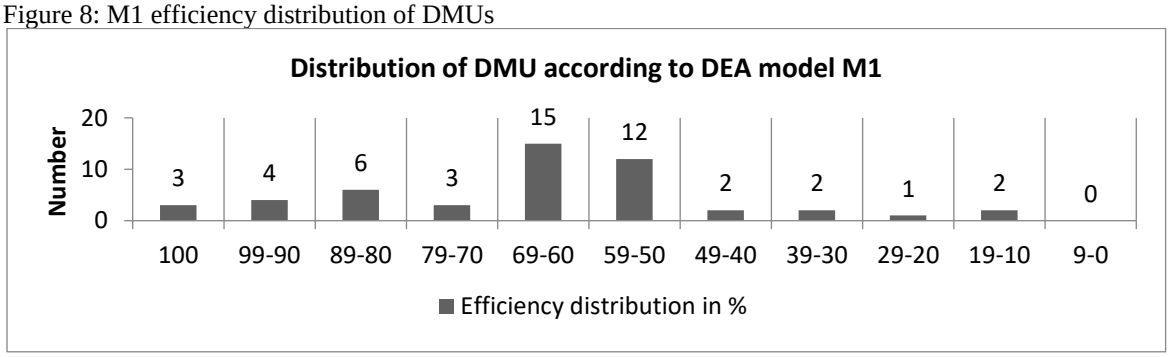
Source: Own illustration based on Statistisches Landesamt Baden-Württemberg, 2021.

5.2 DEA model M1 in form of input-oriented CCR, CRS

In an annual consideration of the years 2012, 2016, 2017, 2018 and 2019 of ten selected municipal hospitals in NUTS 3 category, a total of 50 DMUs (n=50) is obtained as a result. The following five input factors were considered: Number of beds, number of physicians, number of nurses, number of other staff and full-time equivalents. The number of cases (inpatient and outpatient cases) was used as the output factor.

Figure 6 shows the DEA model M1, which was calculated with constant returns to scale (CRS). It can be seen that, with 27 DMUs, more than half of all DMUs considered are in the efficiency range between 50 % and 69 %. Only three DMUs are considered efficient. All DMUs below 100 % are considered inefficient, i.e. 47 DMUs here. Table 2 shows the detailed results and 5 shows the names of the listed DMUs in an overview in the appendix.

Figure 8: M1 efficiency distribution of DMUs



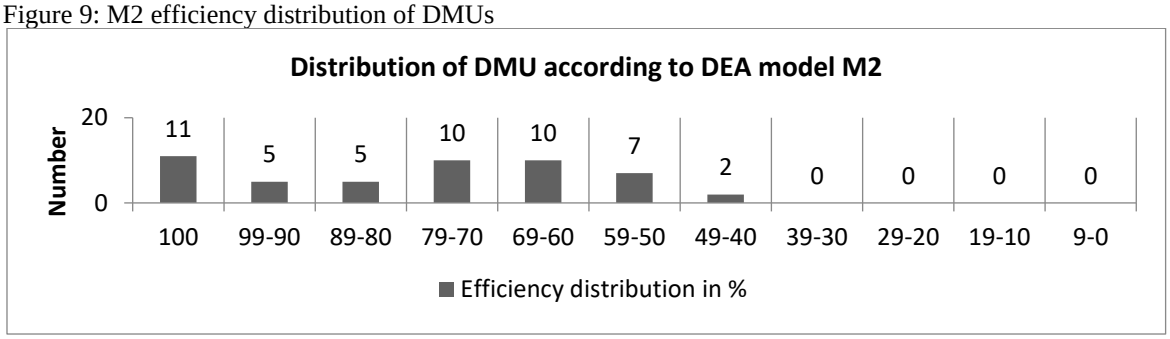
Source: Own illustration.

Interestingly, it can be seen that DMU H3 (Böblingen Hospital) is considered efficient once in 2016 and in 2017 (out of only 3 efficient DMUs). In the years before, H3 was also in the upper half with 60%-69%. DMU 7 (medius Klinik Kirchheim) turns out to be comparatively inefficient. In the years under consideration, the hospital was only at a comparative efficiency of 10 %-49 % and thus performed worst.

5.3 DEA model M2 in form of input-oriented CCR, VRS

Figure 7 shows the DEA model M2, which was calculated with variable returns to scale (VRS). The picture is substantially different. Now 11 DMUs are efficient (100 %) and the entire distribution shifts almost completely above the 50 % mark. The majority of DMUs are in the range between 60 % and 79 %.

Figure 9: M2 efficiency distribution of DMUs



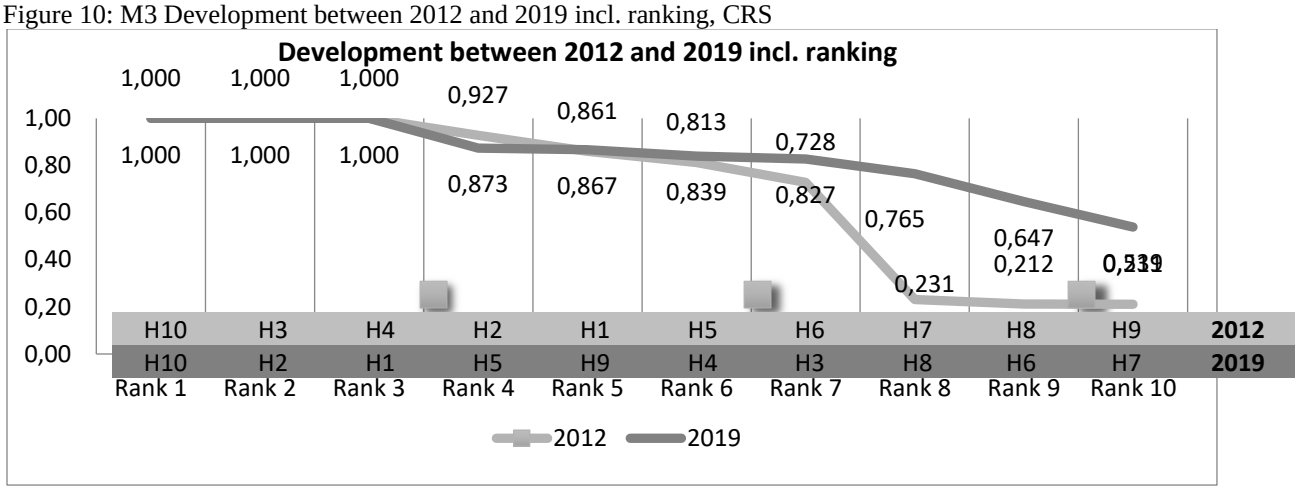
Source: Own illustration.

In terms of variable returns to scale, DMU H4 (Herrenberg Hospital) can be classified as efficient at 100% in all the years considered and is thus the top performer compared with the other DMUs. Furthermore, DMUs H1 (Klinikum Stuttgart - Katharinenhospital, Olgahospital / Frauenklinik) and H3 (Klinikum Böblingen) can be classified as efficient for two years each, and H6 (Kliniken Sindelfingen) and H10 (Klinikum Esslingen) for one year each. Nevertheless, most hospitals use their inputs inefficiently in the different years, i.e. 39 DMUs. Table 3 shows the detailed results in the appendix.

5.4 DEA model M3 in form of input-oriented CCR, CRS

A year-on-year comparison of the years 2012 and 2019 reveals the developments shown in Figure 8 with regard to the efficiency of the individual hospitals, with constant returns to scale. DMU H10 (Klinikum Esslingen GmbH) was efficient in both 2012 and 2019 and is the most efficient hospital compared to the other DMUs over the years. In both comparison years, there are three DMUs that are efficient and seven DMUs that use their inputs inefficiently. It should also be noted that efficiency has nevertheless improved slightly. Whereas in 2012 there were still three DMUs with an inefficiency of around 20%, in 2019 there are only two DMUs, which bring about the lowest efficiency at 54% and 65% respectively.

Figure 10: M3 Development between 2012 and 2019 incl. ranking, CRS

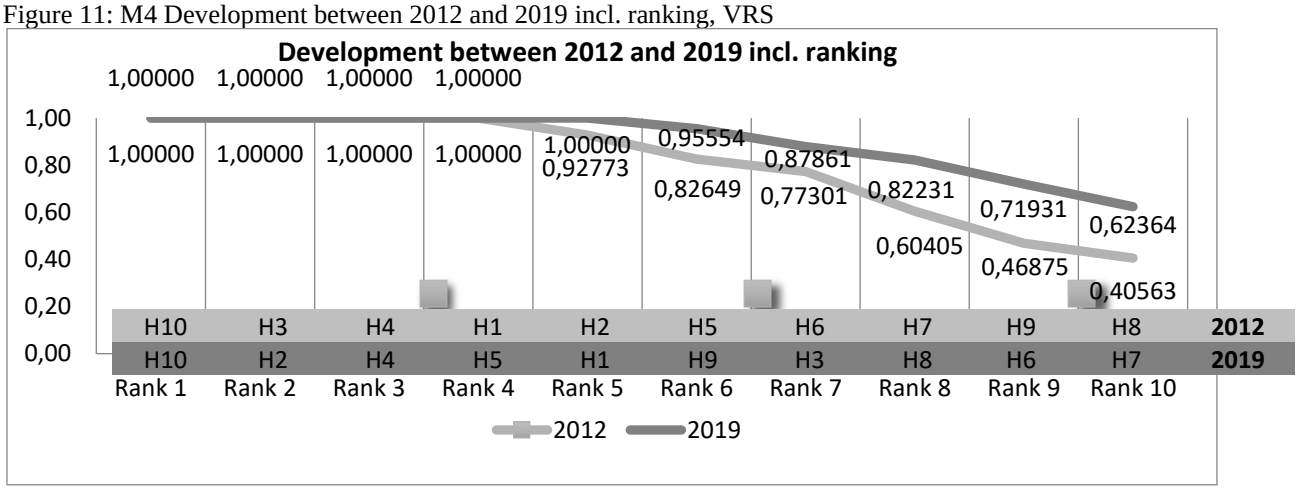


Source: Own illustration.

5.5 DEA model M4 in form of input-oriented CCR, VRS

The following three input factors were considered for the yearly analysis of the years 2012 and 2019: Number of beds, number of physicians and number of nurses. The number of cases (inpatient and outpatient cases) was used as the output factor. When looking at the years 2012 and 2019 with variable returns to scale, it can be seen that four DMUs are efficient in 2012 and even five DMUs in 2019. In addition to H10 (Klinikum Esslingen GmbH), H2 (Klinikum Stuttgart - Krankenhaus Bad Cannstatt), H4 (Krankenhaus Herrenberg), H5 (Krankenhaus Leonberg) and H1(Klinikum Stuttgart - Katharinenhospital, Olgahospital / Frauenklinik) are also efficient in 2019. Overall, the efficiency level has improved over the years.

Figure 11: M4 Development between 2012 and 2019 incl. ranking, VRS



Source: Own illustration.

5.6 Malmquist Index Model

To measure productivity for a time comparison from 2012 to 2019, the Malmquist Productivity Index is used. According to this index, the change for two time periods of DMUs can be determined. The results of the MI tell whether the productivity of the DMUs has improved ($M_0 < 1$), remained the same ($M_0 = 1$), or worsened ($M_0 > 1$) as a result.

In an evaluation with constant returns to scale, six DMUs have improved their productivity and one DMU (H10) has remained the same. This is explicable in the case of H10, since this DMU was already considered efficient in 2012 and 2019 with 100% from the M3 model. Three DMUs actually worsened their productivity over the years. The most downgrading occurred at DMU H3 (Klinikum Böblingen) (MI = 1.209), because according to M3 this hospital was still efficient in 2012 and has dropped to rank 7 in 2019. Table 10 (Appendix) shows the other results.

5.7 Results of the expert survey on the efficiency of municipal hospitals

In order to be able to answer further open questions relating to the efficiency of hospitals under municipal ownership, an anonymous survey was conducted. Only experts who could answer these questions from their professional experience were included in the survey. A total of 23 experts were contacted who are responsible for the quality reports of 45 municipal hospitals. The survey was conducted in the period from 03.05.2021 to 06.05.2021 via an online survey. The response rate was 26.09% (n=6). The survey contained 8 closed questions with a 5 parameter scale (agree/agree less, disagree less/disagree /can't answer) and 2 open questions to give the experts the opportunity for further explanations. Due to the small sample, this survey is not representative. It can only show trends.

Figure 10 shows that the majority of experts (50%) believe that their hospitals operate efficiently. However, 66.67% say that their municipal hospitals are not as efficient as private hospitals. A majority of the experts (50%) therefore also state that the efficiency of municipal hospitals can be improved. According to the experts, hospitals tend to be well equipped with physicians, but the majority (66.67%) still need more staff at all levels.

A rather heterogeneous result is that, according to the arithmetic mean, the experts do not think their hospital could achieve the same level of efficiency with fewer staff. Nevertheless, one third state that this would absolutely not be possible and again one third claim that this would rather be possible (33.33 % in each case). Thus, the tendency of this question is rather that the same quality could not be achieved with fewer staff, but in individual cases this is nevertheless seen as possible. It is clearly predicted that case numbers and bed utilization will definitely fall in 2020 due to the Corona pandemic.

In the first question, which was open, where the greatest challenges in the future for municipal hospitals are seen, the following main points could be filtered out:

- Future financing
- Less the question of ownership and more the question of the size of the hospitals
- Shortage of skilled workers in Germany, respectively decreasing personnel resources.

In summary, the experts state that they see particular problems in the financing, possibly of deficit units, as well as in relation to size. Larger hospitals or hospital associations are more efficient than smaller hospitals. Many smaller hospitals will be closed in the future, especially if the public owner is no longer able or willing to bear the resulting deficits. However, the experts also take a critical view of this, since smaller hospitals are often concerned with the supply accessibility of different areas. If the number of hospitals decreases due to the closure of smaller units, residents will have to travel longer distances. One possible solution is seen in creating concentration points in the smaller hospitals in order to increase efficiency. However, this would not be seen as positive by the population in return.

In the second open question, to what extent the efficiency of municipal hospitals can be increased in the future compared to private hospitals, the experts state that, on the one hand, processes should be slimmed down (lean management). On the other hand, efficiency could be increased through the aforementioned specialization / formation of focal points, particularly in urban areas, and through less political influence on strategic orientation (in this case, that smaller hospitals are being kept open). Interestingly, one expert responds that moving away from a planned economy would bring more efficiency. Despite the fact that Germany has the economic system of social market economy, according to this expert, the tendency of free market economy would also bring more efficiency. Figure 10 (see appendix) shows the summarized results of the survey.

6 Discussion

The results for answering the question of how the efficiency of municipal hospitals has changed in recent years show, first, that the municipal hospitals under consideration have improved overall and steadily in their efficiency in recent years. The Malmquist Index revealed that overall, six out of ten hospitals have improved from 2012 to 2019. Hospital H10 (Klinikum Esslingen GmbH) is especially noteworthy. This hospital was classified as efficient in 2012 and 2019. Therefore, efficiency has not improved here either. In addition, this hospital is efficient in all observations, i.e., with constant and variable returns to scale. DMU H10 is a larger hospital (approx. 660 beds), with the third highest number of beds. Nevertheless, it is not H1 (Klinikum Stuttgart - Katharinenhospital, Olgahospital / Frauenklinik) as the largest hospital with the highest number of beds of approx. 1,900 that is most efficient, but units that are in the upper third of size.

The forecast for 2020, taking into account the Corona pandemic, in terms of hospital efficiency does not look good or positive. The majority assumes that the number of cases and utilization will fall substantially this year. Since it did not lead to layoffs of employees in the same proportion as the reduction in output – but rather the compensation payments of the federal government for the provision of beds (so-called empty bed flat rate in accordance with the law to compensate COVID-19 conditional financial burdens of hospitals and other health care facilities) (Bundesministerium für Gesundheit, 2020) – can definitely be assumed that there will be a major drop in efficiency.

7 Conclusion

The results clearly show that – also in view of the theory of the New Institutional Economy – significant potential for improvement is seen in the processes and also in relation to ownership rights. Municipal hospitals, for example, are less able to operate leanly because they have to take political or governmental interests into

account in the background. Smaller hospitals are maintained even though they are not efficient, since the state must intervene here with regard to the distribution of hospital services. In some cases, it is not possible to guarantee an adequate and evenly distributed distribution of services, and in order to be able to provide care for people in areas that are not close to population centers, for example, hospital units are maintained here – despite inefficiency.

According to this, the links to the above-mentioned theories (new institutional economics, welfare state theory, public choice theory) become clear here. As a result, on the one hand, the German state's obligation to provide services of general interest for all inhabitants makes it difficult to run smaller hospitals in rural areas just as efficiently as larger hospitals in urban areas. On the other hand, due to the influence of political elected representatives – and their position as principals according to the principal-agent theory – the strategic orientation and implementation of strategic processes is often not as efficient as possible or as that of private hospitals. Political decision-makers may also make decisions that a private operator would not make in the same form.

In conclusion, it can be said that the efficiency of public hospitals has improved steadily in a year-on-year comparison from 2012 to 2019. Despite annually rising personnel and material costs as well as rising costs per treatment case, it has also been possible for the municipal units to improve their efficiency. Nonetheless, the critical issues, such as the barriers to more agile and efficient units that have been identified, should be looked at more closely in the future. The state and its intervention administration in the area of health care in Germany – in the existing economic order of the social market economy – has significant reasons for better resource allocation. Nevertheless, these entities often struggle with lower efficiency. This situation (in the form of a dilemma) should be considered in more detail theoretically-empirically in the future.

Acknowledgements

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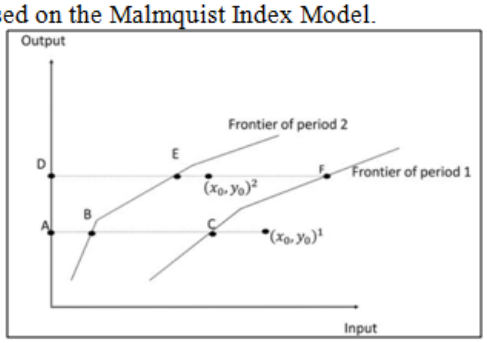
Appendix

Figure 1: Technical efficiency change based on the Malmquist Index Model.



Source: Sánchez, 2018.

Table 2: Aggregated results of modeling M1

%	Number	DMU
100	3	H3_2016, H3_2017, H6_2016
99-90	4	H10_2018, H1_2016, H1_2019, H10_2019
89-80	6	H2_2016, H10_2012, H10_2016, H2_2019, H5_2012, H4_2016
79-70	3	H9_2019, H1_2018, H4_2012
69-60	15	H5_2017, H5_2019, H4_2017, H3_2012, H5_2018, H9_2017, H4_2018, H9_2018, H10_2017, H3_2018, H1_2017, H4_2019, H9_2016, H3_2019, H8_2019
59-50	12	H8_2017, H8_2018, H2_2012, H1_2012, H2_2018, H2_2017, H5_2016, H6_2019, H6_2018, H6_2017, H8_2016, H6_2012
49-40	2	H7_2016, H7_2019
39-30	2	H7_2017, H7_2018
29-20	1	H8_2012
19-10	2	H7_2012, H9_2012
9-0	0	

Source: Own illustration.

