

DIFFERENCES IN LONGITUDINAL DEVELOPMENTS OF FINANCIAL PERFORMANCES OF CZECH HOSPITALS

LENKA KOMÁRKOVÁ

University of Economics in Prague, Faculty of Management, Department of Exact Methods,
Jarošovská 1117/II, Jindřichův Hradec, Czech Republic
email: komarkol@fm.vse.cz

TÁŇA HAJDÍKOVÁ

University of Economics in Prague, Faculty of Management, Department of Management,
Jarošovská 1117/II, Jindřichův Hradec, Czech Republic
email: hajdikova@fm.vse.cz

PETR PIROŽEK

Masaryk University, Faculty of Economics and Administration, Department of Corporate Economy,
Lipová 41a, Brno, Czech Republic
email: pirozek@econ.muni.cz

ARNOŠT KOMÁREK

Charles University in Prague, Faculty of Mathematics and Physics, Department of Probability and
Mathematical Statistics,
Sokolovská 83, Prague, Czech Republic
email: arnost.komarek@mff.cuni.cz

Abstract

The aim of this contribution is to analyze the longitudinal developments of financial performances of Czech hospitals over the period 2007–2011 following the transformation of the legal form of many hospitals from contributory organizations to business companies. By using an appropriate statistical model, we determine whether and how the development of hospital economic results differs depending on the legal form of the hospital. The operating region is also taken into account. To evaluate the financial performance of hospitals, a dataset of 155 hospitals was collected (out of a total of 189 hospitals registered in the Czech Republic as of the end of 2011). In particular, a linear mixed model was used to analyze the data. The results demonstrate the instability of the economic results during the period analyzed. The influence of the transformation of the legal form on the long-term financial performance has not been proved. On the contrary, we showed statistically significant differences in the developments of economic results in different operating regions.

Key words: Hospitals, economic result, legal form, longitudinal data, linear mixed model.

1. Introduction

The Czech healthcare system has been financed mostly by public resources including public health insurance and government budget. In particular, the public expenditures were over 240 billion CZK annually in the last years (Institute of Health Information and Statistics, 2014). The issue of the hospital financial management is thus a center of interest, this mainly due to a significant share of total costs on health care consumed.

In this paper, we focus on the long-term financial performance in the perspective of hospitals transformation which was performed in the period 2005–2007. In particular, there has been a change of a legal form of many hospitals from non-profit organizations to the form of a business company (joint-stock company or limited liability company). The regional governments who are also founders of most of the hospitals stated that the main reason for the transformation was the flexibility for the decision-making of their managers stemming from the legal form of a business company with the more effective use of the received funds (Kalinová et al., 2012). This is supposed to have a positive impact on the financial management of hospitals leading to a positive or balanced financial outcome. Besides the legal forms, we additionally differentiate hospitals managed by the Ministry of Health as their proportion on the costs of all hospitals makes almost 50% (Institute of Health Information and Statistics, 2014). Moreover, we also include operating regions in our analysis. We will examine the validity of the following three hypotheses:

H1: Hospitals in the form of a business company achieve better results in the long run than comparable hospitals operating in the form of subsidized organizations, which are not owned by the state.

H2: The long-term financial performance of hospitals in the form of subsidized organizations depends on whether or not the owner of the hospital is a government institution.

H3: The long-term financial performance of hospitals is different in various regions.

This analysis may enhance present research results (Kalinová et al., 2012; Votápková and Šťastná, 2013; Hajdík et al., 2013, 2014; Vaňková and Vrabková, 2014) by adding further view to the possibility of a better understanding of the real situation of the Czech hospitals.