Table 3: Aggregated results of modeling M2

%	Number	DMU
100	11	H6_2016, H4_2016, H1_2019, H4_2012, H3_2016, H4_2017, H3_2017, H4_2018, H10_2018, H1_2016, H4_2019
99-90	5	H2_2016, H5_2012, H10_2019, H10_2012, H2_2019
89-80	5	H5_2017, H5_2018, H5_2019, H10_2016, H9_2019
79-70	10	H1_2018, H9_2017, H3_2012, H9_2018, H9_2016, H3_2018, H3_2019, H5_2016, H1_2017, H7_2012
69-60	10	H8_2017, H8_2019, H8_2018, H10_2017, H7_2016, H1_2012, H6_2019, H6_2018, H6_2017, H8_2016
59-50	7	H6_2012, H2_2012, H2_2018, H8_2012, H2_2017, H7_2019, H7_2017
49-40	2	H7_2018, H9_2012
39-30	0	
29-20	0	
19-10	0	
9-0	0	

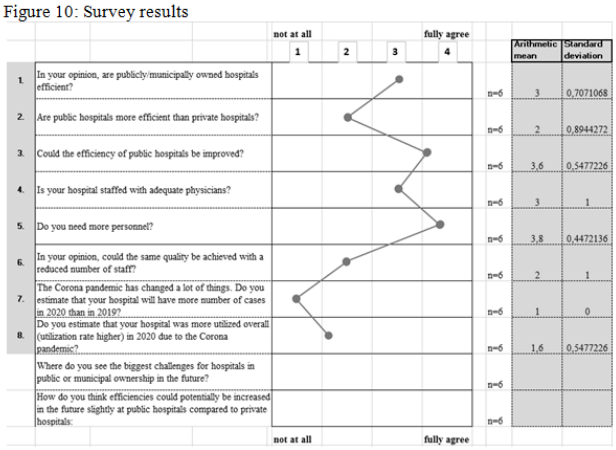
Source: Own illustration.

Table 5: Name of the hospitals (DMUs)

DMU	Name of public hospital
1	Klinikum Stuttgart - Katharinenhospital, Olgahospital / Frauenklinik
2	Klinikum Stuttgart - Krankenhaus Bad Cannstatt
3	Klinikum Böblingen
4	Krankenhaus Herrenberg
5	Krankenhaus Leonberg
6	Kliniken Sindelfingen
7	medius KLINIK KIRCHHEIM
8	medius KLINIK NÜRTINGEN
9	medius KLINIK OSTFILDERN-RUIT
10	Klinikum Esslingen GmbH

Source: Own illustration.

Figure 10: Survey results



Source: Own illustration.

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Fuzzy Trinomial Tree Pricing Model of Real Options and its Application

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Abstract According to the common features in the venture capital investment—high input, high yield and high risk, people always invest by stages which is becoming more and more important in economic activities with the more complicated market environment. So the evaluation of the investment is getting more people's attention. And the traditional evaluation method such as comparison method, proportion method, maturity method, the internal rate of return method, scene analysis method, decision trees method and the net present value method and so on, not fully considering the uncertainty and the Characteristics of stage of the investments of the project, can't estimate the value of the project rationally. So we come up with the fuzzy real options method.This paper firstly introduces the venture investment and real option theory briefly. Next it construct the classic Trinomial tree pricing method of American options, whose underlying asset the executed price are given beforehand, and analysis the real options existing in the project and their interactions, then use the method to calculate the value of the growth options combined with the choice the investment scale.

1. Keywords

2. Real option, Fuzzy method, Trinomial Tree.

JEL Classification G11

1 Introduction

Before the emergence of real option theory, company managers and decision makers always rely on intuition and experience to perceptually measure the interaction between management flexibility and decision-making strategy. Hayes and Abernathy (1980) [1], and Hayes and Garvin (1982) [2] have long recognized that traditional NPV methods often underestimate the value of projects, leading to short-term decisions, insufficient investment, and even loss of competitiveness. The reason is because they did not consider it reasonably. The value of strategic decisions. In view of this situation, Hertz (1964) [3] and Magee (1964) [4] suggested using simulation and decision tree methods to estimate the value brought by management flexibility, but there are still certain limitations. Then Myers (1987) [5] demonstrated that the widespread application of the NPV method in basic theory is part of the reason for this problem, and proposed that the traditional NPV method has great limitations. What it means is simple because it is based on the assumption that future cash flows occur according to a set budget, and that investments are reversible and irreversible. Most of these assumptions are not met in reality, so he proposed that the real option method is used for major decision-making projects. The best way to evaluate. Since then, more and more research on the theory of real options.

Leons Trigeorgis(1996)[6] divided the real option into eight categories: option to defer, default option, abandon option, expansion option, Shrinking option, shutdown and restart options, conversion options and growth options. Kester(1984) and Trigeorgies (1998)[7] propose a real-options classification scheme that is motivated by similarities and differences with financial options, distinguishes between simple and compound options, and proprietary and shared options.

Due to the complexity of the financial environment, investors often do not adopt a one-time investment method, but instead use a gradual approach to enter the project to diversify risks. Therefore, venture capital is mostly a staged investment. Then, there are real options in each stage of venture capital, and these options do not exist alone but affect each other. Trigeorgis (1993) [8] specifically studied the mutual effects of real options. He pointed out that the existence of follow-up options can increase the value of

pre-emptive options, and the exercise of pre-emptive options will also affect the value of follow-up options. This is because the exercise of a leading option can change the value of the underlying asset itself, thereby affecting the value of subsequent options. Therefore, the value of a set of real options will be significantly different from the sum of individual options, that is, the value of real options is not Additivity.

The pricing of real option can be found from the paper which Black and Scholes (1973)[9] and Merton(1973)[10], this is the famous function, B-S model. After that Cox, Ross and Rubinstein(1997) propose the generalized Cox-Ross-Rubinstein Binomial models, it can be used to pricing discrete time option. Geske (1979) [11] gives compound options (that is, options whose underlying assets are options) evaluation method. In a multi-stage binary tree model, Silvia, Muzzioli, Costanza, and Torricelli (2004) [12] use standard triangular fuzzy numbers to estimate the probability distribution of stock prices move, and then calculate the option price based on the average of the probabilities obtained. Christer Carlsson and Robert Fuller (2002) [13] used trapezoidal fuzzy numbers to estimate the project cash flow discount value and investment cost, and used the B-S pricing model to calculate the value of delayed real options. Later, the trapezoidal fuzzy numbers were applied to multi-stage venture capital. And multi-step tri-tree model for solving.

Zhihua Hei and Meiqiong Yang(2006)[14] propose the price of European option under the ternary option model, which is of two different discrete kinds. That is, it is assumed that there are three states of the change in the price of the underlying asset, namely, rising, constant, and falling, and the probability that the price is constant is constant. The author first calculates the value of a single-term tri-tree option, then uses the backward method to derive the value of the option at each node, and finally gives the option price expression by mathematical induction.

Liu Shuxia (2008) [15] wrote an article about the research and development of option pricing theory in a fuzzy environment from four aspects. One is the study of European option pricing based on fuzzy theory, mainly the introduction of B-S method. The study of American option pricing; the third is the study of binary tree pricing based on fuzzy theory, which mainly introduces the fuzzy European option binary tree pricing and the fuzzy American option binary tree pricing; the fourth is the study of real option pricing based on fuzzy theory. The author suggests that the fuzzy binary tree model Used in real options calculations. Zhu Danmei, Zhang Tie, Chen Dongling, Gao Hongxia (2008) [16] use normal fuzzy numbers to process the discounted value of the project's net income cash flow, calculate its mean and variance, and insert it into the BS formula (the mean is the value of the underlying asset, and the variance is Is the volatility of the underlying asset change), and the value of the real option is obtained.

Zdenek Zmeskal(2010)[17] had proposed the generalized soft binomial American real option pricing model. It is stochastic discrete binomial models and continuous models are usually applied in option, and valuation under fuzzy numbers(T-numbers).

In this paper, we will study the Fuzzy Trinomial Tree Pricing Model of Real Options and its Application. The paper will be divided into three parts, first part is introduction, we will describe the real option research in world, refer some famous theory and papers. The second part is about theory and formulations, we describe the Trinomial Tree Pricing Model and introduce the fuzzy theory into it, then use the Fuzzy Trinomial Tree Pricing Model to calculation our example. Last part we will make a conclusion for our results.

2 Methodology and Data

Definition 1: A fuzzy set is commonly defined by a membership function(μ) as representation from [0,1], $\mu_A(X)$ is the X to collection $\tilde{A}$.

Definition 2: If the collection $\tilde{A}$ is in U, $\lambda\epsilon[0,1]$, $\tilde{A}_\lambda$={x|x$\epsilon U, \mu_{\tilde{A}}(X) \geq \lambda$}, we named the $\tilde{A}_\lambda$ is the Cut.

Definition 3: Non-linear triangular fuzzy collection $\tilde{A}$, we remember M(a,b,c), a<b<c, $m, n \geq 0$, the membership function is:

$$\mu_{\tilde{A}}(X)\begin{cases} 0, x < a \\ 1-\left(\frac{b-x}{b-a}\right)^{m}, a \le x \le b \\ 1-\left(\frac{b-x}{b-c}\right)^{n}, b < x \le c \\ 0, x > c \end{cases}$$

Probability mean and variance of nonlinear triangular fuzzy numbers:

Assumption $\tilde{A}$ and $\tilde{B}$ are non-liner triangular number, it means A=M(a_1, a_2, a_3), B=$M(b_1, b_2, b_3)$, so we can get the cut for λ, $\tilde{A}_\lambda = [\tilde{A}_\lambda^-, \tilde{A}_\lambda^+]$, $\tilde{B}_\lambda = [\tilde{B}_\lambda^-, \tilde{B}_\lambda^+]$, $\forall\ \lambda\epsilon[0,1]$.

According to the Goetschel and Voxman (1986), we can get the rank:

$$\tilde{A} < \tilde{B} \Leftrightarrow \int_0^1 \lambda(\tilde{A}_\lambda^- + \tilde{A}_\lambda^+)d\lambda \le \int_0^1 \lambda(\tilde{B}_\lambda^- + \tilde{B}_\lambda^+)d\lambda \quad (2.1)$$

Garlsson and Fuller give the $\tilde{A}$ cut λ a mean:

$$\overline{M}(A) \coloneqq \int_0^1 \lambda\left(\tilde{A}_\lambda^- + \tilde{A}_\lambda^+\right)d\lambda = \frac{\int_0^1 \lambda \frac{\left(\tilde{A}_\lambda^- + \tilde{A}_\lambda^+\right)}{2} d\lambda}{\int_0^1 \lambda\, d\lambda} \quad (2.2)$$

So we can get the upper limit of the cut:

$$\overline{M}^*(A) = \frac{\int_0^1 Pos[A \ge \tilde{A}_\lambda^+] \times max\tilde{A}_\lambda d\lambda}{\int_0^1 Pos\left[A \ge \tilde{A}_\lambda^+\right] d\,\lambda} \quad (2.3)$$

The under limit of cut is：

$$\overline{M}_*(A) = \frac{\int_0^1 Pos[A \le \tilde{A}_\lambda^+] \times min\tilde{A}_\lambda d\lambda}{\int_0^1 Pos\left[A \le \tilde{A}_\lambda^+\right] d\,\lambda} \quad (2.4)$$

Assumption on the Trinomial Tree Pricing Model:

(1) The market is complete, meaning no arbitrage opportunities.

(2) The change of the underlying asset over time obeys geometric Brownian motion:

$$\frac{\Delta S}{S_0} = \mu\Delta t + \sigma\varepsilon\sqrt{\Delta t} \quad (2.5)$$

Write in the differential from:

$$dS = S\mu dt + S\sigma dz \quad (2.6)$$

In This formulation, ΔS is the change of the underlying assets, S_0 is the initial price, μ is the Expected rate of return on the underlying asset per unit of time. σ is the volatility of the underlying assets, ε obey the normal distribution and Δt is the time period, S is the Value of the underlying asset, dz is the wiener process.

(3) The risk-neutral world assumes that no transaction fees and taxes are paid when investing in a project.

(4) Assume that the three states of the underlying asset price change are rising, unchanged, and falling. The corresponding proportions are *u*, *m*,*d*, it means when the underlying assets rise

to *uS*, unchanged is *mS*, and down to *dS*, and corresponding probability is $p^+, p\ \ , p^-,$ and sum of them is 1.

(5) It is assumed that the value of the underlying asset after two applications is irrelevant to the movement order, that is, if the value of the underlying asset first decreases and then rises, it is consistent with the value after rising and then decreasing.

We know the underlying assets obey the geometric Brownian motion, so in very tiny time period (Δt), the underlying assets change obey $\frac{\Delta S}{S} = \mu\Delta t + \sigma\varepsilon\sqrt{\Delta t}$, it same as $dS = S\mu dt + S\sigma dz$, so we can get:

$$E(S) = Se^{\mu\Delta t} \tag{2.7}$$

Because investors are risk-neutral in a risk-neutral world, the expected return on the underlying asset is μ = r, where r is the risk-free rate of return, so the above formula can be rewritten as:

$$E(S) = Se^{r\Delta t} \tag{2.8}$$

According to the Ito's lemma, we can get the formulas:

$$\Delta S^2 = \left(\frac{\partial(S^2)}{\partial S}r + \frac{\partial(S^{2)}}{\partial t} + \frac{1}{2}\cdot\frac{\partial^2(S^2)}{\partial S^2}\right)\Delta t + \frac{\partial(S^2)}{\partial S}\Delta z \tag{2.9}$$

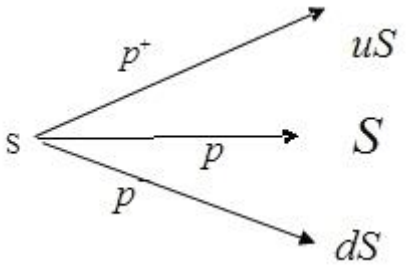
$$\Delta S^3 = \left(\frac{\partial(S^3)}{\partial S}r + \frac{\partial(S^{3)}}{\partial t} + \frac{1}{2}\cdot\frac{\partial^2(S^3)}{\partial S^2}\right)\Delta t + \frac{\partial(S^3)}{\partial S}\Delta z \tag{2.10}$$

If we simplify them we can get:

$$E(S^2) = S^2e^{(2r+\sigma^2)\Delta t} \tag{2.11}$$

$$E(S^3) = S^3e^{(3r+3\sigma^2)\Delta t} \tag{2.12}$$

From the assumption (4) we can know the figure below:



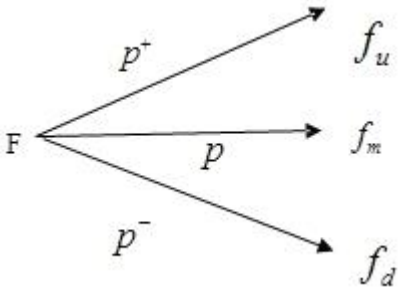


Figure1: Assets price change (Single step) Figure2:Option Price change (Single step)

According to the expectation, we can get the formulas below:

$$E(S) = p^+uS + pS + p^-dS \tag{2.13}$$

$$E(S^2) = p^+(uS)^2 + pS^2 + p^-(dS)^2 \tag{2.14}$$

$$E(S^3) = p^+(uS)^3 + pS^3 + p^-(dS)^3 \tag{2.15}$$

We can get the equation set based on the assumption (4), and formula (2.6), (2.9) and (2.10).

$$\begin{cases} p^+ + p + p^- = 1 \\ ud = 1 \\ up^+ + p + dp^- = e^{r\Delta t} \\ u^2p^+ + p + d^2p^- = e^{(2r+\sigma^2)\Delta t} \\ u^3p^+ + p + d^3p^- = e^{(3r+3\sigma^2)\Delta t} \end{cases} \tag{2.16}$$

We solve the equations set: we can get at$[i\Delta t, (i+1)\Delta t)$, we have:

$$p^+ = \frac{e^{r\Delta t}(1+d) - e^{(2r+\sigma^2)\Delta t} - d}{(d-u)(u-1)} \tag{2.17}$$

$$p = \frac{e^{r\Delta t}(u+d) - e^{(2r+\sigma^2)\Delta t} - 1}{(1-d)(u-1)} \tag{2.18}$$

$$p^- = \frac{e^{r\Delta t}(1+u) - e^{(2r+\sigma^2)\Delta t} - u}{(d-u)(1-d)} \tag{2.19}$$

$$u = M + \sqrt{M^2 - 1} \tag{2.20}$$

$$d = M - \sqrt{M^2 - 1} \tag{2.21}$$

$$M = \frac{e^{r\Delta t} + e^{(3r+3\sigma^2)\Delta t} - e^{(2r+\sigma^2)\Delta t} - 1}{2\left[e^{(2r+\sigma^2)\Delta t} - e^{r\Delta t}\right]} \tag{2.22}$$

These formulas is very complex, so we use Taylor formula to simplify, we can get:

$$p^+ = \frac{1}{6} + \left(r - \frac{\sigma^2}{2}\right)\sqrt{\frac{\Delta t}{12\sigma^2}} + o\left(\sqrt{\Delta t}\right) \tag{2.23}$$

$$p = \frac{2}{3} + o\left(\sqrt{\Delta t}\right) \tag{2.24}$$

$$p^- = \frac{1}{6} - \left(r - \frac{\sigma^2}{2}\right)\sqrt{\frac{\Delta t}{12\sigma^2}} + o\left(\sqrt{\Delta t}\right) \tag{2.25}$$

$$u = e^{\sigma\sqrt{3\Delta t}} = 1 + \sigma\sqrt{3\Delta t} + \frac{3\sigma^2\Delta t}{2} + o(\Delta t) \tag{2.26}$$

$$u = e^{-\sigma\sqrt{3\Delta t}} = 1 - \sigma\sqrt{3\Delta t} + \frac{3\sigma^2\Delta t}{2} + o(\Delta t) \tag{2.27}$$

Here we sign the $\tilde{V} = M(v_1, v_2, v_3)$, $\tilde{I} = M(i_1, i_2, i_3)$, in this we have $v_1 < v_2 < v_3$, and the $i_1 < i_2 < i_3$, so we can get the cut for $\tilde{V}$ and $\tilde{I}$.

$$\tilde{V}_\lambda = [\tilde{V}_\lambda^-, \tilde{V}_\lambda^+] = [v_2 - (v_2 - v_1)(1-\lambda)^{\frac{1}{m}}, [v_2 - (v_2 - v_3)(1-\lambda)^{\frac{1}{n}}), \forall\, \lambda\epsilon[0,1] \tag{2.28}$$

$$\tilde{I}_\lambda = [\tilde{I}_\lambda^-, \tilde{I}_\lambda^+] = [i_2 - (i_2 - i_1)(1-\lambda)^{\frac{1}{m}}, [i_2 - (i_2 - i_3)(1-\lambda)^{\frac{1}{n}}], \forall\, \lambda \epsilon [0,1] \quad (2.29)$$

According to the formula (2.37) and (2.38), we can get the mean and variance of $\tilde{V}$ and $\tilde{I}$, they show below:

$$\bar{M}(\tilde{I}) = i_2 - \left[\frac{2n^2(i_2 - i_3)}{(1+n)(1+2n)}\right] - \left[\frac{2m^2(i_2 - i_1)}{(1+m)(1+2m)}\right] \quad (2.30)$$

$$\bar{M}(\tilde{V}) = i_2 - \left[\frac{2n^2(v_2 - v_3)}{(1+n)(1+2n)}\right] - \left[\frac{2m^2(v_2 - v_1)}{(1+m)(1+2m)}\right] \quad (2.31)$$

$$Var(\tilde{V}) = \left[\frac{n^2(v_2 - v_3)^2}{4(1+n)(1+2n)}\right] + \left[\frac{m^2(v_2 - v_1)^2}{4(1+m)(1+2m)}\right] - \left[\frac{m^2n^2(v_2 - v_1)(v_2 - v_3)}{(m+n+2nm)(m+n+mn)}\right] \quad (2.32)$$

We know the variance of $\tilde{V}$ is the variance of the net present value of project, so we can get the volatility of the project's discounted flow value $\tilde{\sigma}(\tilde{V})$, similarly, we can get the volatility of the investment cost $\tilde{\sigma}(\tilde{I})$, at the given risk free rate and estimate $\tilde{\sigma}(\tilde{V})$, according to formular (2.15) to (2.22), we can get the fuzzy parameters $\tilde{u}$, $\tilde{d}$,$\tilde{p}^+$, $\tilde{p}$, $\tilde{p}^-$.
We can get the European put:

$$F\left(M(\tilde{V}_0), 0\right) = e^{-rn\Delta t} \sum_{i,j=0}^{n} \frac{n!}{i!\, j!\, (n-j-i)!} \tilde{P}^{+i} \tilde{p}^j \tilde{p}^{-(n-j-i)} \left(M(\tilde{I}) - M(\tilde{V}_0) \tilde{u}^i \tilde{d}^{(n-j-i)}\right)^+ \quad (2.33)$$

European Call:

$$F\left(M(\tilde{V}_0), 0\right) = e^{-rn\Delta t} \sum_{i,j=0}^{n} \frac{n!}{i!\, j!\, (n-j-i)!} \tilde{P}^{+i} \tilde{p}^j \tilde{p}^{-(n-j-i)} \left(M(\tilde{V}_0) \tilde{u}^i \tilde{d}^{(n-j-i)} - M(\tilde{I})\right)^+ \quad (2.34)$$

3 Application

Company X, located in Beijing, is a group-owned joint-stock company specializing in the development, production, sales and service of medical equipment, medical spare parts and medical information management software.

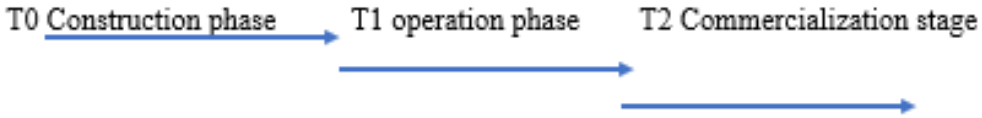
Now company X will invest 2200(in 10 thousand) to R&D, and the investment will be divided into 3 terms. $\boldsymbol{I_0 = 500, I_1 = 100, I_2 = 1600}$.

Table 1. Expected net cash flow

Year	3	4	5	6	7	8	9	10
Stage 2	35	35	35	35	35	35		
Stage 3		500	500	500	500	500	500	500

We know the benchmark rate of return project in this industry w=17%, and the risk-free rate r=10%.

Figure 1. Multi-stage investment.



In this paper we treat the project has three stage, it has two expansion option, so the project initial value is:$ENPV = NPV + F_1 + F_2$

Table 2.Fuzzy Trinomial Real Option Pricing Model

m	n	v_1	v_2	v_3	i_1
2	2	29	35	41	81
i_2	i_3	$M(\tilde{I})$	$M(\tilde{v})$	$Var(\tilde{S})$	$\tilde{\sigma}$
100	120	113	35	1464	38%

Source: Calculation

From formula (2.28) to (2.32) we can get the table 2, in this number m and n are from the experts, them reflect the degree of change in the discounted value of the project's net income and investment costs, which are related to the market conditions of the industry involved in the project.

Table3: trinomial of F1

TIME($\Delta t = 0.25\ year$)				
t_0	$t_0 + \Delta t$	$t_0 + 2\Delta t$	$t_0 + 3\Delta t$	$t_0 + 4\Delta t(T_1)$
15.836	47.072	93.11	160.27	254.18
	15.927	44.15	89.90	157.43
	2.9931	12.11	41.65	85.97
		1.285	7.216	40.51
		0	0	0
			0	0
			0	0
				0

Source: calculation

Table3: trinomial of F2

TIME($\Delta t = 0.25\ year$)				
t_1	$t_1 + \Delta t$	$t_1 + 2\Delta t$	$t_1 + 3\Delta t$	$t_1 + 4\Delta t(T_2)$
297.76	728.91	1452.50	2471.36	3863.88
	247.33	680.48	1413.90	2341.87
	48.44	188.85	632.95	1374.31
		22.64	116.40	593.27
		0.5227	2.9343	16.4717
			0	0
			0	0
				0

Source: calculation

So we can get the results:

$$ENPV = NPV + F1 + E^{-r(t1-t0)}F2 = 128.9438 > 0$$

4 Conclusion

This paper first introduces the classic three-tree real option pricing model and applies it to venture capital, then points out its shortcomings, introduces the theory of non-linear triangular fuzzy numbers, and constructs it based on the uncertainty and phased nature of venture capital. Fuzzy Trinomial Real Option Pricing Model. The advantages of this model are: (1)Take into account the flexibility of project management and strategic decision-making that are not considered in traditional project evaluation methods, and use real options to calculate their value, making project evaluation more reasonable; (2) Classic three-trinomial real options The discounted value of project cash flow returns and investment costs treated as precise values in the pricing model are fuzzy treated with a non-linear triangular fuzzy number, and the volatility of the discounted value of cash flow returns also becomes a fuzzy number (discounted cash flow value) The probability variance is a fuzzy number), so that the uncertainty of the real environment is introduced into the model, and the interval range of each parameter is obtained through expert evaluation methods, and the original mean value is replaced by its probability mean. Because when calculating the magnitude and probability of the target asset's rise, invariance, and decline, they are all characterized by volatility, so the amplitude and probability of their rise, invariance, and decline become fuzzy numbers. Because the external environment has a large amount of uncertainty, the fuzzy-triangulated tree model can better reflect this uncertainty into the real option pricing model, thereby more realistically estimating the value of the project and providing investors with more decisions.

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CONVERGENCE OF HEALTH EXPENDITURE OF EUROPEAN UNION COUNTRIES

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Abstract

In 2004, Slovakia became part of the member states of the European Union. However, the accession negotiations were conditional on the fulfilment of the Maastricht criteria focused on the country's macroeconomic indicators. After 17 years, we consider it beneficial to find out whether Slovakia is approaching European countries in the field of health and healthcare. The aim of the paper is to assess the convergence of health expenditure in the countries of the European Union. The theoretical part of the paper focuses on professional studies using the convergence method in the field of health. Based on the analysis of absolute β-convergence and σ-convergence we find that there is a convergence of health expenditures between the examined countries in the period 2004-2019. We use mathematical-statistical methods of linear regression and cluster analysis to examine convergence. The results show that the examination of the indicator of health expenditure (per capita) leads to the convergence of the member states of the European Union. However, we include Luxembourg among the outliners of the member states of the European Union.

Keywords

Health. Convergence. Expenditure. Healthcare. European Union.

JEL Classification
I15. H51. C58

1 Introduction

The process of examining convergence took place most significantly at the time of Slovakia's accession to the Member States of the European Union. During this period, it was a matter of monitoring uniformly determined indicators of equilibrium development (Kowalski, 2003), i.e. the convergence of certain macroeconomic indicators to a level that would ensure the economic stability of the state in an integrated European territory. The so-called *The Maastricht criteria* also conditioned the adoption of a common European currency.

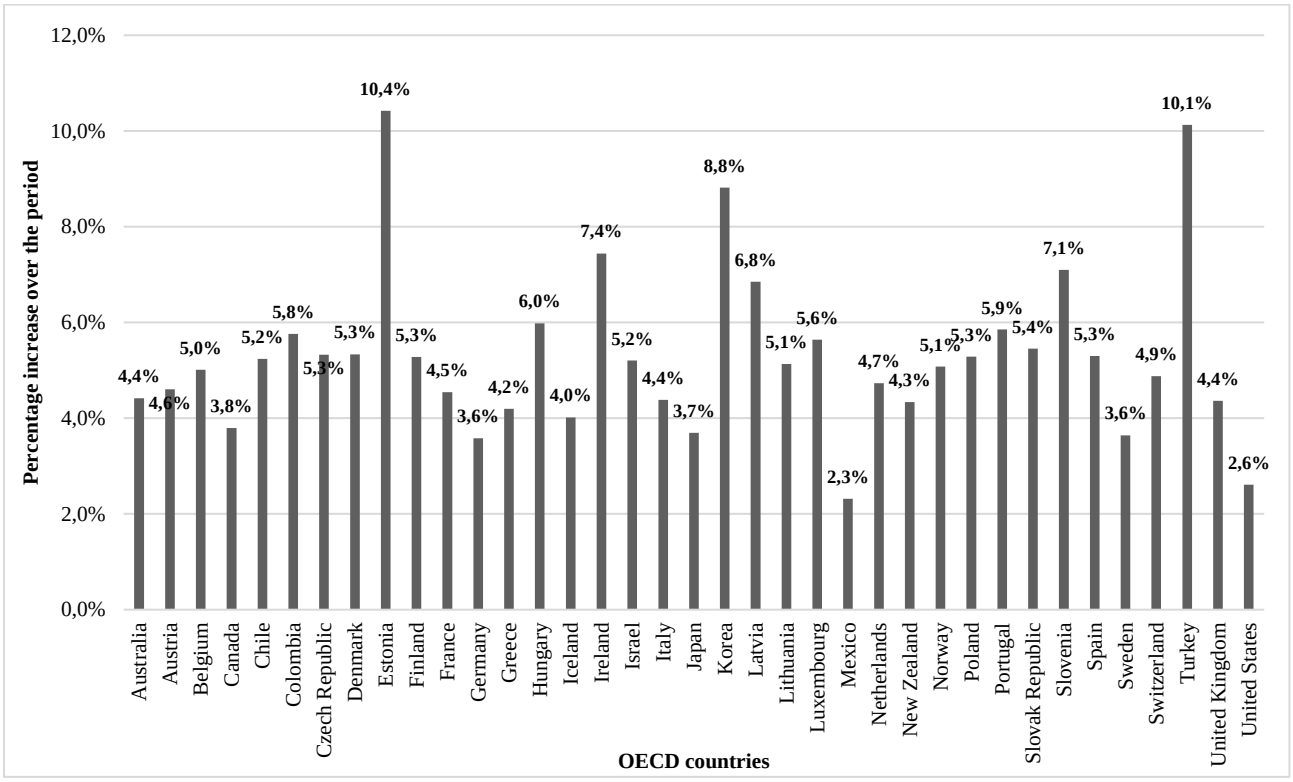
The concept of convergence from a general point of view (Berančok, et al., 2006) expresses the process of balancing the differences of various economic indicators within a group of countries. Barro and Sala-i-Martin (1992) state that convergence addresses a key economic problem, namely whether countries with low per capita gross domestic product (GDP) tend to grow faster than countries with higher GDP. That is, whether there are automatic forces that over time lead to the convergence of income levels per capita. Monitoring the convergence of GDP per capita in the countries of the European Union has been the subject of several expert papers (Blackwell, Hefner, Lindberg, 2014; Bergeaud, Cette, Lecat, 2019; Pietrzykowski, 2019; etc.). In the article, we extend this perception to the field of health.

Health and economic performance are interlinked. The good health of the population contributes to the economic recovery and development of the country. The health situation of the population is influenced by various socio-economic factors, like the health policy applied in the country and the resources spent on health (Ondruš, Ondrušová, 2017). Sachs (2001) states that the health situation of the population is also reflected in macroeconomic indicators, when countries with poor health or educational conditions are much more demanding in achieving economic growth.

2 Literature Review

These claims are confirmed by research by Bloom, Canning, Sevilla (2001), who added the parameter life expectancy to the study of economic growth. Research has shown that health has a positive and statistically significant effect on economic growth. Improving life expectancy contributes to a 4 % increase in production. This effect suggests that increased spending to improve the health of the population has a positive effect primarily on labour productivity and secondarily on the country's economic growth. Based on this, we conclude that the convergence study can also be applied to health-related indicators.

Figure 12. Total change in average life expectancy in OECD countries in the period 2000 – 2018 (in %)



Source: own processing according to OECD data (2021)

Several authors have addressed the relationship between health and economic growth (Kalemi-Ozcan et al., 2000; Jamison, et al., 2004; Aslan, 2008; Apergis, Padhi, 2013; Pan, Wang, Qin, 2013; etc.). Analysis of the interrelationships between health and economic growth are performed at the level of individuals, at regional levels within a country (most often through the NUTS division), as well as at the national and international levels (Bhargava, et al., 2001).

Aslan (2008) examined the convergence of health expenditures (per capita) in 19 OECD countries between years 1970 and 2005. The results showed that inequalities in health expenditure (per capita) between OECD countries will not disappear over the period under review but are transforming. The

research confirmed the strong position of the United States of America, which has long had high per capita expenditures, expressed as a share of GDP expenditures. At the same time, it is important to add that life expectancy in the United States of America has one of the lowest growth rates compared to OECD countries. This is graphically presented in Figure 1. The overall increase in life expectancy in the United States of America is only at 2.6 % level in the period 2000-2018, an increase to 0.143 % per year. Compared to this result, the average of the countries of the European Union reaches an overall increase of 5.476 % over the period of the observed years.

Authors Kerem, Püss, Viies, Maldre (2008) studied the convergence of health expenditure in the 23 member states of the European Union. In this work, they use the study of β-convergence, σ–convergence and
γ-convergence, through which they determine the convergence of indicators of total health expenditure expressed as a percentage of GDP and total health expenditure expressed in purchasing power parity per capita. The results of the analysis suggest that the convergence rate has been growing at 7 % since 1992 (lasting around 10 years), before closing about half of the health expenditure gap (as a share of GDP) between the
EU-8 and the EU-15. Compared to the base period up to the year 2000, statistically significant differences in the assessment of individual countries arose, later the convergence process stabilized. The countries in the lowest position, namely Portugal, Austria, and Greece, have improved their position and the countries of Finland and Denmark have fallen from their initial positions.

The analysis, which in turn did not show convergence at the regional level, was performed by Pan, Wang, Qin, et al. (2013). The results show that there are large regional differences in government health spending (referred to as GHE) in China. The authors applied the concept of convergence to test whether the Chinese provincial GHE is approaching between 1997 and 2009. Based on the panel data of the provinces, the author found that the provincial GHE per capita in the short term does not show absolute β-convergence or conditional
β-convergence. Using the breakdown into convergence clubs (East, Middle and West), the results also show no evidence of short-term β-convergence at the regional level. The analysis confirms significant regional differences in the monitored indicators.

3 Materials and Methods

Based on the theoretical knowledge of convergence research compiled from studies, the aim of the paper is to identify the convergence of health expenditure in the countries of the European Union. Following the research model (Kerem, Püss, Viies, Maldre, 2008), health expenditure is monitored through indicators, health expenditure as a share of GDP (in %) and health expenditure in purchasing power parity per capita (in EUR). The object of the research is the member states of the European Union in the period 2004 - 2019, i.e. including the United Kingdom. The database was created from data published by the OECD Statistics portal (2021) for the period 2004 - 2019. The monitored time series is limited to 2019 due to the unavailability of newer data. For further research, we recommend considering the consequences of the corona crisis and their impact on health expenditures. In the paper we use the method of absolute β-convergence and σ-convergence.

Convergence is considered a dynamic tool based on the neoclassical theory of growth. The presence of β -convergence (Vyrostová, 2010) exists if an economically weaker country tends to grow faster than an economically stronger country. From an economically weaker country, there is a "catch-up" in terms of per capita income or product. β-convergence expresses a negative relationship between the initial value and the average growth rate coefficient (Kováč, Gerulová, Buček, 2011). Based on the β-convergence calculation, it is possible to calculate the σ-convergence using the coefficient of variation. β-convergence is a necessary condition for the study of σ-convergence. Using the σ-convergence method, we examine how the distribution between indicator levels has changed or how the differences in indicators within groups of countries change compared to the average (Barro, Sala-i-Martin, 1992). The econometric expression of absolute β-convergence (1) is as follows:

$$\frac{1}{T} log \left(\frac{Y_{iT}}{Y_{i0}}\right) = \alpha - \beta \log Y_{i0} + \varepsilon_i \quad (1)$$

It holds that if the parameter β <0, then there is absolute convergence. We will determine the absolute β-convergence based on the result of the linear regression function (2) according to the formula (Ostertágová, 2013):

$$Y_{iT} = b_0 + b_1 * Y_{i0} + \varepsilon \quad (2)$$

For statistical evaluation, we use the p-value test, while the level of significance is set at α = 0.05. We use the mathematical-statistical program SPSS Statistics to calculate the linear regression analysis. To calculate
σ-convergence (3), we use the expression using the coefficient of variation (Simionescu, 2014):

$$\sigma^2 = \frac{1}{n}\sum_{i=1}^{N}\left[\log(Y_{iT}) - \overline{logY_T}\right] \quad (3)$$

σ-convergence occurs when the value of the indicator σ decreases during the observed period. Convergence means converging the indicator of a given country. The opposite term is called divergence, which means the distance of the country and the emergence of disparities. To evaluate disparities (Stankovičová, Vojtková, 2007) it´s appropriate to apply multidimensional statistical methods such as cluster analysis,
in-depth data analysis, factor analysis, correlation analysis, etc.

4 Empirical Results

In Table 1, we express the values for the calculation of the absolute β-convergence of the health care expenditure indicator expressed in purchasing power parity per capita.

Table 3. Expenditure on health (per capita) of EU countries

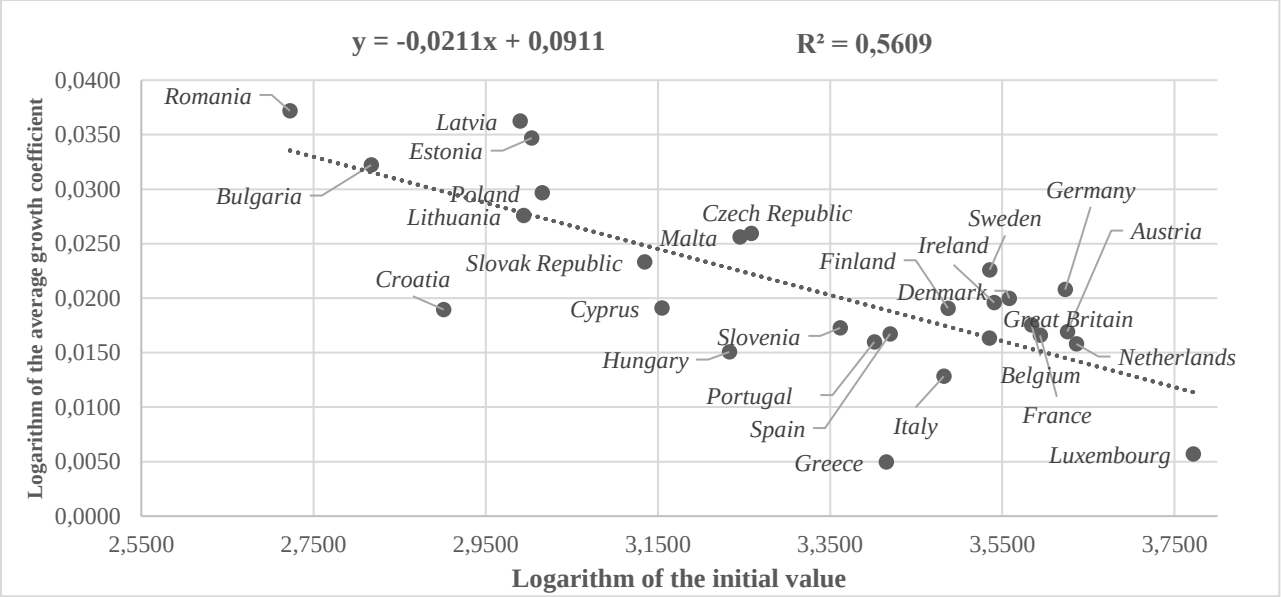
Country	2004 (Y_{i0})	2019	Average growth coefficient (Y_{iT})	log Y_{i0}	log Y_{iT}
Austria	4 222,69 €	7 577,12 €	1,040	3,626	0,017
Belgium	3 836,45 €	7 029,20 €	1,041	3,584	0,018
Czech Republic	1 812,46 €	4 439,14 €	1,062	3,258	0,026
Denmark	3 615,68 €	7 210,43 €	1,047	3,558	0,020
Estonia	1 007,84 €	3 339,54 €	1,083	3,003	0,035
Finland	3 068,58 €	5 929,05 €	1,045	3,487	0,019
France	3 925,54 €	6 961,53 €	1,039	3,594	0,017
Germany	4 198,59 €	8 606,26 €	1,049	3,623	0,021
Greece	2 600,73 €	3 086,80 €	1,011	3,415	0,005
Hungary	1 710,24 €	2 878,04 €	1,035	3,233	0,015
Ireland	3 472,30 €	6 831,83 €	1,046	3,541	0,020
Italy	3 034,33 €	4 725,72 €	1,030	3,482	0,013
Lithuania	985,92 €	2 554,48 €	1,066	2,994	0,028
Latvia	977,25 €	3 416,38 €	1,087	2,990	0,036
Luxembourg	5 912,59 €	7 198,03 €	1,013	3,772	0,006

Netherlands	4 326,38 €	7 465,80 €	1,037	3,636	0,016
Croatia	796,61 €	1 747,52 €	1,044	2,901	0,018
Poland	1 036,83 €	2 887,33 €	1,071	3,016	0,030
Portugal	2 519,42 €	4 375,32 €	1,037	3,401	0,016
Slovak Republic	1 362,57 €	3 047,97 €	1,055	3,134	0,023
Slovenia	2 299,92 €	4 175,11 €	1,041	3,362	0,017
Spain	2 628,53 €	4 683,31 €	1,039	3,420	0,017
Sweden	3 431,29 €	7 488,07 €	1,053	3,535	0,023
Great Britain	3 427,93 €	6 025,71 €	1,038	3,535	0,016
Bulgaria	656,00 €	1 996,00 €	1,077	2,817	0,032
Cyprus	1 428,00 €	2 760,00 €	1,045	3,155	0,019
Malta	1 760,00 €	4 262,00 €	1,061	3,246	0,026
Romania	528,00 €	1 907,00 €	1,089	2,723	0,037

Source: own processing according to OECD data (2021)

We consider the year 2004 (column Y_{i0}) to be the initial year of the survey. Then we log the value of the average growth coefficient for each country (log Y_{iT} column). Based on the calculated values, we performed a linear regression analysis. Figure 2 presents the processing of the result of absolute β-convergence.