2. Data and Methodology

Data regarding the financial management of hospitals for the five-year period 2007–2011 (directly followed the transformation) were obtained from publicly available annual reports and from the public register of companies. As the financial performance indicator, we have chosen the economic result (earnings after taxes). In addition to the economic result for the selected years, we also recorded region in which the hospital operates and a hospital type: state hospital (university, military and prison, founded by the Ministry of Health or by the central authorities), commercial hospital (joint stock companies and limited liability companies) and non-commercial hospital (form of contributory organization or charitable society) excluded from the category of state hospitals. There were data available from 155 hospitals out of a total of 189 (24 state, 121 commercial and 44 non-commercial non-state) hospitals registered in the Czech Republic as of December 31, 2011 (Institute of Health Information and Statistics, 2012). The distribution of hospitals in the research set according to region and legal form of hospital is shown in Table 1. It is useful to mention that it was not possible to obtain information on the economic result for all five years from all hospitals (Table 2). Full information is available for only 43 hospitals. Table 3 and Table 4 show basic descriptive statistics of economic result given the type of hospital, and the operating region, respectively.

Table 1. Frequency of hospitals covered in research according to type in individual regions.

Region	State	Hospital Type		Total
		Commercial	Non-commercial	
Praha (PHA)	13	9	3	25
Středočeský (STC)	0	18	0	18
Pardubický (PAR)	0	6	1	7
Královéhradecký (HRA)	1	6	0	7
Liberecký (LIB)	0	5	3	8
Ústecký (UST)	0	8	4	12
Karlovarský (KAR)	0	4	0	4
Plzeňský (PLZ)	1	7	1	9
Jihočeský (JHC)	0	8	0	8
Vysočina (VYS)	0	1	5	6
Jihomoravský (JHM)	5	2	11	18
Zlínský (ZLI)	0	7	0	7
Moravskoslezský (MSK)	1	9	8	18
Olomoucký (OLO)	1	7	0	8
Total	22	97	36	155

Source: Own research.

Table 2. Frequency of hospitals covered in research according to the number of identified values of economic result for the years 2007–2011.

The number of known values of economic result	1	2	3	4	5
Frequency	16	35	30	31	43

Source: Own research.

Table 3. Descriptive statistics for economic result (in thousands of CZK) given the type of hospital.

Hospital Type	Mean	Standard Deviation	Median	Lower Quartile	Upper	Size
State	17 363	69 944	5 554	1 335	25 208	80
Commercial	-2 986	24 150	332	-6 525	3 634	312
Non-commercial	-316	11 135	49	-868	1 789	123

Source: Own research.

Given a relatively high number of outliers and clearly skewed distribution of economic result (ER), the following data transformation was performed prior the main analysis:

$$\begin{aligned}
 s\text{IER} &= \log_{10}(1 + ER) \quad \text{for } ER \geq 0 \\
 s\text{IER} &= -\log_{10}(1 + |ER|) \quad \text{for } ER < 0
 \end{aligned}
 \tag{1}$$

The decimal logarithm was used in order to achieve an easier interpretation of results.

Table 4. Descriptive statistics for economic result (in thousands of CZK) given the operating region.

Region	Mean	Standard Deviation	Median	Lower Quartile	Upper	Size
Praha (PHA)	16 330	65 693	3 615	436	12 192	69
Středočeský (STC)	-3 519	17 145	437	-8 444	4 327	51
Pardubický (PAR)	-11 006	17 223	-7 464	-17 30	65	32
Královéhradecký (HRA)	2 588	16 714	-5	-3 364	4 915	22
Liberecký (LIB)	-446	10 893	237	-5 124	3 080	28
Ústecký (UST)	1 119	5 253	869	-452	2 821	37
Karlovarský (KAR)	-21 768	37 514	-5 672	-36 48	1 806	12
Plzeňský (PLZ)	-4 564	23 204	-538	-7 162	734	36
Jihočeský (JHC)	6 571	16 403	1 554	472	2 296	36
Vysočina (VYS)	-2 930	19 525	168	-4 359	1 496	22
Jihomoravský (JHM)	767	14 738	298	-4	4 332	60
Zlínský (ZLI)	-14 465	41 497	42	-13 15	2 553	28
Moravskoslezský (MSK)	10 024	28 350	1 109	12	9 458	57
Olomoucký (OLO)	-8 853	58 292	1 246	-17 22	10 042	25

Source: Own research.