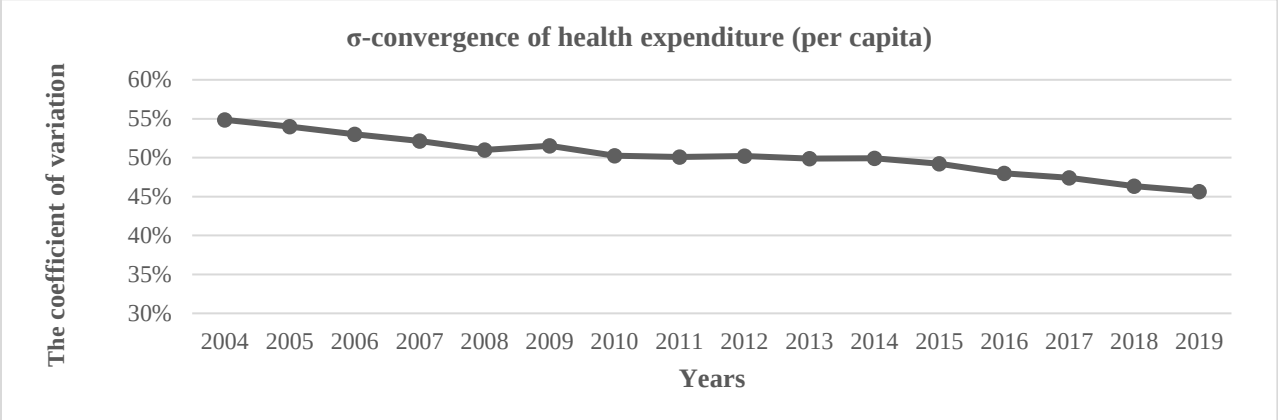
Figure 2. The result of absolute β-convergence of health expenditure (per capita) of EU countries



Source: own processing (2021)

The calculated linear regression function is as follows: log $Y_{iT} = - 0.0211Y_{i0} + 0.0911$ at the coefficient of determination 100R2 = 56.09%. The result of the p-value is as follows: α = 0,05, p-value = 0.003. Overall, we state the p-value < α, so the result of the linear regression analysis is of statistical significance. Absolute β-convergence showed that the monitored indicator converges countries. We notice the outliners, which are Greece and Luxembourg. These countries show a low increase in health care expenditure expressed in purchasing power parity per capita in the reference periods. To verify the result of the absolute β-convergence we perform σ-convergence analysis.

Figure 3. Result of σ-convergence of health expenditures (per capita) of EU countries (in %)



Source: own processing (2021)

The analysis of σ-convergence in Figure 3 shows that the coefficient of variation expressed as a percentage in the period 2004 - 2019 has the shape of a decreasing curve. This result confirms that there is a convergence of European countries in the indicator of health expenditure (per capita).

Table 2. Expenditure on health (% GDP) of EU countries

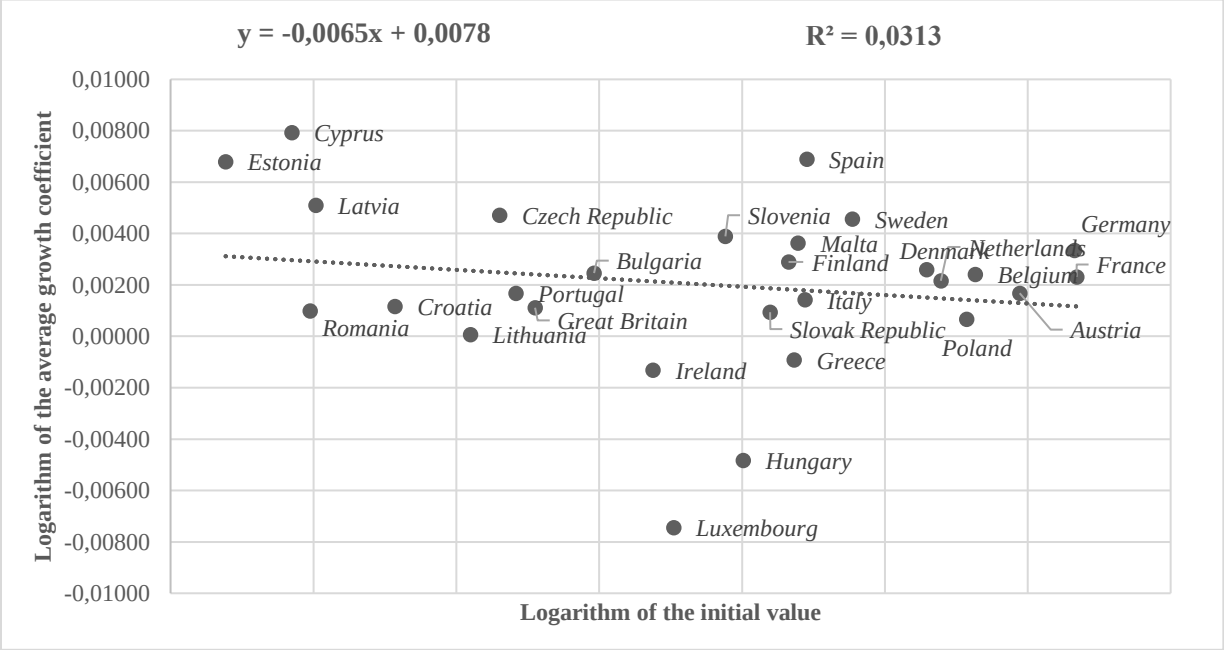
Country	2004 (Y_{i0})	2019	Average growth coefficient (Y_{iT})	log Y_{i0}	log Y_{iT}
Austria	9,7 %	10,4 %	1,004	0,987	0,002
Belgium	9,4 %	10,3 %	1,006	0,972	0,002
Czech Republic	6,4 %	7,8 %	1,011	0,805	0,005
Denmark	9,0 %	10,0 %	1,006	0,955	0,003
Estonia	5,1 %	6,8 %	1,016	0,709	0,007
Finland	8,1 %	9,1 %	1,007	0,906	0,003
France	10,2 %	11,2 %	1,005	1,007	0,002
Germany	10,1 %	11,7 %	1,008	1,006	0,003
Greece	8,1 %	7,8 %	0,998	0,908	-0,001
Hungary	7,8 %	6,4 %	0,989	0,890	-0,005
Ireland	7,2 %	6,8 %	0,997	0,859	-0,001
Italy	8,2 %	8,7 %	1,003	0,912	0,001
Lithuania	6,2 %	6,3 %	1,000	0,795	0,000
Latvia	5,5 %	6,8 %	1,012	0,741	0,005
Luxembourg	7,3 %	5,4 %	0,983	0,866	-0,007
Netherlands	9,1 %	10,0 %	1,005	0,960	0,002
Croatia	5,9 %	6,2 %	1,003	0,769	0,001
Poland	9,3 %	9,6 %	1,002	0,969	0,001
Portugal	6,5 %	6,9 %	1,004	0,811	0,002
Slovak Republic	7,9 %	8,3 %	1,002	0,900	0,001
Slovenia	7,7 %	9,0 %	1,009	0,884	0,004
Spain	8,2 %	10,9 %	1,016	0,913	0,007

Sweden	8,5 %	10,3 %	1,011	0,929	0,005
Great Britain	6,6 %	6,9 %	1,003	0,818	0,001
Bulgaria	6,9 %	7,6 %	1,006	0,838	0,002
Cyprus	5,4 %	7,5 %	1,018	0,732	0,008
Malta	8,1 %	9,4 %	1,008	0,910	0,004
Romania	5,5 %	5,7 %	1,002	0,739	0,001

Source: own processing according to OECD data (2021)

In Table 2 we express the values for the calculation of the absolute β-convergence of the health care expenditure indicator expressed as a percentage of GDP. However, based on the values of the average growth coefficient, we can assume that convergence will not be demonstrated in this case. Several countries show a decline in the share of health expenditure in GDP over the period. For verification, we perform a linear regression analysis. The graphical representation is shown in Figure 4.

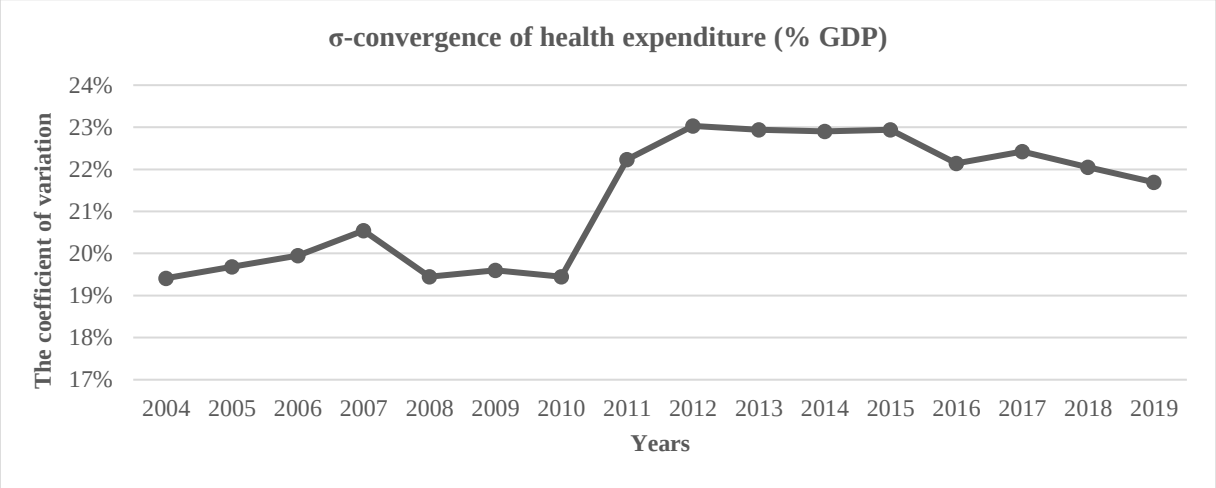
Figure 4. The result of absolute β-convergence of health expenditure (% GDP) of EU countries



Source: own processing (2021)

The equation of the linear regression function has the form: log Y_{iT} = - 0.0065Y_{i0} + 0.0078. Statistical test:
$\alpha = 0{,}05$; p-value = 0.007. We state that the p-value < α. Linear regression analysis has statistical significance. The coefficient of determination has a value of 100R2 = 3.13%, which is very low. We confirm our assumption that when examining the absolute β-convergence of the indicator health expenditure expressed as a percentage of GDP, does not converge countries. To confirm, we perform σ-convergence.

Figure 5. Result of σ-convergence of health expenditures (% GDP) of EU countries (in %)



Source: own processing (2021)

From the performed σ-convergence we state (Figure 5) that in the period 2007-2010 and 2017-2019 there is a slight convergence of expenditures on health care expressed as a percentage of GDP. During the years 2004 - 2007 and the period 2010 - 2015, there is a divergence of expenditures (% of GDP). The disparities between countries deepened. The results confirm that the examination of this indicator does not lead to the convergence of the countries of the European Union. For this reason, we use a multidimensional statistical method of cluster analysis. We perform cluster analysis by dividing the examined countries into 4 groups using the logarithm of the initial value and the logarithm of the average growth coefficient.

From the results of the cluster analysis, we find that in the first group are European countries with stronger economies like France, Germany, Austria, Belgium, the United Kingdom, Sweden, Malta, Finland, Spain, Denmark, and the Netherlands. Expenditure on health care accounts for a relatively high percentage of GDP in the initial period (country average 8.90 % of GDP). Also, expenditure on health (% of GDP) is growing faster per year (average of 0.765 % per year) than the average of the European countries surveyed. We can state that the indicator in this group of countries tends to diverge, grow faster, and move away from other member states.

The second group included the countries of Cyprus, Estonia, and Latvia. These countries showed below-average starting values (country average 5.34 % of GDP) combined with above-average annual growth (country average 1.53 % per year) of health expenditure (% of GDP). For this group of countries, the indicator examined will converge to the countries in the first group.

The third group included Slovakia, Bulgaria, Poland, Lithuania, Croatia, Ireland, Czech Republic, and Romania. For these countries, it is a combination of below-average baselines (country average 6.39 % of GDP) combined with below-average annual growth (country average 0.314 % per year) of health expenditure (% of GDP). The indicator examined in these countries will grow more slowly and fall behind the countries in the first group.

The fourth group consists of Italy, Slovenia, Greece, Hungary, and Portugal. These countries show above-average starting values (country average 8.25 % of GDP), but below-average annual growth (country average 0.124 %) of health expenditure (% of GDP). The decrease in the examined indicator is most pronounced in Ireland and Hungary, which reach negative values of the logarithm of the average growth coefficient. According to a report from the European Commission (2019), Hungary has the third lowest level of spending on health compared to other member states of the European Union, and the

average life expectancy is just 76 years.

Significant deviations occur in the case of Luxembourg, where the position of the outliner has been reaffirmed. The country shows a low growth in the share of health expenditure in GDP, while in calculating this expenditure per capita, it shows the third largest volume of funding within the countries of the European Union. We consider this to be the reason for the fact that Luxembourg is mostly occupied by citizens of neighbouring countries who are insured in their home countries. According to the WHO (2017), only 25 % of workers are insured in Luxembourg. However, the calculation of health expenditure (per capita) is based on the number of inhabitants residing in the country. The result is a paradox where, on the one hand, there is a low level of increase in health care expenditure in the period under review, on the other hand, in terms of economic maturity, a high value of health care expenditure per capita.

5 Conclusion

The aim of the paper is to assess the convergence of health expenditure in the countries of the European Union. An empirical analysis of health expenditure (per capita) carried out by examining the absolute β-convergence and σ-convergence of the countries of the European Union has shown that the countries are converging. However, when observing the absolute β-convergence and σ-convergence of health expenditure (% of GDP) in European countries in the period 2004-2019, convergence was not confirmed. Countries show different percentages of GDP for health expenditure and different growth of this indicator over the period. The same result was recorded in their research by the authors Kerem, Püss, Viies, Maldre (2008). Comparing the results, Luxembourg's position as an outliner was confirmed. The country shows above-average initial values (health expenditure per capita at 5,912 EUR in 2004) and low growth of indicators in the monitored periods.

When examining the convergence of health expenditure (per capita), we can also consider Greece as an outliner. Despite the above-average initial value (health expenditure per capita at 2,601 EUR in 2004), the country shows a low average growth of the indicator (at 1.15 % per year). According to the European Commission (2019), this development is due to the implementation of policies aimed at reducing the impact of the economic crisis in the period from 2008 to 2015. In 2017 Greece spent 1,623 EUR on health, which was below the European Union average (2,884 EUR per capita in 2017). In terms of financing the health system, more than a third of health expenditure in Greece comes from direct household payments for health.

Slovakia has not been studied in the research of Kerem, Püss, Viies, Maldre (2008). Based on the convergence, we find that Slovakia´s health expenditure per capita (at the level of 3,048 EUR for 2019) is close to the average of the V4 countries (average of the V4 countries at the level of 3,313 EUR in 2019), but below the average of European Union countries (average of countries EU at 4,878 EUR for 2019). A cluster analysis of health expenditure (% of GDP) showed that Slovakia ranked in the third group of countries. These countries are characterized by below-average initial values and below-average growth of the indicator during the observed period. Observing the average growth rate, we find that health expenditures (% of GDP) increased by 0.385 % annually and health expenditures (per capita) increased by 5.514 %. The Czech Republic recorded a similar placement result. However, when monitoring the values of the examined indicators in the case of the Czech Republic, they grow faster in the observed period, in contrast to Slovakia.

This paper confirms the link between economic growth and health expenditure. The Scandinavian countries, namely Sweden, achieve the best values of the surveyed indicators from the countries of the European Union. This country shows above-average values of health expenditure (per capita), as well as the second fastest growth of health expenditure (% of GDP) in the monitored periods. While maintaining the growth of indicators, the country will gradually deviate from the line of the linear regression function, divergences from other member countries and the position of an outliner. This development can also occur in the case of European countries with strong economies. Thus, the indicator

for health expenditure (% of GDP) will deepen disparities between the member states of the European Union.

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New insights into Family Business in the Czech Republic from the point of view of MCDM

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Abstract
In both Czech and international economies, family businesses are undeniably significant. They are also critical in the globalization process. They have always been the main source of private sector employment in the world. However, there has never been a unified concept of family business, making it difficult for the government to differentiate between family and non-family businesses. As a result, the administrative and legal process became more complex. Finally, in 2019, the Czech Republic's concept of a family business was established, making certain administrative and legal process easier. Simultaneously, the management of Czech family companies is undergoing the first "post-revolutionary" transformation. Many companies are debating whether to keep their current business organizations or change them. The aim of this article is to figure out which legal type of business is best for micro family business. The TOPSIS method and the Saaty pair comparison method are used in this article. The article employs a variety of approaches, including analysis, synthesis, and comparison, as well as selected method of multiple criteria decision- making. The decision analysis revealed that the most optimal legal model of the family business is self-employed, based on the parameters, considered (legal, accounting, tax, and managerial). Aside from the findings, the study adds value to this subject for the Czech business climate, allowing potential scholars to compare the Czech Republic to other countries.

Keywords
Family business; stewardship, Multiple criteria decision-making, Saaty's method, TOPSIS.

JEL Classification
M10; M41; H20; K20.

1 Introduction

In both developing and developed economies, family businesses are the most powerful business influencers. Family businesses account for 70-90 percent of global trade and 70-90 percent of GDP (Pindalo et al. 2012). According to the most recent statistics, they generate 50-80% of all jobs worldwide. Family businesses are even more relevant in Europe, according to (Sáenz and Gárcia-Meca, 2014). Family businesses are even more relevant in Europe, according to. They accounted for 70% of the country's gross domestic product. They also help to expand the economies of South and East Asia, Latin America, and Africa (Villalonga and Amit, 2006).

Their influence on the business climate is likely to rise soon. In recent years, the Czech Republic's first generation of family businesses has had to consider how to pass their businesses on to the next generation. The most difficult period of family business, according to, is the transition from the first to the second generation. According to study from Bennedsen et al. (2007) succession planning will inevitably become a hot topic among family businesses. De Almmeida et al. (2018) demonstrated that succession mechanisms, such as a shift in the debt rate, had a significant impact on overall results. In comparison to family businesses, traditional businesses may experience high staff turnover due to mutual ignorance among employees, especially in a volatile environment.

Fang et al. (2018) investigated the connection between company performance and family business succession planning. The sample base is made up of Italian businesses, and contrasted businesses

operated by the founders' heirs to businesses controlled by outsiders. Vilčeková et al. (2018) concluded that keeping family management in place has a detrimental impact on business success. Especially in competitive business sectors, the impact is greater. The findings indicate that the family business system does not have inherent superiority, and they stress the value of performing management research under various institutional conditions.

In the Czech Republic, family business has a long history and is undeniably important to the national economy. Small and medium-sized businesses, as well as micro enterprises, used to play a major role in the Czech economy and politics (Evropský parlament, 2015) Unfortunately, the Czech Republic's centrally planned economy halted the age of family businesses. Until 1989, family enterprises in the Czech Republic were rapidly disappearing. The family business boomed again after the Velvet Revolution, thanks to the transformation of the centrally planned economy into a market-oriented economy. As a result, many family companies have started to reinvest in their operations (Kalls and Probst, 2013)

Using the chosen multiple criteria decision-making process, the main goal of this study is to decide which of the possible variants of family firms that vary in the legal type of business is the most beneficial for micro family enterprises (Saaty and TOPSIS).

The following is the structure of this paper: Section 2 contains the related literature's conclusions, Section 3 contains the methods used in this study, Section 4 addresses the research's input data, Section 5 contains the study's interpretation and evaluation, Section 6 concludes the study, and Section 7 contains the acknowledgement.

2 Literature Review

The concept of “family company” places a high value on the business climate. It assists family businesses in identifying laws that apply to them, allowing the family business management team to respond quickly and flexibly to laws while avoiding needless bureaucracy. After decades of uncertainty over what family business is, a concept of "family business" was eventually introduced to the Czech Republic in May 2019 (Kalls and Probst, 2013). The economic effects of family enterprises can be objectively and realistically evaluated. It also launches structural changes, such as the possibilities of tax relief or value added tax rates changes that have influence on prices of products and services (Chua et al., 2012)

Not only do family businesses contribute to global economies, but they also generate high-quality jobs. Their lack of sustainability, on the other hand, could be cause for concern. It is projected that only 30% of family enterprises survive to the second generation, with even less than 14% surviving to the third generation (Labelle et al., 2018).

According to De Massis et al. (2018) one of the main reasons for the relatively high failure rate on family business is because of the inability of family businesses to be prepared on succession process.

In a family company, the transition of management and the CEO from the current generation to the next generation usually takes many years. Successors are often involved with the business since childhood, as they assist, engage, see, and hear what is being solved in the company (Chua et al., 2018). If the business offers more opportunities for the successors to expand, the younger generations will typically bring new wind and new ventures such as opening e-shops, taking a different marketing strategy, using social networks, and so on. They have the potential to expand the family business.

Samara et al. (2018) discovered that family firms with a higher equity ratio are more likely to endure tough times of recession and deflation. This fundamentally promotes the overall economic stability. They can rapidly adjust to changes in the economic and social climate, and they play an important role in regional growth by establishing long-term relationships with workers, consumers, suppliers, and local communities. Family enterprises exhibit a high level of integrity. They value corporate social responsibility and are strongly involved in environmental and sustainability issues.

Arzubiaga et al. (2018) on the other hand, stressed that while the older generation can have experiences and information, recognizing new business models or opportunities must be done by the younger generation. This may be a problem, as Molly et al. (2019) said, and he suggested that family businesses with significant success employ non-family managers.

3 Methodology and Data

The article employs various criteria decision-making approaches, especially for weighting the criteria of the Saaty process. The TOPSIS approach was used to find the best variety. Methods of classification, analysis, synthesis, and comparison are used in addition to these.

3.1 Saaty Pair Comparison Method

Saaty's method is one of the most widely used weight-determination methods (Saaty, 1998). To begin, the pairs of criteria are always compared, and the rating is stored in the Saaty matrix S = (sij). The size of the preference is then calculated. The size of the choice is expressed as a set number of points on a point scale with descriptors. As a result, the Saaty approach is distinct from the pairwise comparison method, which compares preferential path.

Use (1) to determine the weight of criteria v_i,

$$v_i = \frac{G_i}{\sum_{i=1}^{n} G_i} \tag{1}$$

where G_I is the geometric mean of the *i*-th criterion. The relevance of evaluating the weight of the criteria is verified by the consistency factor *CR* determined (2),

$$CR = \frac{CI}{RI} \tag{2}$$

where *RI* is random index. *CI* is the consistency index determined by (3),

$$CI = \frac{\lambda_{,max} - N}{N - 1} \tag{3}$$

where λ_{max} is the largest matrix´s own number and *N* number of criteria. λ_{max} is determined by (4),

$$\lambda_{max} = \frac{1}{N} \sum_{i}^{N} (S.w)_i / w_i \tag{4}$$

where *N* is the number of criteria, *w* is a vector and *S.w* is the *i*-th element of vector.

3.2 TOPSIS Method

TOPSIS is a strategy for separating the negative-ideal solution from the order preference by similarity to an ideal solution. Two co-authors suggested and investigated it (Hwang et al., 1993). Several studies have recently centred on the TOPSIS method and applied it in a variety of fields such as financial performance assessment and organization evaluation, as well as business management. TOPSIS was described by Junior et al. (2014) as a method based on the selection of variants that are closest to the so-called ideal variant. It is distinguished by a vector of the best criterion values that is also the furthest away from the so-called basal variant. The basic variant is the one whose feature is determined by the vector of the worst critical values. The TOPSIS method consists of the following steps:

Elements of matrix y_{ij} are transformed to the values of the r_{ij} according to (5),

$$r_{ij=}\frac{y_{ij}}{\left(\sum_{i=1}^{n} y_{ij}^{2}\right)^{1/2}} \tag{5}$$

Calculate the elements of the weighted criterion matrix W = (w_{ij}) as $w_{ij} = v_j r_{ij}$ where v_j is the weight of *i*-th criterion.
From the elements of the matrix W, the ideal variant with critical values is determined (H_1, H_2,…H_k) and basal variant with values (D_1, D_2,…D_k), where $H_j = \max(w_{ij})$ and $D_j = \min_i(w_{ij})$, j = 1, 2, …k.

The distance of the variants from the ideal and basal variants is calculated according to (6) and (7),

$$d_i^+ = \left[\sum_{i=1}^{k}\left(w_{ij} - H_j\right)^2\right]^{1/2} \tag{6}$$

$$d_i^+ = \left[\sum_{i=1}^{k}\left(w_{ij} - D_j\right)^2\right]^{1/2} \tag{7}$$

Calculate c_i (8) as the relative distance of the variants from the basal variants:

$$c_i = \frac{d_i^-}{d_i^- + d_i^+} \tag{8}$$

Values ci are form the interval <0. 1>. they have values of 0 for basal variation and 1 for ideal variant. Variants can therefore be arranged according to decreasing values of indicator ci.

3.3 Input data

The research was conducted between April and June of 2020. Data on micro family businesses (i.e., number of employees 9) is collected for this study with the help of the Family Business Association in the Czech Republic (Machek, 2017).

Even though the concept of family businesses was defined in 2019, the lack of a consistent definition for a long time has resulted in almost no relevant data on the exact number of family businesses in the Czech Republic. As previously mentioned, the research was carried out in the Moravian-Silesian region, which will have 33,867 industrial companies by 2020 (czso, 2020). As a result, this number is regarded as the scale of the sample base.

To determine the sample size, formula (9) is used

$$n = \frac{z^2.N.r(1-r)}{(d^2.N) + [z^2.r\,(1-r)]} \tag{9}$$

where *N* is size of base population, *z* is coefficient of confidence, *d* is tolerance rate and *r* expected deviation rate. The input values were determined according to the methodological instructions and recommendations from the Auditors chamber of the Czech Republic. The number of respondents in questionnaire survey is 30 micro companies.

$$n = \frac{1{,}96^2.33\,867\,.0{,}02(1-0{,}02)}{(0{,}05^2.33\,867) + [1{,}65^2.0{,}02\,(1-0{,}02)]} = 30$$

3.4 Evaluation of Criteria

When assessing the advantages of different legal forms of family businesses, legal, accounting, tax and managerial criteria are considered. In total, five different options are distinguished by the legal form of business.

- V_1 - Family businesses in the legal form of self-employed
- V_2 - Family businesses - legal entity in legal form of joint-stock company
- V_3 - Family businesses - legal entity in legal form of limited liability company
- V_4 - Family businesses - legal entity in legal form of limited partnership
- V_5 - Family businesses - legal entity in legal form of public company

As previously mentioned, selecting the best version affects four classes of parameters. The first collection consists of legal requirements (K1). Legislation such as the Civil Code or the Commercial Corporation serves as the foundation for evaluating the j-th version while keeping the i-th criterion in mind. Self-employed companies are more beneficial than other business enterprises because the method of establishing them is simpler. Setting up a joint-stock corporation, on the other hand, is the most difficult of all companies, according to (Urbano et al., 2019).

The accounting principles are the second collection to be considered (K2). If the self-employed person's turnover for the accounting period does not surpass the turnover determined by the Accounting Act, he or she is permitted to hold tax proof. Tax proof is less demanding than bookkeeping (Krzikallová and Tošenovský, 2020). Legal organizations are required to maintain accounting records as Gonzáles et al. (2020) claims.

Criterion K3 ensures that the tax element of decision making is considered. In terms of taxation, the tax burden is reflected by an income tax – either personal or corporate, depending on the legal type of the corporation (Krajňák, 2019). The tax dimensions should not consider the nominal tax rate. The nominal tax rate does not always represent the true tax burden. As a result, the effective tax rate is needed.

The fourth and final category of four compared is one that focuses on administrative aspects (K4). Managerial elements are given the same weight as all the other parameters. According to this viewpoint, special emphasis was placed on the presumption of family and non-family members for the performance of managerial functions in family businesses, as well as the degree of interest of family and non-family members in the sense of ownership/co-ownership share in family business (Molly et al., 2019). In this scenario, the reviewer maintains the same ranking for all four categories of legal entities. Tab. 1 contains a rundown of the assessment results for the i-th criterion.

Table 1. Matrix of absolute utility

	V_1	V_2	V_3	V_4	V_5	Type
K_1	1	3	3	3	3	MIN
K_2	1	5	4	4	4	MIN
K_3	1	5	4	3	2	MIN
K_4	1	3	3	3	3	MIN

Source: own calculations

4 Empirical Results

The weighting of requirements was calculated in the introduction by using (1). The findings in Tab. 2 show that the K4 criterion – administrative aspects – received the most weight. Criteria K2 and K3 have the lowest weight and measure the accounting and tax aspects of the company.

Table 2. Consistency verification

	K_1	K_2	K_3	K_4	g_i	v_i	CR
K_1	1	2	3	1/3	1,189	0,254	0,064
K_2	1/2	1	1	1/3	0,639	0,136	0,009
K_3	1/3	1	1	1/3	0,577	0,123	0,04
K_4	3	3	3	1	2,279	0,479	0,062
					4,685	1	

Source: own calculations

Formula (2) verifies consistency of the data. Since the CR index in all cases are less than 0.1, the data in the matrix is consistent.

Evaluation of the variants is shown in Tab. 3. For best option, it is typical that the value c_i (8) should be as high as possible. This condition is fulfilled in variant V_1 – when family business is in a legal form of self-employed person. On the other hand, from the point of view of the considered criteria, joint stock company is the least favourable in micro family business, which is V_2. The variants V_3, V_4 acquire similar values of c_i. and V_5 is slightly lower than the two previous.

Legal forms of public companies, limited partnership and limited liability companies achieved similar results. The reason is because the same absolute utility for K_1, K_2 and K_4 criteria considered. Setting up a company in the legal form of the self-employed is the reason why variant V1 gets in the index of value 1 and therefore is the strongest among the collection of business entities because it has the lowest tax burden and the fewest legal constraints.

Table 3. TOPSIS Method

	K_1	K_2	K_3	K_4	di+	di-	c_i
V_1	0,042	0,016	0,016	0,081	0	0,202	**1**
V_2	0,125	0,081	0,082	0,241	0,123	0	**0**
V_3	0,125	0,064	0,048	0,241	0,261	0,035	**0,125**
V_4	0,125	0,064	0,048	0,241	0,261	0,035	**0,120**
V_5	0,125	0,064	0,064	0,241	0,263	0,023	**0,08**
Ideal	0,042	0,016	0,016	0,081			
Bazal	0,125	0,081	0,081	0,239			

Source: own calculations

5 Conclusion

The aim of this article was to test different legal business type variants using a multiple criteria decision-making process (TOPSIS and Saaty). Given that the weight of parameters differed and was greatly affected by the resulting order of variants, the result shows that operating a self-employment corporation is the best option for micro family enterprises; a joint-stock company is the least advantageous option.

From a managerial perspective, the study was primarily concerned with evaluating the efficiency of managerial roles in family enterprises, as well as the degree of participation of family and non-family employees in leadership positions. Management parameters have been given the same importance in all forms of businesses because authority and performance of managerial functions are equally relevant for family businesses in self-employed form as well as those of others. Regardless of the size of the company, the position of manager is critical in all types of companies and leads to its proper operation. It is obvious that family members would be more involved in family businesses than non-family members.

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Short-term managerial decisions in implemented financial and marketing strategies: a case study of RoadAbroad online language school

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Abstract
Short-term managerial decisions in implemented financial and marketing strategies is a crucial part of organisation management. This component helps to keep track of the changes of current customers' preferences and fulfil the demand on certain groups of goods and services. Companies may underestimate the importance of short-term decision-making in accounting, finance and marketing strategies which in turn may sometimes lead to creating lower value to the products or services and having lower returns on the investments. As a result, such businesses develop slower than they potentially could. They may involuntarily take higher risks of financial losses. This paper presents a case study of an online language school in Russian Federation that faced similar problems. Balancing the implemented financial and marketing strategies is believed to be vital for value creation, sustainable development, organization of better customer service and continuous quality improvement in the future.

Keywords
Short-term managerial decisions, marketing policies, finance and personnel management, sustainable development.

JEL Classification
L19

1 Introduction

This paper presents a case study of an online language school that has been on the market in Russian Federation and China over 5 years. Balancing theoretical background with practical implications in strategic marketing and finance is believed to be vital for sustainable development, organization of better customer service and continuous quality improvement in the future.

It is attempted to comment on managerial decisions in personnel management, accounting and strategic marketing of the business in order to reveal stronger and weaker sides of building an organisation from scratch without external investments. We hope that this retrospective analysis may help amateur entrepreneurs to enhance their business vision and to use quality resources of information specified in the theoretical section above. The managerial decisions discussed in the study will refer to resources management, personnel management, product quality management and marketing solutions. The period of five years will be described.

It might seem clear that having no or little knowledge of business and marketing strategies imposes severe risks on a business, it is still necessary to pinpoint the most important reasons for entrepreneurs

to beware of their financial and marketing strategies. Through the current case-study analysis amateur entrepreneurs will learn to:

- discover the role of financial and marketing strategies in strategic goal-setting;
- recognize the role of short-term decisions on competitive positioning;
- interpret various elements of financial and marketing strategic decisions and apply them in their current work environment
- balance theoretical findings in financial and marketing decision-making with real-word business situations
- use analytical frameworks to solve specific marketing problems and issues.

Based on these principles it was decided to focus the current case study on the following topics with an emphasis on the problems and solutions and organise it as follows: 1. observe the business environment from the perspective of a manager and find out what areas might be changed; 2. evaluate personnel management and performance; 3. discuss the difference between traditional costing and activity-based costing; 4. build relationships with customers through marketing strategies; 5. create value.

The topic of applying well-thought strategies is quite popular due to the fact that a lot of online businesses in education were established online in 2020-2021 because of the COVID19 pandemic. Various other offline educational businesses expanded online. The authors hope that the current case study will be useful for amateur entrepreneurs, not only they could find out theoretical approaches to building short-term strategies, but also learn about what did work in the case of RoadAbroad language school.

Literature Review

From the perspective of a manager it is vital to ensure that the business functions with profit, uses its resources efficiently, follows legal regulations, brings real value to stakeholders. According to Crosson and Needles (2011, p. 35) timely and accurate accounting information is crucial in decision-making process that is transitioned to all business spheres: personnel management, marketing, finance. The authors compare and contrast financial accounting and management accounting. Financial accounting is performed mostly for external use, it should be objective and its figures should be based on unbiased and reliable resources. Management accounting, on the contrary, is likely to be performed for internal use, could be based on predictions and therefore, at times it could mean that the reports may represent subjective views and opinions.

Resource-based view of the firm (RBV) is claimed to be a very important concept in strategic marketing (Barney, 1991). The effort of top management is assumed to be a a sustainable competitive advantage (SCA). Therefore, the figure of the chief executive officer or the top manager is not underestimated under this approach. Such an executive along with other senior staff is responsible for developing and allocating key resources in order to create value to the products or services and ensure returns on the investments. In this particular case study the steps executed by a business owner, founder and developer will be described in order to illustrate how this approach actually works in practice.

What sets a particular difficulty in measuring personnel performance is the fact that there is no unified definition for the term “organizational performance”. It is indeed very difficult to define this term as there are a great number of businesses (both for-profit and non-profit ones) that belong to various industries. Therefore, there are a few points of view on how to assess organization efficiency (Terech, 2018). In the rational-goal model, for example, performance may be measured as the threshold at which

organisation's goals are achieved. Quite a handy approach was proposed by Neely in 1995 which suggests to measure organization's performance by calculating efficiency and effectiveness of actions taken within this organization. Almost 10 years later researchers Carmona and Sieh described efficiency as the relation of outputs to inputs. Effectiveness, however, is a relation of outcomes and outputs. By far, measuring effectiveness and efficiency within publicly owned organizations is considered to be complex as the workflow processes are divided into the ones that have business features and the ones that do not. That means that the measurements could involve multi-dimensional indicators and clear methodology on how to interpret the results.

Using Bourdieu's concept of 'capital' Hohne (2020) stresses the idea that culture capital by which he understands both formal and incorporated standards of skills and knowledge, is being devalued. The conclusion focuses on the three main topics: 1. Online employment often represents low income; 2. The analysis showed "a decline of cultural capital in terms of formal professional standards"; 3. Individual competitiveness has been increasing and leads to greater social inequalities including race, gender, etc. Therefore, it might be important to point out that the online business described in this case study fights against all three of these uncomforting conclusions. RoadAbroad management treats its employees well willing to invest in its staff in the long-run perspective, its employees are 80% women from 25 to 35 years old, and it values formal professional standards like education and experience.

It is crucial to measure the cost of the product or service in order to improve the quality of managerial decisions. The better companies estimate these costs, the more accurate actions could be performed on the market. In 2016 Weygandt, Kimmel and Kieso pointed out there is no possibility to find out the exact cost of the product/service and described differences between traditional costing and activity-based costing in the following way. In traditional costing systems it is usually fairly easy to calculate direct costs of raw materials. It seems to be considerably more difficult to measure overhead costs. The problem of understanding the idea behind measuring the effect of direct labor brings up the key difference between the two systems. Direct labour used to make up the largest share of total manufacturing costs. The workers used to spend their working days at the factory doing a lot of manual operations. However, over the recent decades the workflow has been changing drastically. People spend time watching automated processes run on their own which leads to a decreasing share of direct labour. In order not to experience distortions caused by using overhead rates based on direct labour when these two numbers do not correlate significantly, companies implement activity-based costing system (ABC) to receive a better estimation of overhead costs.

Not only it is important to create and develop a quality product or service, but also it is vital to be able to sell it to the customers by communicating values to them clearly and building strong and long-lasting relationships with them. That aspect is illustrated by Kotler and Keller in 2016. They stressed that the customers are becoming increasingly informed and aware of the product qualities/variations. That means that on top of having a greater choice and instant opportunities to purchase goods and services, the customers expect the companies to recognise their needs, wants and feedback and respond to these aspects effectively. Technological progress results in higher competitiveness of the businesses on the market. No customer may be taken for granted, therefore, the companies need to be exceptionally careful with their marketing strategies, establish their brand and its value firmly on the market and bond with their potential customers. This might be a tough thing to do for start-ups and smaller firms as they simply lack the budget to fit these criteria.

In this case study we will address all of these points with the reference to the language school. The current study consists of the following parts: the former problems are presented and the main players are described. Then we analysed the situation in order to define and structure the approach. The solutions

are specified with the data available. In the concluding part of the case study we consolidated limitations, future development of the aspects discussed and summarised the findings.