The aim of the research is to describe the development of economic result over time by using an appropriate model and to determine whether and how this development relates to the type of hospital and the operating region. The values of the observed economic result can be viewed as panel or longitudinal data (individual hospitals represent economic subjects, for which we repeatedly observe the economic result in time). For a given problem we use a linear mixed model which, among other things, allows us to use all available data, also from hospitals where the value of the economic results is not available for all years under consideration. Mixed models were used, e.g., to analyze data from longitudinal studies of Swiss or American hospitals during the period of 1998–2003, or 1996–2010, respectively (Farsi, 2008; Ding, 2014). In the Czech Republic, Votápková and Šťastná (2013) analyzed the longitudinal (panel) hospital data from the period 2001–2008 using Stochastic Frontier Analysis which is a parametric approach based, in the case of panel data, on the mixed models as well.

Let $Y_{i,t}$ denote the value of the transformed economic result (sIER) for the i -th hospital in the t -th year, where $t = 0$ represents year 2007 and $t = 4$ year 2011. Given that for each hospital we have up to 5 values, we will use only a model with a linear trend (it would not be possible to estimate more complex trend curves with a reasonable accuracy given that five observed values are available for each hospital at most):

$$Y_{i,t} = B_{i,0} + B_{i,1}t + \varepsilon_{i,t}, \quad i=1,\dots,155, t=0,\dots,4. \quad (2)$$

Intercepts $B_{i,0}$ and slopes $B_{i,1}$ (characteristics of i -th hospital) are considered as random variables and $\varepsilon_{i,t}$ is a random deviation from the trend of the i -th hospital in the t -th year. We assume that the expected value of the random intercepts $B_{i,0}$ depends on the type of the hospital and operating region.

Table 5. Parameterization of the population intercept of the sIER trend for various types of hospitals in each region according to model (3).

Region	State	Hospital Type	
		Commercial	Non-commercial
Praha (PHA)	β_0	$\beta_0 + \beta_{2,1}$	$\beta_0 + \beta_{2,2}$
Středočeský (STC)	$\beta_0 + \beta_{3,1}$	$\beta_0 + \beta_{2,1} + \beta_{3,1}$	$\beta_0 + \beta_{2,2} + \beta_{3,1}$
Pardubický (PAR)	$\beta_0 + \beta_{3,2}$	$\beta_0 + \beta_{2,1} + \beta_{3,2}$	$\beta_0 + \beta_{2,2} + \beta_{3,2}$
⋮	⋮	⋮	⋮
Olomoucký (OLO)	$\beta_0 + \beta_{3,13}$	$\beta_0 + \beta_{2,1} + \beta_{3,13}$	$\beta_0 + \beta_{2,2} + \beta_{3,13}$

Source: Own research.

Since all three types of hospitals are not represented in every region, we cannot consider different effects of the hospital types in different regions. In other words, we cannot consider interaction between the type of hospital and operating region and must assume their additive effect. The model for the expected value of the random intercepts is then expressed as follows

$$E(B_{i,0}) = \beta_0 + \beta_{2,1}x_{i,2,1} + \beta_{2,2}x_{i,2,2} + \beta_{3,1}x_{i,3,1} + \dots + \beta_{3,13}x_{i,3,13}, \quad (3)$$

where $x_{2,1}$ and $x_{2,2}$ are dummy variables indicating commercial and non-commercial hospitals, respectively while considering state hospitals as a reference category. Analogously, variables $x_{3,1}, \dots, x_{3,13}$ are dummy variables indicating operation of the i th hospital in one of 13 non-Prague regions of the Czech Republic while considering Prague (PHA) as a reference category. The mean value of the random slopes $B_{i,1}$ is the same for all types of hospitals and regions, i.e. $E(B_{i,1}) = \beta_1$.