2 Methodology and Data

The data from RoadAbroad private archives from 2016 to 2021 in organisation management, accounting, finance, marketing and personnel management system was analysed for this case study. The processes of building and developing a successful business model in online schooling have been reviewed retrospectively. It was proposed by Dul and Hak (2007) to differentiate between three key activities that benefit theoretical development: exploration research, theory-building research and theory-testing research. We are particularly interested to gather important information about how the business has functioned over the years in order to identify some gaps in the theoretical knowledge that were used by the management. Therefore, we will work with exploration and theory-testing research. Tellis (1997) outlined that case studies are multi-perspectival analyses that refer to a triangulated research strategy as it is crucial to prove the validity of a particular case. Therefore, various sources of data are used in this case study: data on managerial decisions, feedback from the organisation's website, financial reports, data on personnel development. Our goal is to be unbiased and treat the data responsibly and accurately in order to go along with the research on providing accurate information (Lee, 2017). It is necessary to combine such methods as comparing and contrasting ideas, evaluating what worked well and what did not. Combining several approaches and methods is more effective as it provides a fuller picture of the online business we intend to describe. We intend to have a clearer understanding on the successes and failures as it may later help the managers of the business to perform business processes re-engineering (BPR) (Bonoma, 1985; Kettinger et al 1997; Johansson, 2007).

3 Empirical Results

3.1. Creating a good team

In order to create a team, the manager could rely on, she started investing the sources available into people. On the one hand, it was beneficial to invite a lot of people who she previously met at various networking events as that helped to maintain friendly atmosphere at the time there were no clear commercial goals set up. On the other hand, that meant that the people involved in the project from the beginning did not wish to undertake any extra work or any other tasks they were not eager or interested in doing. It put a lot of pressure and additional to-do lists on the manager of the business. Instead of thinking global she had to concentrate on smaller things none of her employees cared about. As a result, in 6 months from the start of the business, there were no clear goals, no vision, no fixed deadlines. The manager did her best to keep her team members interested in the project by coaching them in person. The main principle was to find out what skills one particular employee wanted to develop and assign specific tasks to that person that would have to do with his/her field of interests. Eventually the manager came to the logical conclusion that such attitude to her business will not allow her organisation to grow and thrive on. That is why she started thinking about developing a clear system of tools that would help to create transparency in accounting, marketing and personnel processes, communicate values and vision both to employees and customers. At the moment every teacher has professional goals and KPIs, speaking clubs with native speakers are available on a regular basis for the whole team to keep mastering and practicing the languages they teach.

3.2. Developing well-functioning tools that could help to communicate with customers and employees effectively

There are a number of tools that could enhance work with employees or customers. However, the manager had an idea to build such a tool that not only could correspond to the needs of customers and employees creating a transparent system for giving online language lessons, but also would help her see bottleneck places in the business workflow quicker. Such a solution was believed to make her reactions more efficient. The tool was found and the manager started working on the plan for the independent website that would belong to her language school. The website was supposed to cover payment systems,

keep track of payments and left-over classes, set up clear procedures for measuring overhead rates, track students' progress, create courses, give an opportunity to keep homework and other language assignments in one place, ensure that students and teachers gave timely and informative feedback to each other.

The solution took time and financial resources to develop and implement. It was rather costly to pay for this tool around CZK 150.000 momentarily. The process included creation of a prototype, setting basic functions and their development. Therefore, the investments were made gradually and it took another 5 years for the website to start functioning properly, a lot of functions were added on the go. By the end of 2016 the customers (students) could clearly see how many classes they paid for, how many of them they have visited, what homework they have for the next lesson, what extra resources they can use, they were able to receive regular feedback from their teachers and see their progress in language learning. When these processes became automated, it allowed teachers and the manager to cope with their tasks in less time and resolved a lot of common misunderstandings in communication between students and teachers.

Additionally, prospective students were able to try out their personal accounts becoming enrolled into free or demonstrative lessons. In our opinion, it was a very powerful tool to organise the system, make workflow operations transparent and advertise the school even more. Very few online schools in Russia in 2016 had such a great working tool in language learning.

3.3. Tracking progress, incoming payments and overhead costs

Before the website was introduced and implemented tracking students' progress was rather a subjective matter. Teachers used to do that on their own and gave feedback directly to the students. It was not possible to understand flaws and weaker points in language learning from lesson A to lesson B. Having no transparent tracking system for homework, progress and payments resulted in the fact that a number of students complained to the manager that they lose track of how many lessons they have actually attended, what homework their group received while they missed a class.

As the business project was started, employees and teachers were paid a fixed amount of money per hour. In 2018 it occurred that this system of direct labour costing did not work. Employees often experienced lack of motivation to do their job well. This problem was discussed by Weygandt, Kimmel and Kieso (2016). As a result, activity-based-costing was implemented in 2019 and the system of recognising work achievements by giving out specific bonuses had to be established. At the moment there is 1. a fixed rate and 2. a competitive rate for teaching skills and 3. special bonuses for keeping clients over 50 lessons. The accountants normally rely on when they check the payroll procedure that is carried out by the website automatically in the end of the month. Such a system increased employees' loyalty and motivation greatly.

Last but not least, some teachers appeared to be not loyal to their employer and competed with the business. In particular, they stole the customers that the school had attracted and privately taught them online. It is such an important issue that it was decided to dedicate a separate paragraph to it below.

4. Gathering quality feedback from customers and employees

When the business was on the market for over a year it became clear that lack of quality feedback and communication among stakeholders, namely, teachers, students and managers resulted in the loss of profits. Some clients would leave without notice. Some would complain to the manager towards the end of the course about the lack of some service they wanted to have. Consequently, the number of unsatisfied customers who would not recommend online language learning and RoadAbroad in particular was not decreasing.

It was decided to create a specified feedback from that worked with certain needs and wants of both customers and teachers. It allowed the manager to keep track of the product quality, employees and customer's satisfaction and react quicker in implementing changes. It was a crucial thing to do for a small business that has to respond to the needs of the market as soon as possible to compete with other

firms effectively. Customers and teachers needed to have the form that would pop up regularly on the website asking to fill in a few questions.

5. Building a business system for scaling up

According to Crosson and Needles (2011) and Ted Dako (2019) mentioned the importance of building firm and well-structured processes that have to be developed for a business to grow. Most small businesses that never become medium-sized or large businesses lack development of clear and independent processes of running a business and serving a customer. If the workflow is not transparent enough for someone to understand the instructions, the company might have to focus on implementation processes rather than on sales. That means that lack of transparency may become a bottleneck of the business.

Over 6 years, the manager has gradually implemented specific job requirements, created a certain list of values to pick her new employees. New lists of interview questions were introduced and piloted in 2018. New feedback forms asking for more specific information on the parts of the course were created (as opposed to more general feedback questions like: "How did you like this language course?"). New evaluation forms for employees were issued to develop a motivation system and bonus system. Solving the problem of keeping track of this information on a regular basis, analysing it as fast as possible, was finally resolved with the help of the website. From mid-2018 it was possible to start thinking of attracting more customers, increasing sales, broadening the product range and scaling up the business. The manager concluded that she would need to implement new marketing strategies. As a result, the employment system that initially relied on 2 basic criteria for prospective teachers (education and language skills) developed into a system that had a specific portrait of a successful employee. Who is portrayed as a potential employee of RoadAbroad at the moment? It is a person who knows how to teach languages online and skilled/interested/technically prepared to do so. It is a person who wished to develop their online teaching skills, get to know online teaching platforms and tools. This is a person who is experienced in teaching for at least 4-5 years. More information on what did not work well, what was done and what process started to function better could be found below.

6. Managing the quality of the services

Currently RoadAbroad is selling a wide range of services, it has individual and group study schemes, 9 languages are taught online at the moment. Evidently, it has not offered as many services in 2016. In the beginning it was very difficult to track progress of a student enrolled on a course. As a result, it was difficult to say how beneficial it was for a student to study online. However, as the school grew, developed, and hired the best employees, it was expected to create tools to ensure the courses are taught in a unified manner using the most modern language resources and techniques. The success of the students was evident and easy to capture with the help of internal (within the school) and external (international) testing. More and more customers were satisfied by the services.

The manager decided to further discover the topic of enhancing the quality of the services offered by RoadAbroad and hired a person responsible for courses' content and design. This methodologist also worked with teachers to check the quality of their online lessons on a regular basis giving them quality feedback and training if needed. At the moment there are two people responsible for course content and design. They motivate teachers to have short online discussions every week to resolve all sorts of problems and regulate the possible psychological pressure of the employees that may come from experiencing technical difficulties, going through a three-months traineeship for newly-employed teachers. Such weekly support meetings help to communicate the problems right away and, in most cases, before they even occur as problems.

This system of constant course enhancement, design and implementation of best teaching practices, support system for teachers and monthly teacher evaluation has greatly improved the quality of the courses and allowed to run more quality courses, hire more employees and consequently, teach more languages in a better way.

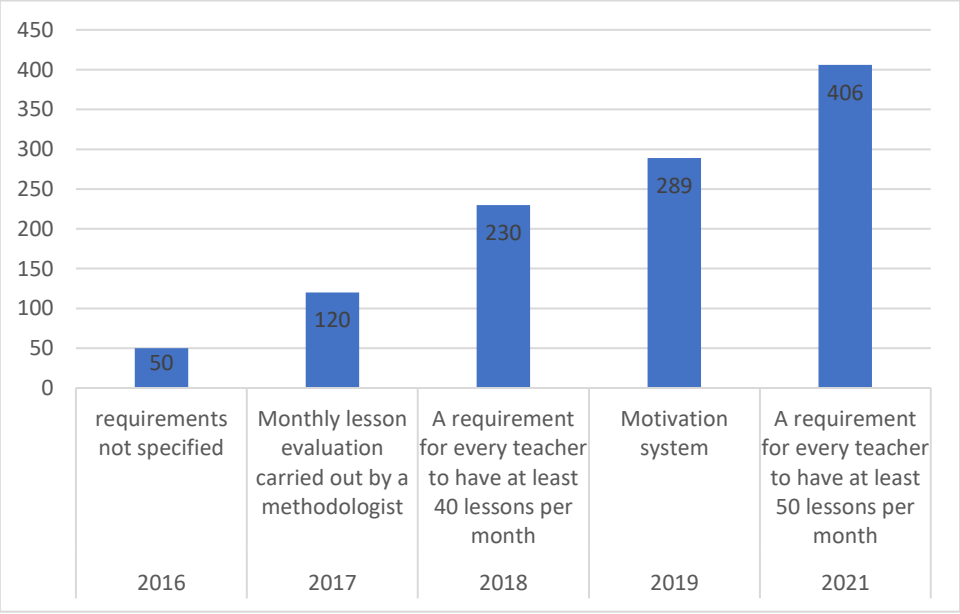
7. Resolving a problem of fidelity

The problem of teachers' competitiveness and eagerness to steal customers from the business offering students private classes off the language school capacity and venue might become a serious matter if not taken seriously. In our case, such unpleasant situations occurred from the beginning. Arguably, teachers may have "stolen" around 5% of clients per year from 2016 to 2019. It is rather difficult to calculate the exact number of students who became private students of a particular teacher or simply stopped studying the language altogether. That resulted in decreasing revenues, higher cost of every customer, lower conversion rates.

As it was states above, a clear tracking system was implemented to resolve this issue. Moreover, the business owner has decided to invest in her personnel greatly. The first even that was organised by the business owner to target this issue was a cross-country online conference with lots of professional teachers invited as speakers to cover the topics on how to teach students online, methods, problems and solutions. The teachers of RoadAbroad took part in this conference for free (in expense of the language school). The manager networked and partnered with the largest educational venues and professionals in Russia to ask them to participate in the conference as speakers. This event was quite a success as it clearly demonstrated to the employees how keen their manager is to invest in them.

Figure 1 shows the connection between the number of lessons per teacher and their KPIs. The trend is gradually increasing. Even though it may not seem obvious as there are many other factors that influence the number of lessons teachers give on a monthly basis, it is demonstrated that there should be some correlation between these two variables. Not only it is important and beneficial for the business owner to have a greater number of full-time teachers, but also it makes the staff more motivated and raises the loyalty and fidelity of the employees which could be specified as a secondary positive effect. The requirement that ensures the teachers take a certain amount of lessons per month is combined with an effective bonus system at the moment. It helps every teacher to develop professionally. In 2019 the briefing system was introduced which helped teachers solve every-day issued in a non-pressing manner.

Figure 1. Influence of teachers' KPI on the number of lessons given per month



Source: Author's work.

Secondly, the policy was introduced into every contract of employment. In case such a situation got revealed, cheating employees were to be fired immediately. Two methodologists who were professional human resources managers were hired to support and develop the team. At the moment, the predictable share of clients who might leave to private sessions with teachers is estimated to be 1%. At the moment an automated learning system for teachers controlled by methodologists and management is regularly

used in the company. There is also a library of electronic resources available for teachers to design quality lessons quicker.

8. Developing a brand

Following the ideas of some researchers (Gemunden, 2015; Cutrone, 2013; Kuksov and Villas-Boas, 2010; Diehl and Poynor, 2009) it was decided not to overload the customers with the types of services offered by the school. It is known that if the number of services or products is high, consumers may prefer fewer choices, otherwise they might experience frustration, confusion, and regret. If customers feel there are too many differentiated products, they opt for less complicated products and services. Taking these facts into consideration, the manager decided to be cautious to the issues of information overload.

As soon as the business was functioning, the team created social networks for RoadAbroad: specifically, WeChat, Instagram, Vkontakte (and Telegram later in 2018). In the beginning, the manager was using her own writing skills to make a series of posts that appear on social networks to increase customer awareness and interest. Starting from 2018 a social network manager and copy-writer was hired. Social networks were the key advertising channel that was used to communicate with potential customers and conquer their attention. It was decided to focus on how useful the content is. A lot of social network marketologists believe that there is a strong correlation between social networks' content and customers' loyalty.

What did not work well in 2016-2018 in particular, was the brand recognition and potential customer's audience development. The number of real and potential customers grew slowly from cca 10 regular clients per month in 2016 to 30 regular clients per month in 2018. Therefore, it was decided to start creating a brand – the company's own databases, its own website, labelling and brand recognition on social networks. Externally hired marketing professionals advised to rework marketing policies that will be covered in the next part.

9. Implementing new marketing strategies

Prior to discussing new strategies that the company has been using from 2019, it might be useful to mention which marketing strategies were used as the business was founded. As the business is privately owned, there were no external funding involved. It means there are only private financial resources of the entrepreneur being invested into the business. The initial marketing strategy was to advertise the school on WeChat, Instagram and VKontakte. The owner of the business communicated with every customer herself, wrote and posted useful information on language learning and travelling. The school offered free lessons, free private lessons to participate in. There was a discount system for clients. Every customer was asked to share information about the school on their private social networks to raise awareness and attract more potential customers. As it was mentioned, the audience did not start growing quick enough to cover the costs of monthly investments.

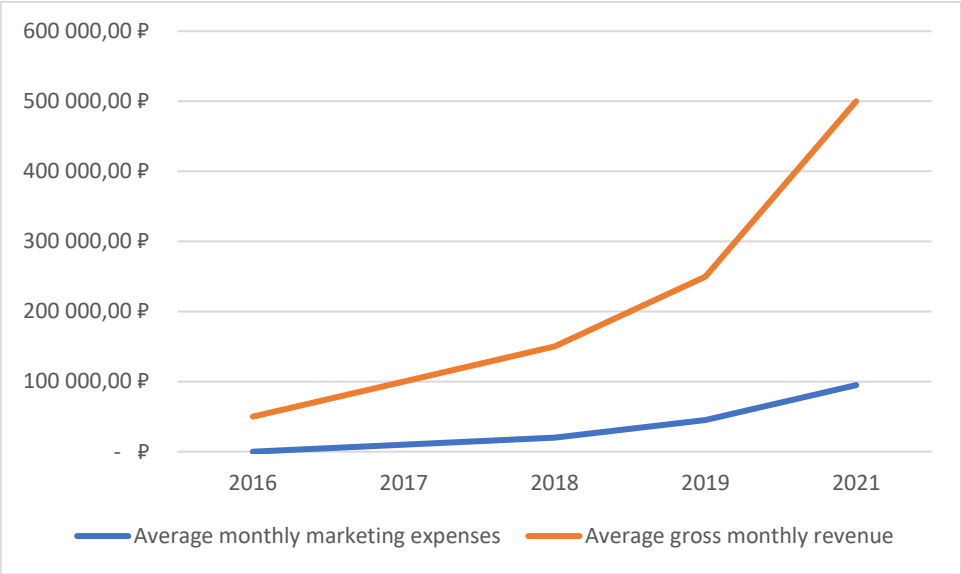
The marketing campaigns happened rarely and depended on personal earnings of the business founder. Consequently, it was not possible to calculate conversion rates, lead costs, the costs of attracting one customer. The main paradox was that on the one hand, it was evident that the business needed to grew to have regular marketing campaigns. On the other hand, in order to grow there had to be more marketing campaigns carried out.

The first step was to create a database of current and potential clients in Microsoft Excel. Trial lessons, paid and free, were offered to potential customers. A few demo lessons were made available on the website. However, the business still lacked a reliable sales funnel. The second step was to widen the number of individual products available to customers (three languages were chosen to be taught: Russian as a foreign language, Chinese and English). The product lines specific for each of the three languages started to be developed in 2019. A few short courses are offered as additional products or bonuses to the clients at the moment. In most cases, unlike regular language courses, they are not subject to any timing and can be completed anytime. The third step was to develop specific questionnaires for perspective and current students in order to have a better understanding of target audience's needs and wants. The CRM

(Customer Relationship Management) system that has been implemented in 2020 automatically gathers contact information of people who are interested in learning languages. Lead-magnets help to create additional occasions when the business communicates with its potential customers making them warmed-up and interested to buy a service from the company. At the moment the business still lacks regular marketing campaigns, an advanced sales funnel. It is also crucial to find out the costs of each particular client. The process of testing various marketing hypotheses takes a lot of time and financial resources. The pandemic crisis made the online language learning market highly competitive which resulted in higher costs on advertising and higher costs per internet link leads.

Figure 2 shows clear connection between marketing spending and gross monthly revenue of the school. Arguably, it supports the thesis stated above that the results cannot be reached by one-time marketing campaigns.

Figure 2. Marketing expenses and their impact on gross monthly revenue



Source: Author's work.

4 Conclusion

In this case study it was attempted to comment on managerial decisions in personnel management, accounting and strategic marketing of the business in order to reveal stronger and weaker sides of building an organisation from scratch without external investments. To summarise the experience of a privately-owned online language school RoadAbroad over the last 6 years, it is important to point out the following ideas:

1. As soon as the business is founded it is important to start with clear vision and goal setting. Due to the fact that this business was a relatively new type on the market at 2016 long-term goals have undergone great changes. It is vital for managers to use most modern quality resources that could help them build strategic thinking skills. Then it is crucial to concentrate on building a transparent system that would be easy to understand, manage, scale up and maintain. In our case, the investments into creating a website paid off greatly. Setting up tracking system with the help of the website was a milestone on the way of business development.

2. Personnel management: a lot of work has been done to build the team, to improve the attitude to work and goal setting for language teachers, to enhance relationship of employees and management. It is crucial to invest in team and develop teaching skills of all teachers. At the moment there are two people responsible for team management, course design, organisation of team building events. The

responsibilities of these employees include looking for external skills improvement seminars and training sessions or organising them within the organisation.

3. Feedback systems that greatly improved communication between students and teachers as well as managers and teachers were implemented with the help of the website.

4. The offer of language courses and services should be extended so that there is an extended choice of services for individual students.

5. It is important to use activity-based costing to determine the salary of the employees. A smaller share of the total sum should be fixed (60%), however, the other share (40%) should depend on individual motivation, attitude and meeting the requirements of the employer and personal KPIs.

6. The fidelity problem should be managed accordingly: special non-competitive conditions listed clearly in the contract and their obedience. On the other hand, it goes without saying that the management should create a system that could motivate and inspire the team members to develop personally and professionally. It is carried out through creating a branded teaching community, branded teaching resources, private electronic library, sustainable learning processes for teachers.

7. It proved to be important to have somebody analyse the data regularly so that better management decisions could be made. It is egregious that sustainable development of a business is possible only by debugging the processes related to data management. The more transparent the business system is, the easier it is to scale up the business and attract more customers.

8. The product quality should be improved with time. The courses need to be updated and reworked, the materials are constantly updated and made handy. The quality of teaching and using such materials is tracked by 2 people on a regular basis with the help of reliable tools, such as demo lessons, students' feedback and teacher's briefing meeting and private interviews.

9. Marketing strategies are still an area in which the business has a lot to develop and improve on. At the moment the business still lacks regular marketing campaigns and a more advanced sales funnel. It is also crucial to find out the costs of each particular client. The process of testing various marketing hypotheses takes a lot of time and financial resources. The pandemic crisis made the online language learning market highly competitive which resulted in higher costs on advertising and higher costs per internet link leads. Nevertheless, the CRM system was implemented in 2020. It currently gathers contact information of people who are interested in learning languages. Lead-magnets help to create additional occasions when the business communicates with its potential customers making them interested to buy a service from the company.

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The phonomenon of "patostreaming" in Poland

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Abstract
The following article describes the phenomenon of "patostreaming" (live webstream containing controversial content) as a new pathological phenomenon occurring on the Internet in the 21st century. The development of technology is a great opportunity, but also a great danger. The risk factors include e.g. the unhealthy, pathological behaviour of Polish content creators while recording so called patostreams. The methods used in the article are analysis of the literature, media content and legal cases. The paper explains the characteristics of "patostreaming", the phenomenon, etiology and preventive methods. In the article the author defines what "patostreaming" is, classifies "patostreaming content", analyses this phenomenon from the legal point of view, takes into account the issues of legal liability of people submitting videos, their viewers and the platforms providing access to this content. The last part contains preventive aspects and describes the difficulties of solving the "patostreaming problem".

Keywords
patostreaming, pathology, Internet, live video streaming

JEL Classification
K14, K39, L82

1 Introduction

The 21st century is an era of change and technological development. The possibilities offered by electronic devices have changed the way the world works and the quality of people's lives. Skills in the use of new technologies seem to be one of the basic competencies of modern man(Tomsia, 2008). It allows us to broaden our perspectives on communication, social functioning, learning, acquiring information and even provides entertainment of previously unknown values. Despite this, it is necessary to remember about the emergence of new dangers associated with the widely understood functioning in the virtual world. Knowledge of the dangers of the present century seems to be necessary in order to protect and counteract the new forms of pathology(Pyżalski, 2011).

In defining "Patostreams", it is important to note the elements included in the term. Streaming is a form of live video broadcasting via the Internet, which is the ability to transmit video or audio in real time using various tools that have access to the Internet. The term pathology (from the Greek *pathos*, meaning suffering, and *logos*, meaning science) has been associated with medicine with the meaning of a disease state and in the social sciences - an abnormality. Therefore, it refers to the type of behavior that contains pathological content. In order to look at this issue in its entirety, one should juxtapose it with the term social pathology, understood as this type of behavior, this type of institution, this type of social functioning, or this type of structure which remains in fundamental, irreconcilable contradiction with the world-view values accepted in a given community. It is therefore about the negative behavior presented by an individual or a group that meets the conditions such as: the violation of norms and values, destructive behavior measured by the scale of social condemnation, occurrence in a larger community or mass scale and the need to use collective force to oppose this type of problem(Pospiszyl,2009). Phenomena of social pathology for many reasons cause interest among educators, psychologists, sociologists, criminologists as well as among other groups in society. The causes of this state of affairs include especially the increase in deviant behavior among young people, such as aggressiveness or juvenile delinquency(Albański,2010). In the context of the above definitions,

we should consider whether the phenomenon of "patostreaming" is only a manifestation of deviant behavior, or whether it has become a general social problem as a new form of social pathology. The purpose of this article is to characterize "patostreams" in the context of the phenomenon of criminal law regulation and the difficulties associated with combating and prevention.

2 Theoretical issues

Livestreaming, as previously mentioned, is the transmission of video or audio in real time through platforms or applications that enable this type of transmission. The term streaming is ambiguous. Nowadays, it is used to describe online services that make content available via data transmission. Similar principles of operation are demonstrated by popular platforms such as Netflix, Spotify, YouTube ect. Using such platforms there is no need to download files and save them on your computer. The situation is similar in the case of streaming games, that is, platforms such as Twitch or OnLive allow users to play games that broadcast actual gameplay data. The idea of live streaming, understood as online broadcasting was popularized by one of the most important functions of social media in the form of satisfying the need for current information. Among the streaming platforms, in addition to Twitch, we should primarily mention YouTube, a popular website that has been enabling viewers to watch livestreaming since 2011. Since 2016, the platform has also allowed Internet users to broadcast streaming(Połowiak, 2016). A registered user with an account on the site can conduct an online broadcast and it does not require any specialized knowledge or technical skills. Livestreaming itself is a popular way of spending time among Internet users, especially among gamers when reporting on the course of video games - this is a form of commentary of the game play, where the player allows Internet users to watch them play the game with their participation, while commenting on what is happening, as well as interacting with viewers via camera, microphone and chat(Klimko,2019). Other areas that broadcast via streaming platforms are sports circles - in terms of broadcasting matches, games, e-tournaments. In addition, an increasing range includes forms of cycle training, webinars, specialized training(Andruszkiewicz,2015), education as well as educational activities. In the era of the COVID-19 pandemic, the use of online transmission has become popular in relation to special events(Kmieciak-Goławska 2009), such as weddings, but also concerts or scientific conferences.

At this point, it is important to point out concepts directly related to the issue of “patostreaming”. An inseparable element are donations (donate) from people watching “patostreamers”, paid via various “tip and donate” platforms. These platforms allow for donations to be made via SMS or bank transfer for example. In addition, in order for streamers not to decrease in popularity, it is necessary for users to subscribe to YouTube, which allows for constant tracking of the streamer's activity. The idea is to get the widest possible audience. Next, these “sessions” - that is, the most spectacular events, are often provoked, pretended or even directed situations in the form of fights, drinking alcohol, taking drugs, brawls, performing tasks to get more donations. Combining the above elements clarifies the full picture of the “patostream” as a live broadcast conducted on Internet services, during which behaviors that are social deviations are presented, including in particular: alcohol libations, domestic violence or numerous vulgarities which are performed in exchange for small monetary donations made by third parties. The number of recipients sometimes reaches several thousand, while the income generated by the most popular streamers may reach PLN 2,000 per transmission.

Within the framework of “patostreaming”, the following content categories can be distinguished: Alcohol-streaming (in press discourse there is also the name drunk-streaming) - drinking alcohol during the stream; Violence-streaming - streaming of various acts of violence; physical violence: beatings reported live, verbal violence: racist content, content inciting to violence, threats, insults, etc. Sex-streaming - streaming situations involving various types of sexual deviation, including acts of pedophilia; Daily-patoststreaming - streaming everyday life, with particular emphasis on broadcasting so-called “smoke and mirrors”(Dek and Popiołek, 2019).

3 Methodology and Data

Starting the research process it was assumed that it is a cognitive process, which is guided by the conscious, deliberate and intentional activities of the subject(Sztumski,1976). In order to realize particular assumptions of the work, research methods appropriate for legal sciences and criminology were used. A method is such a way of proceeding that is suitable for systematic use and is applied with this awareness(Świda,1977). An attempt was made to apply several cognitive methods focused on the same research problems, which allowed the author to look at them from many points of view and to verify the obtained results. Through these kind of activities, the aim was to achieve more reliable and objective results, allowing us to build even more adequate postulates. The research methods were selected and planned so as to achieve the assumed research goal(Bożyczko,1974). The research was carried out on two levels: theoretical and empirical. The aim of the work on the first plane was to obtain deeper and more perfect knowledge, allowing us to better know and understand the phenomenon of "patostreaming". The empirical level was dominated by the process of collecting facts, i.e. information about the phenomena under study. Thanks to the analysis of statistical data, media materials and court judgments it was possible to characterize the cases accurately. The method of literature analysis made it possible to use the literature, thanks to which it was possible to get acquainted with the views of representatives of various branches of science on the issues related to both the definition and characteristics of "patostreams". The method of analysis of statistical studies aimed to obtain information characteristic of the issue in question, allowing to show the scale of the phenomenon. On the other hand, the analysis of judicial decisions allows us to illustrate the views of representatives of the judicature on the issue.

“Patostreaming” as a term does not appear in the English-language literature on the subject. The term appeared among Polish net users and was taken over by researchers of this phenomenon. It is worth noting that the phenomenon itself quickly became the focus of interest in circles analysing the threats resulting from the promotion of cruelty on the Internet(Bek and Popiołek,2019). According to the statistics from the Patostreamy.com website, the number of viewers ranges from a few to several thousand, regardless of the time of day. The same website states that the official record holder in terms of number of viewers on YouTube is Lord Krushwil, who had 240,595 viewers on 24/03/2019. On the other hand, the record holder for the most views was Gural, who recorded 14,851,915 views on 14/02/2018. This is a socially relevant problem due to its scale and huge saturation of aggression. The danger posed by “patostreams” is publicized in the media, as exemplified by the TVN station program "Attention! Children in Network" and the program "Alarm!" by TVP1 journalists.

The research conducted in March and April 2019 on behalf of the Foundation “Dajemy Dzieciom Siłę” in a group of 400 people aged 13-15 shows that less than 40% of the survey participants watch “patostreams”, 5% refused to answer the question, 84% have heard of “patostreaming”, and only 12% encountered the term for the first time by filling out the survey. For most adults “patostreams” may seem like something shocking and incomprehensible, but for many teenagers they are something normal - a form of Internet entertainment.

Undoubtedly, we are dealing with the lowering of the age of "computer initiation". Mobile devices such as smartphones, tablets, but also Internet resources are used by children as young as several years old. In addition, the time of constant access to the Internet is constantly increasing (about 30% of teenagers are online all the time, regardless of their location, and 93.4% use the Internet every day at home(Siedlanowski,2018). According to the CBOS report entitled Children and adolescents on the Internet - use and risks from the perspective of caregivers, 2015, the then middle school graduates and students entering elementary school already had a richer experience of using information technology. Students at the first stage of education, with thousands of hours spent at the computer, smartphone or tablet, have their first experience of using a smartphone or tablet as early as kindergarten. As a result, they outperform their peers at higher stages of elementary school education in the ability to use the Internet(Angielczyk,2019).

4 Results

It is difficult to pinpoint the original behavior of “patostreaming” and who started the trend of sharing pathological messages via the Internet(Polak,2019). One theory is that the first “patostreamer” was Hungarian YouTuber Molnár Krisztián (operating since 2014 under the nickname Bebaszós), who used YouTube to stream pathological content in the form of public drinking. It is alleged that this may have been a wake-up call and inspiration for Polish streamers. Rafonix and Daniel Magical are considered to be the first Polish representatives of “patostreaming”. Both noticed that along with the increase in vulgarity in their broadcasts, the interest and number of people watching their activities also increased. During their transmissions, they intensified the vulgar comments and controversial behavior, in return for which the viewers "rewarded" them by donating money to their accounts(Korus and Hudzik,2018).

“Patostreaming” is not a phenomenon occurring only in Poland. Eastern countries are also struggling with the problem of pathological broadcasting. In Ukraine and Russia, for example, there is a popular channel called "Mops Uncle Dog" run since 2015 by former prisoner Sergey Novik, who follows the instructions of viewers on his channel. The activities that the streamer performs are often pathological in nature, for example, drinking vodka mixed with beer or electrocuting himself. The popularity of the channel at the end of 2019 reached less than 500 thousand subscriptions. Also in the West there are cases of Internet pathology. In Germany, young YouTubers Adlersson, Inkognito Spastiko and Hector Panzer, present drinking alcohol, humiliating colleagues, demolishing apartments, etc. It is characteristic that “patostreaming” is not an incidental event, but becomes a way of life. The creators of pathological transmissions often show their everyday life by being online 24 hours a day, including transmission of sleep or physiological activities. The phenomenon is that children, adolescents and even adults watch this type of video, comment on it and pay the streamers without seeing in it manifestations of deviation or pathology.

“Patostreaming” is classified as harmful content on the Internet, defined as "material that is likely to evoke negative emotions in the viewer or that promotes dangerous behavior". The depicted deviant behavior violates commonly accepted values and social norms. Thus, the phenomenon of “patostreaming” can be considered disturbing and even socially harmful. The criminal law analysis should begin with determining the illegal nature of the behavior of the authors of “patostreams”. Under civil law, personal rights of third parties are violated - neighbours, public officials, and even relatives who *de facto* participate in the recordings, even though they did not give their consent, are sometimes unaware of the fact or are recorded against their will. Personal rights listed in Article 23 of the Civil Code constitute an open catalog, these values such as freedom, health, honour, image or privacy may be distinguished. “Patostreamer”, by making available the image of a third person without their consent, violates fundamental human freedoms. Other acts committed by video streamers are misdemeanours and crimes: using profanity in public places (Article 141 of the Misdemeanours Code) or promoting alcohol in an unauthorised manner (Article 452 of the Act on Upbringing in Sobriety and Counteracting Alcoholism), acts against property, defamation (Article 212 of the Penal Code), insult (Article 216 of the Penal Code), infringement of bodily integrity (Article 217 of the Penal Code), insult or violation of the right to privacy (Article 217 of the Penal Code), libel (Article 233 of the Penal Code) and slander (Article 233 of the Penal Code), insult or violation of the physical integrity of a public official (Article 222 and 226 of the Penal Code), causing damage to health (Article 157 § 2 of the Penal Code), violent crimes (Article 119 of the Penal Code),extortion (Article 191 of the Penal Code), abuse (Article 207 of the Penal Code), participation in a fight or beating (Article 158 of the Penal Code), public presentation of pornographic content (Article 202 of the Penal Code), sexual intercourse with a minor under 15 years of age (Article 200 of the Penal Code), etc. Indicating all the violated provisions of criminal law would require a separate analysis of each of the materials made available online(Bek and Popiołek,2019). The aforementioned research conducted by the Foundation "Dajemy Dzieciom Siłę" (We Give Children Strength) in cooperation with the Ombudsman has shown that the state authorities rarely intervene in these types of cases. The reason for this state of affairs is, on the one hand, the lack of experience and preparation to deal with cases concerning virtual space, and on the other hand, difficulties with identification of persons shown on recordings or running streams. Next, we should point out the difficulties in legal interpretation and assigning legal qualification to acts.

Table 4. Characteristics of selected "patostreamers"

	Presented content	***Criminal liability***
Gural	Vulgarities, broadcasts of drinking alcohol, persuading a 12-year-old girl to undress on camera during live broadcasts, offering minors money for sexually explicit behaviour, inciting violence and threats to interlocutors.	Sentenced to 14 months restriction of liberty for directing criminal threats and battery.
Daniel Magical	Transmission of drinking alcohol, collective libations, vulgarities, verbal abuse, physical violence against the mother, vandalizing the premises, recording images of third parties without their consent, public praise of ones murder	Sentenced to 10 months of restriction of liberty in the form of community service. As a punishment measure, he was banned from running a business of recording and distributing videophonic content on the Internet for 2 years and obliged to abstain from alcohol abuse.
Major	Transmissions during which he is intoxicated, consuming solvent, littering the forest, vulgarity, urinating into a bucket.	Penalty fine in the amount of PLN 500

Source: own

5 Conclusion

"Patostreaming" is a disturbing phenomenon that poses numerous threats to a wide range of people, especially children and adolescents. It is not only a virtual world, but actual actions in real life, occurring in the form of violence, pathology, deviant behavior, alcohol or drug intoxication, which leads to loss of consciousness. This is what makes the "patostream world" attractive. Its expansion is facilitated by the users' confidence of the anonymity of "patostream" messages, which makes them set no boundaries without fear of social ostracism.

In 2018, on the initiative of the Ombudsman Adam Bodnar, a roundtable meeting was organized on the issue of pathological online content. The meeting was attended by representatives of interdisciplinary communities, ranging from lawyers, scientists, journalists, sociologists, representatives of NGOs, technology companies and even YouTubers themselves. The result of the meeting were postulates to take action which could reduce the phenomenon of "patostreaming" and its negative effects, especially in the context of the threat of influence on children and adolescents. As far as legal regulations are concerned, there were postulates to introduce changes that would make it more difficult to make money from publishing pathological content. Despite court sentences, fines and other punishments that have been meted out the transmissions continue and are a source of income. It is important to make the young generation aware of the harmfulness of pathological behavior on the Internet and to undertake extended social activities stigmatizing Internet pathology.

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Railway undertaking costs for the railway infrastructure usage during the line closure

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Abstract
As the railway infrastructure needs constant modernisation and reconstruction, occasional long-term or short-term exclusions are needed, especially on single-track lines. The solution with regard to such situations is either a rail replacement bus service or route diversion. The paper aims to compare the costs for the use of railway infrastructure, which accrue to the railway undertakimg from the use of the route diversion in the case of line closure compared to the original route. The topicality of this contribution is underlined by a series of long-lasting exclusions on the first and third transit corridors. These began in April 2021 and will continue until June 2023, and will bring with it several restrictions with it in relation to both passenger and freight transport.

Keywords
costs, railway infrastructure, closure, route diversion, railway undertaking

JEL Classification
R4

1 Introduction

The railway lines operated need constant maintance. They require regular inspections by the infrastructure manager's staff, who check the safety and technical condition of lines through pre-prepared procedures. At the same time, each track has its own service life, after which a comprehensive reconstruction should take place. What elements are to be modernised in regard such a reconstruction depends on state's support of the railways. The length the closure depends on the length of the track section to be reconstructed. Restrictions in passenger and freight transport depend on the number of tracks on the line as well in the railway station.

During the closures, costs are incurred by all parties involved. The infrastructure manager incurs costs by implementing the closure as such. However, most of these costs are covered by European funds and part is also borne by the state in the form of subsidies. Carriers incur costs that depend on the type of exclusion. The article will present a comparison of costs arising from the use of railway infrastructure in the exclusion activity. It will be a diversion of a domestic train from Brno to Prague via Havličkův Brod in length of 3.2 km of diversion. This comparison's main objective is to find out how much the railway undertaking's costs have increased or decreased by using the railway infrastructure. The paper also presents the possibilities of covering these costs.

2 Literature review

Several studies are dealing with railway infrastructure charges. They bring new knowledge to this area from different angles. This is primarily an operational and economic aspect.

Railway infrastructure charging has its origin in the railway sector transformation into an infrastructure manager and railways undertaking. This process began in Europe with the first railway package, based on European Directive 441/1991. At the same time, two types of transformation have emerged on the European rail network to keep the railways market-oriented. The first type is a vertically integrated carrier, i.e., an infrastructure manager, a passenger and freight carrier in one. In this case, the individual entities must at least be separated from the accounts in order to avoid being fined. An article (Prodan & Teixeira, 2018) is also embedded in this environment, which creates a methodology for charging for railway infrastructure between Denmark and Sweden on the Oresund Bridge. The authors try to respect political and economic principles in pricing.

The second option is the separating the carrier and the infrastructure manager. This method is much more common in the European Union countries. In countries that are candidates for accession to the European Union, such separation of the railway sector is one of the conditions for accession. In a conference paper (Ferizovic, Salketic, & Kosovac, 2018), the authors address the issue of price flexibility for access to railway infrastructure in Serbia. Using different types of costs, they try to set prices so that they are sufficiently flexible and attractive for carriers in the context of rail market liberalisation.

It is important to constantly update the legal framework for access to railway infrastructure. It should particularly consider the current state of the infrastructure manager's operating costs, the state of the infrastructure and should also be sufficiently motivating for carriers. The authors seek to combine these factors in an article (Trampisch, 2017) which reflects the German railway infrastructure. It should also be recalled that the topicality of this article is underlined by the number of submissions to the European Court of Justice for discrimination in market access.