In other words, the slopes of individual hospital's trends randomly fluctuate around a common general population slope β_1 . Intercepts of the trends of the transformed economic result of individual hospitals randomly fluctuate around a value which depends on the type of the hospital and its operating region as indicated by (3) and also depicted more clearly in Table 5. In accordance with classical assumptions of a linear mixed model, two-dimensional normal distribution is assumed for the random intercept $B_{i,0}$ and random slope $B_{i,1}$ as well as a normal distribution for the error terms $\varepsilon_{i,t}$. Further $sd(B_{i,0}) = d_0$, $sd(B_{i,1}) = d_1$, $cor(B_{i,0}, B_{i,1}) = \rho$, $E(\varepsilon_{i,t}) = 0$, $sd(\varepsilon_{i,t}) = \sigma$.

The model for the transformed economic result was estimated by the restricted maximum likelihood method (REML) using the R software (R Core Team, 2014) package lme4 (Bates et al., 2014).

3. Results

The estimation of the mean slope is slightly positive (0.11), see Table 6. It therefore indicates, that the economic result, on average, slightly increases over the years 2007–2011. However, this increase is not statistically significant ($p = 0.503$). On the other hand, different types of hospitals in different regions have different intercepts around which the development of transformed economic result of individual hospitals moves (Tables 5 and 6).

In the case of the type of hospital, the coefficient estimates of $\beta_{2,1}$ ($\beta_{2,2}$ respectively) show an estimate of the difference between the means of transformed economic results of the commercial (non-commercial respectively) and the state hospital from the same region in

a given year. From negative but similar values of estimated coefficients $\beta_{2,1}$ and $\beta_{2,2}$, we conclude that commercial and non-commercial hospitals operating in the same region achieve similar economic results on average, which is lower by more than 3 orders of magnitude than for state hospitals (from the same region).

Similarly, the coefficient estimates of $\beta_{3,1}, \dots, \beta_{3,13}$ gradually show estimated differences between the mean transformed economic result of hospitals in regions outside Prague and in Prague in a given year. The differences relate to the same type of hospital. The estimates conclude that the best standing hospitals are those from the Jihočeský (JHC) region ($\beta_{3,8}$ estimate is 3.16). These hospitals achieve the economic result on average of more than 3 orders of magnitude better than Prague hospitals of the same type during the whole period. The worst standing hospitals are in the Pardubický (PAR) region, which are on average more than 4 orders of magnitude worse than hospitals of the same type in Prague.

Using the likelihood ratio test ($H_0: \beta_{2,1} = \beta_{2,2} = 0$) we can demonstrate ($p = 0.010$) that while controlling for the effect of region there are statistically significant differences in development of economic result between the different types of hospitals. Similarly (for $H_0: \beta_{3,1} = \dots = \beta_{3,13} = 0$), differences in development of economic result ($p = 0.006$) are demonstrable between hospitals of the same type in different regions. Subsequent multiple comparisons were performed using the general method of Hothorn, Bretz and Westfal (Hothorn et al., 2008). The results of multiple comparisons are presented with respect to the type of hospital in Table 7 and with respect to the operating region in Table 8.

We can see that state hospitals significantly differ from the other two types. In contrast, commercial and non-commercial non-governmental hospitals do not differ significantly, as is also shown in Figure 1. From the 91 pairwise comparisons conducted with respect to the operational region, only six pairs (most different from the view of a statistical significance) are shown in Table 8. For those pairs the difference is statistically significant at the level of 20%. At the 5% level there are significant differences between the Jihočeský (JHC) region and the Pardubický (PAR) region and between Moravskoslezský (MSK) region and Pardubický (PAR) region, where in both cases hospitals in the Pardubický (PAR) region reach significantly worse results than hospitals in the Jihočeský (JHC) or Moravskoslezský (MSK) regions.