It is also appropriate to compare individual rates in other countries to optimally set fees for railway infrastructure use. Based on a comparative comparison, this was sought by the article (Dolinayová, Čamaj, & Kanis, 2017). The article also summarises the advantages and disadvantages of individual charging models. A similar survey is carried out in the article (Arrigo & Di Foggia, 2014), where the authors examined two pricing models. These were the marginal and full costs models. The entire research took place in the context of the burden on public finances.

Local railway lines are closely monitored in connection with costs. Even though the state transport system’s backbone should be formed by rail transport, performances on lines of this type are often cancelled. The main reason is the low passenger use regarding passenger transport and customers in freight transport. Most passengers and customers use road transport. As one of the biggest costs for the carrier is railway infrastructure use and for the infrastructure manager it is maintaining it, it is necessary to set this fee so that it is not too high for either of the parties involved. At the same time, care must be taken to ensure that the amount is not reflected in the level of passenger fares and the number of railway carriage for customers. This problem is addressed in an article (Abramovic, Pasagic Skrinjar, & Šipuš, 2016) which describes Croatian regional passenger services.

The acticle by (Dolinayová & Ľoch, 2013) examined the relationship between the change in the level of the infrastructure charge and the individual carriers traffic performance. This dependence is investigated to assess the change in the impact of the modal split. In the Slovak Republic conditions within the liberalised transport market, railway transport loses traffic performance, which is unfavourable in several respects.

The number of marginal costs was more clearly determined only after at least the accounting department of the infrastructure manager and carriers. These costs form one of the cost items of the railway infrastructure charge. How they contributed to the costs of railway infrastructure on Greek Railways between 2000-2004 is described in the article (Tsionas, Baltas, & Chionis, 2011). This period

was crucial for Greek Railways, as they were bought by Italian Railways. Simultaneously, this period could be considered to be the starting point for the structure of the railway infrastructure charge in Greece.

The principles of toll railway transport in Bulgaria are discussed in the article (Nikolova, 2008). The article points out shortcomings associated with applying this charge. At the same time, it presents a methodology that can predict the price development for railway infrastructure use. Such an instrument is important because the development of transport on the Balkans' railways has been declining and unfavourable for a long time.

Various factors may be involved in the infrastructure charge. For example, in some countries, it is a noise factor. In the article by (Andersson & Ogren, 2007), the authors deal with charging for the externality of noise based on marginal costs. Noise charging can be motivating for haulers, as this can lead to the purchase of new vehicles with lower noise levels. Simultaneously, this can help residents who live near tracks where no noise-reduction walls have been built.

The railway infrastructure capacity on sidings is a special chapter. For example, this issue is addressed with a conference paper (Nachtigall, Široký, Sourek David, Ježek, & Matuška, 2019). In the context of the railway market liberisation, this problem is topical and the authors' proposed procedures can also help in the capacity allocation on railways of national and regional importance.

3 Methodology and Data

The costs of railway infrastructure use are among the most significant direct costs for carriers. The same applies to revenues from the railway infrastructure use for infrastructure managers. Therefore, in the event of any exclusion, this item is also closely monitored on both sides.

This section will be divided into two units. First of all, it is important to imagine the types of exclusionary activities and their impact on operation. In the second part, we will present the components and methodology with regard to calculating the railway infrastructure fee. It is in this second part that the practical application in the field of exclusions and route diversions will be subsequently demonstrated.

3.1 Exclusions

Exclusion is a term denoting a planned or unplanned cessation or operation restriction in relation to a railway infrastructure element, or another element of railway transport (Správa Železnic, s. o., 2021).

The exclusion that is presented in this article is long-term. It lasts from April 2021 until June 2023. These are reconstruction works in the bottlenecks of the first and third transit corridors. Simultaneously, these are the last unreconstructed sections that create bottlenecks. A map with the excluded sections is shown in Figure 1.

Figure 1. Map of sections to be reconstructed between April 2021 and June 2023.

Source: Správa Železnic, s. o. (2021)

We can see from the picture that the most restrictions affect tracks 260 (Brno – Česká Třebová) and 010 (Česká Třebová – Kolín). The measures taken in passenger rail transport from April 6th, 2021 are described in Table 1.

Table 1. Impacts and measures due to large-scale exclusion taken in passenger transport.

Railway undertaking – passenger transport	*Train lines*	*Measure taken*
REGIOJET, j. s. c.	(Hungary/Slovakia) – Brno - Prague	change of time positions and route diversion through the Havličkův Brod station with a new stop at the Kolín station
	(Slovakia) – Návsí – Prague	change of time positions

Source: (REGIOJET, a. s., 2021)

In this part of achieving the goal, we will deal with the REGIOJET company and its train line Brno - Prague operation in terms of changing costs for the use of railway infrastructure. The main objectives and exclusion results are presented in Table 2.

Table 2. Main goals and construction results

Main goals	*Main results*
Improving the line's technical condition and parameters	construction of a new switch connection at Bezpráví stop, which enables the transition of trains between the 1st and the 2nd track lines what enables to minimises the impact of emergencies on the regularity of transport
increase in safety and reliability of operation	modifications at Brandýs nad Orlicí station, where new platforms, including shelters, will be built
ensuring grade-separated and barrier-free access of passengers to the platform	

Source: Správa Železnic, s. o. (2021)

Despite the significant improvements presented in Table 2, passengers need to be prepared for possible major delays in passenger trains during the exclusion's duration.

3.2 The theoretical basis for calculating the fee for railway infrastructure use in the Czech Republic

European Union legislation demands that any carrier wishing to operate a rail service has to obtain a Licence. This Licence allows the carrier to apply for a railway capacity for their trains. Each carrier has an obligation to use at least the minimum access package offered by the infrastructure manager. The price for allocating path capacity depends on the system used to resolve the request and the number of requested framework routes. In calculating the price for capacity allocation, the cost of operating the electronic information systems of SŽ, s. o. and other professional activities necessary for the incorporation of the general routes into the train timetable are considered (Správa Železnic, s. o., 2020).

Within the minimum access package, the infrastructure manager calculates (Správa Železnic, s. o., 2020):

- the price of the infrastructure manager for the allocation of track capacity (including the elaboration of a timetable),
- the price of the infrastructure manager for the train to use the track.

The dependencies and components of the price for allocating the railway infrastructure capacity are described in Table 3.

Table 3. Dependencies and components of the price for allocating railway infrastructure capacity

Price dependence factors for allocating railway infrastructure capacity	*Components of the price for allocating the railway infrastructure capacity*
the length of the time interval between submitting an application for the allocation of track capacity and the required day of its drawdown	payment for the process of allocating track capacity
the relationship between the submitted application for the allocation of track capacity and the deadline for the compilation of the annual timetable or its planned change	payment for processing the train timetable (excluding the costs of printing and distribution of aids) allocated to the carrier's request
the complexity of demands processing	payment for the operational introduction of the train and a surcharge for the short-term discussion and processing the application.

Source: Správa Železnic, s. o. (2020)

The price for allocating the track capacity is calculated according to the following formula (Správa Železnic, s. o., 2020):

$$Price = K_1 + K_2 * l_t + K_3 * Pd_j\ [CZK] \quad (1)$$

where:

K_1 – the rate for processing, determining the timetable and allocating track capacity [CZK]

K_2 - rate for constructing the train path [CZK/km]

l_t – train path length [km]

K_3 - rate per day of train path allocation [CZK/day]

Pd_j – number of days the train is running [days]

This price is valid for all routes within the train traffic diagram 2020/2021, which always changes in December.

All price model parameters for calculating the price for the train using the track must be by the applicable price regulations. The price model follows the principles of price regulation for operations related to railway infrastructure use within the minimum access package. The price calculation for the train using the track may only include costs that meet the direct expenditure conditions on rail transport operation to the extent specified by the valid assessment of the Ministry of Finance (Správa Železnic, s. o., 2020).

The price is constructed as a two-component with a separate calculation (Správa Železnic, s. o., 2020):

- for own train running,
- for the use of access roads for passengers.

In calculating the basic prices for the above price components, costs directly incurred for rail transport operation assigned to the individual components were used. The final price using the train path for a specific train on a line in a given category is calculated according to the following calculation formula (Správa Železnic, s. o., 2020):

$$C_v = C_s + C_{pk}\ [CZK] \tag{2}$$

where:

C_v - price for a train using the railway infrastructure [CZK]

C_s - price for using the railway infrastructure by running one sub-train [CZK]

C_{pk} - price for the use of access roads for passengers in a passenger train [CZK]

To complete the infrastructure charge calculation, the factor C_s must be calculated using the following formula (Správa Železnic, s. o., 2020):

$$C_s = L * Z * K * P_x * S_1 * S_2\ [CZK] \tag{3}$$

where:

L – length of a sub-train journey [km]

Z - basic price for 1 km of train journey [CZK/km]

K – the coefficient category of a railway line

P_x – product factor from P_1 to P_5

S_1 and S_2 – specific factors

The last partial relationship, whereby the resulting value is placed in the basic relationship for calculating the railway infrastructure charge by running a train, is access to railway stations. We calculate it as (Správa Železnic, s. o., 2020):

$$C_{pk} = n * m_{pk} * N_{zn}\ [CZK] \tag{4}$$

where:

n - basic price for one planned passenger train stop for passengers to board and/or disembark at railway stations and stops of category n [CZK/stopping * weight]

m_{pk} - train weight for price calculation for the use of access roads in a passenger train (without locomotive weight) [t]

N_{zn} - the planned number of passenger train stops for passengers to board and/or disembark at railway stations and stops of category n

The individual factors will be presented and quantified in a practical application on a model example of price comparison in the following chapter.

4 Empirical Results

The results will be compared on the REGIOJET line on the section Brno – Praha hl. n. in two parts. In the first part, the minimum access package costs will be quantified when driving on a train path entered in the timetable and on a diversion route. In the second part, the fee for railway infrastructure use will be calculated when driving through Pardubice and when driving by diversion through Havlíčkův Brod. All calculations will be applied to one train within a given line. Specifically, it will be the RJ 1042 train, which runs daily, except December 25th, 2020 and January 1st, 2021 between Brno and Prague.

4.1 The minimum access package cost before and after the start of the line closure

The data from relation 1, which is necessary for calculating the price for allocating railway infrastructure capacity, are given in Table 4.

Table 4. Data needed for price calculation for allocating railway infrastructure capacity.

Indicator[4]	*Status before the start of the exclusion valid until April 5th, 2021*	*Status after the start of the exclusion valid from April 6th, 2021*	*Difference*
K_1	**1,700 CZK**		-
l_t	254 km	257.2 km	257.2 km – 254 km = **3.2 km**
Pd_j	112	249	-
K_2	8 * 254 = **2,032 CZK**		
K_3	10 * 361 = **3,610 CZK**		
Σ	**7,342 CZK**		

Source: authors by (Správa Železnic, s. o., 2020)

Individual coefficients do not change despite the route diversion and therefore the increased distance. For carriers who placed orders for their trains in the annual timetable on time, the infrastructure manager did not apply increased coefficient rates. The difference between the coefficient K2 is 25.6 CZK per day for one train and one direction. For the planned 249 days of exclusion, it is 6,225 CZK. These costs will be borne by the infrastructure manager.

4.2 Comparison of the charge for running a train on railway infrastructure due to line closure

The calculation methodology depends on various factors. First, the values are substituted into relation 3 and according to them, it is possible to determine the final value of relation 2. The first two variables represent the train running distance and the basic price for 1 km of the train journey, which represents a fixed rate of 21.50 CZK per 1 train kilometre. Table 5 compares the route through Česká Třebová and the diversion route through Havličkův Brod

Table 5. Comparison of distance and fixed rate per train kilometre

Indicator	*Status before the start of the exclusion valid until April 5th, 2021*	*Status after the start of the exclusion valid from April 6th, 2021*	*Difference*
L	254 km	257.2 km	257.2 km – 254 km = **3.2 km**
Z	**21.5 CZK**		-

Source: Authors by (Správa Železnic, s. o., 2020)

The price difference is already slightly higher and reaches almost 70 CZK. With annual use, this difference would amount to up to 24,974.4 CZK. And only on the way in one direction.

Track category coefficient K represents a combination of factors which, during the DJ annual timetable's validity period, affect the quality of services provided by carriers on a given track section, partially consider the demand for capacity allocation in a given section, cost ratio of lines support the infrastructure manager to maintain or increase the scope of ordered capacity on tracks in the given category. The classification of tracks into individual categories is the result of an assessment of their current technical condition, equipment with technical equipment, and considering the demand for capacity allocation on TEN-T tracks and other lines (Správa Železnic, s. o., 2020). A comparison of coefficient K is given in Table 6.

[4] a proper request for the allocation of track capacity to the annual timetable for indicators $K_1 – K_3$

Table 6. Comparison of coefficients K

Track section until April 5th, 2021	*Track categories*	*The value of the coefficient*	*Track section from April 6th, 2021*	*Track categories*	*The coefficient value*
Brno – Česká Třebová	2	1.12	Brno hl. n. – Brno-Maloměřice	2	1.12
Česká Třebová – Prague	1	1.15	Brno-Maloměřice – Kolín	3	1
			Kolín – Prague	1	1.15

Source: Authors by (Správa Železnic, s. o., 2020)

It is clear from the table that when a diversion route is implemented, the route is divided into several categories. Combined with longer distances, this will again mean an increase in cost for the carrier with regard to railway infrastructure use.

Product factor P_x is a factor that considers segmenting the market into services with different price levels. The reason for the differentiation is either the direct costs spent on the service or the support of the relevant market segment with the use of co-financing from the state budget. Product factor P_1 with a value of 1 is specified for passenger transport (Správa Železnic, s. o., 2020).

The specific factor S_1 reflects varying wear on the track by running trains of different weights. Total train mass (in tonnes) means the sum of the masses of all vehicles in a train, including the mass of passengers or freight, rounded up to the nearest tonne. The values of the specific factor are determined for the given ranges of the total weight of the train (Správa Železnic, s. o., 2020). To correctly determine the train weight range based on which the specific factor S_1 is determined, it is necessary to know the planned wagon combination. This is in Table 7.

Table 7. Planned wagon combination on the RJ 1042 train.

The vehicle	*Series*	*Weight*
locomotive	386	85 t
wagon no. 1 (class Low Cost)	Bmpvz	48.5 t
wagon no. 2 (class Low Cost)	Bmpz	54 t
wagon no. 3 (class Standard)	ABmz	53 t
wagon no. 4 (class Business + Relax)	Ampz	51 t
wagon no. 5 (class Business + Relax)		
wagon no. 6 (class Low Cost)	Bmpvz	48.5 t
Σ	**391 t**	

Source: (Vagonweb.cz, 2020)

Based on the resulting value of the masses of rolling stock included in the train, it is possible to determine the mass interval in the range of 300 - 399 tonnes. The width of this interval corresponds to

the value of the coefficient 0.94. In practice, this means that this factor will reduce the price slightly for a train running on the railway infrastructure. This is because there is a direct correlation between the rate of rail wear and the train weight.

Specific factor S_2 speaks of the use of the European automatic train control system ETCS. If the locomotive is equipped with this automatic train control system, the coefficient value is 0.90 and if not, the coefficient value is 1. The purpose of this fee is to favour those carriers which contribute to greater operational safety and invest in the purchase or rental of new modern locomotives. The carrier REGIOJET fulfils this condition, as it has invested significantly in its locomotive fleet in recent years.

The last factor is the fee for access to railway stations. To calculate the price for access roads, all railway stations and stops on the Railway Administration's network are divided into five categories marked 11 to 15. The categorisation of railway stations and stops is performed according to their equipment with access roads. Table 8 compares prices for access to railway stations and their change resulting from the exclusion activity.

Table 8. Comparison of infrastructure prices for train stops at railway stations.

Stops at stations until April 5th, 2021	*Categories of stations and stops*	*Category price*	*Stops at stations from April 6th, 2021*	*Categories of stations and stops*	*Category price*
Brno hl. n.	11	0.08	Brno hl. n.	11	0.08
Brno-Židenice	14	0.04	Brno-Židenice	14	0.04
Pardubice hl. n.	11	0.08	Kolín	11	0.08
Praha hl. n.			Praha hl. n.		

Source: Authors by (Správa Železnic, s. o., 2020)

From the table, we can see that the number and category of stops remain the same despite the different routes. Therefore, the costs of access to railway stations and stops will remain the same. In summary table 9, calculations and approximate results are performed within the price comparison for a train running under the current measures.

Table 9. Resulting in values related to one train.

Price until April 5th, 2021	*Price from April 6th, 2021*
C_s = (89.8 * 21.5 * 1.12 * 1 * 0.94 * 0.9) + (164.2 * 21.5 * 1.15 * 1 * 0.94 * 0.9) = **5,264.01 CZK/day**	C_S = (4 * 21.5 * 1.12 * 1 * 0.94 * 0.9) + (189.8 * 21.5 * 1 * 1 * 0.94 * 0.9) + (63.4 * 21.5 * 1.15 * 1 * 0.94 * 0.9) = **4,859.92 CZK/day**
C_{pk} = (0.08 * 306 * 3) + (0.04 * 306 * 1) = **85.68 CZK/day**	C_{pk} = (0.08 * 306 * 3) + (0.04 * 306 * 1) = **85.68 CZK/day**
C_v = (5,264.01 + 85.68) * 112 = **599,165.28 CZK**	C_v = (4,859.92 + 85.68) * 249 = **1,231,454.40 CZK**

Source: Authors by (Správa Železnic, s. o., 2020)

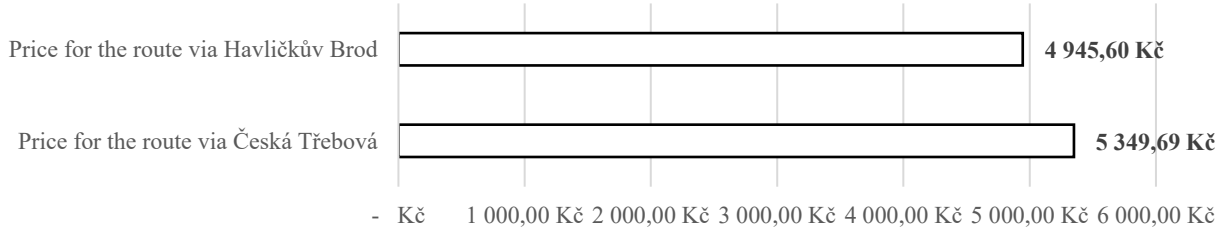
Based on the results, it can be stated that the C_s indicator is cheaper by 404.09 CZK when using the diversion route. The price of the C_{pk} indicator is the same due to the same number of stops. And the resulting indicator C_v is 632,289.12 CZK more expensive when using the diversion route. However, this

enormous price increase is due to the higher number of days when the train is guided by a diversion route.

5 Conclusion

Costs for railway infrastructure use, consisting of access to infrastructure and running trains. The article compared these costs due to diversions caused by exclusionary activity. It was a comparison of these fees for the REGIOJET carrier's train from Brno to Prague during the validity of the timetable 2020/2021, which is valid from December 13th, 2020 to December 11th, 2021. Until April 5th, 2021, the train was routed via Česká Třebová and Pardubice, and from April 6th, 2021, the train was routed via Havličkův Brod and Kutná Hora. The resulting values were recalculated for one day and then for the entire year. While the annual values yielded the expected results due to the uneven number of days, the results related to one day brought a surprise. The resulting daily values are shown in Figure 2.

Figure 2. Price comparison for railway infrastructure use by running a train in one day.



Source: authors

The price reduction for railway infrastructure use when running a train through Havličkův Brod is the result of the distance travelled on the category 3 track from Brno to Kolín. In a total distance of almost 190 km using the track 1 coefficient, these two attributes had the strongest effect on the price reduction.

As a result, the carrier's costs for using the railway infrastructure are lower when using the diversion route. However, this is generally not the case and the main recommendation is for the infrastructure manager to bear the difference in the increased costs for railway undertakings. Another milestone in the research presented in this conference paper could be the reduction in ticket sales due to exclusion. As the train will not be routed through the Pardubice junction long-term, it is questionable how this will affect the number of transported passengers. However, this research depends on statistics on passengers carried. However, this data is the carrier's internal data, so it is assumed that it will not be easy to obtain.

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