A picture on the variability of intercept trends of particular hospitals around the intercept of population trend for hospitals of given type in given region is provided by Table 9. We can also find here an estimate of the standard deviation of the slope of individual trends of hospitals from the population trend common for all types of hospitals across the Czech Republic. Relatively high value of estimate σ indicates the instability of economic result achieved for one hospital over time. With a modified likelihood ratio test (Molenberghs and Verbeke, 2007) we can determine that the slopes show statistically significant variability ($p = 0.001$) and also the variability of individual intercepts is significantly positive ($p < 0.001$), see Table 9.

Summing up the presented results in relation to the research hypotheses, the analysis did not confirm the hypothesis H1 and vice versa it confirmed the hypotheses H2 and H3.

Table 6. Estimates of the fixed effects in the model for the development of the sIER.

Effect	Estimate	Standard Error	95% Confidence Interval
β_0 : Intercept	5.65	1.13	(3.57, 7.81)
β_1 : Slope	0.11	0.17	(-0.22, 0.45)
$\beta_{2,1}$: Type – Commercial	-3.41	1.30	(-5.85, -1.03)
$\beta_{2,2}$: Type – Non-commercial	-3.71	1.39	(-6.37, -1.16)
$\beta_{3,1}$: Region – Středočeský (STC)	-1.63	1.64	(-4.71, 1.44)
$\beta_{3,2}$: Region – Pardubický (PAR)	-5.61	1.97	(-9.25, -1.97)
$\beta_{3,3}$: Region – Královéhradecký (HRA)	-3.92	1.99	(-7.63, -0.19)
$\beta_{3,4}$: Region – Liberecký (LIB)	-1.01	1.95	(-4.66, 2.60)
$\beta_{3,5}$: Region – Ústecký (UST)	-0.31	1.77	(-3.55, 3.04)
$\beta_{3,6}$: Region – Karlovarský (KAR)	-4.77	2.59	(-9.61, 0.06)
$\beta_{3,7}$: Region – Plzeňský (PLZ)	-3.05	1.81	(-6.46, 0.27)
$\beta_{3,8}$: Region – Jihočeský (JHC)	3.16	1.94	(-0.42, 6.77)
$\beta_{3,9}$: Region – Vysočina (VYS)	-0.30	2.17	(-4.33, 3.81)
$\beta_{3,10}$: Region – Jihomoravský (JHM)	-0.63	1.50	(-3.41, 2.17)
$\beta_{3,11}$: Region – Zlínský (ZLI)	-2.30	2.01	(-6.13, 1.47)
$\beta_{3,12}$: Region – Moravskoslezský (MSK)	1.01	1.55	(-1.87, 3.92)
$\beta_{3,13}$: Region – Olomoucký (OLO)	-1.62	1.97	(-5.26, 2.13)

Source: Own research.

Table 7. Multiple comparison of various types of hospitals based on the model for the development of the sIER. Estimates of differences between mean values of the sIER together with p-values adjusted for multiple comparisons.

Compared Types	Estimate	95% Confidence Interval	P-value
Commercial – State	-3.41	(-6.44, -0.37)	0.023
Non-commercial – State	-3.71	(-6.96, -0.46)	0.020
Non-commercial – Commercial	-0.30	(-2.86, 2.26)	0.958

Source: Own research.

Table 8. Multiple comparison of various regions based on the model for the development of the sIER. Estimates of differences between mean values of the sIER together with p-values adjusted for multiple comparisons.

Compared Regions	Estimate	95% Confidence Interval	P-value
PAR – PHA	-5.61	(-12.17, 0.95)	0.187
JHC – PAR	8.78	(1.60, 15.96)	0.003
MSK – PAR	6.63	(0.26, 13.00)	0.032
JHC – HRA	7.09	(-0.32, 14.50)	0.076
JHC – KAR	7.94	(-1.10, 16.97)	0.155
JHC – PLZ	6.22	(-0.68, 13.11)	0.128

Source: Own research. The table includes a comparison only for regions for which the difference is statistically significant at the 20% level.

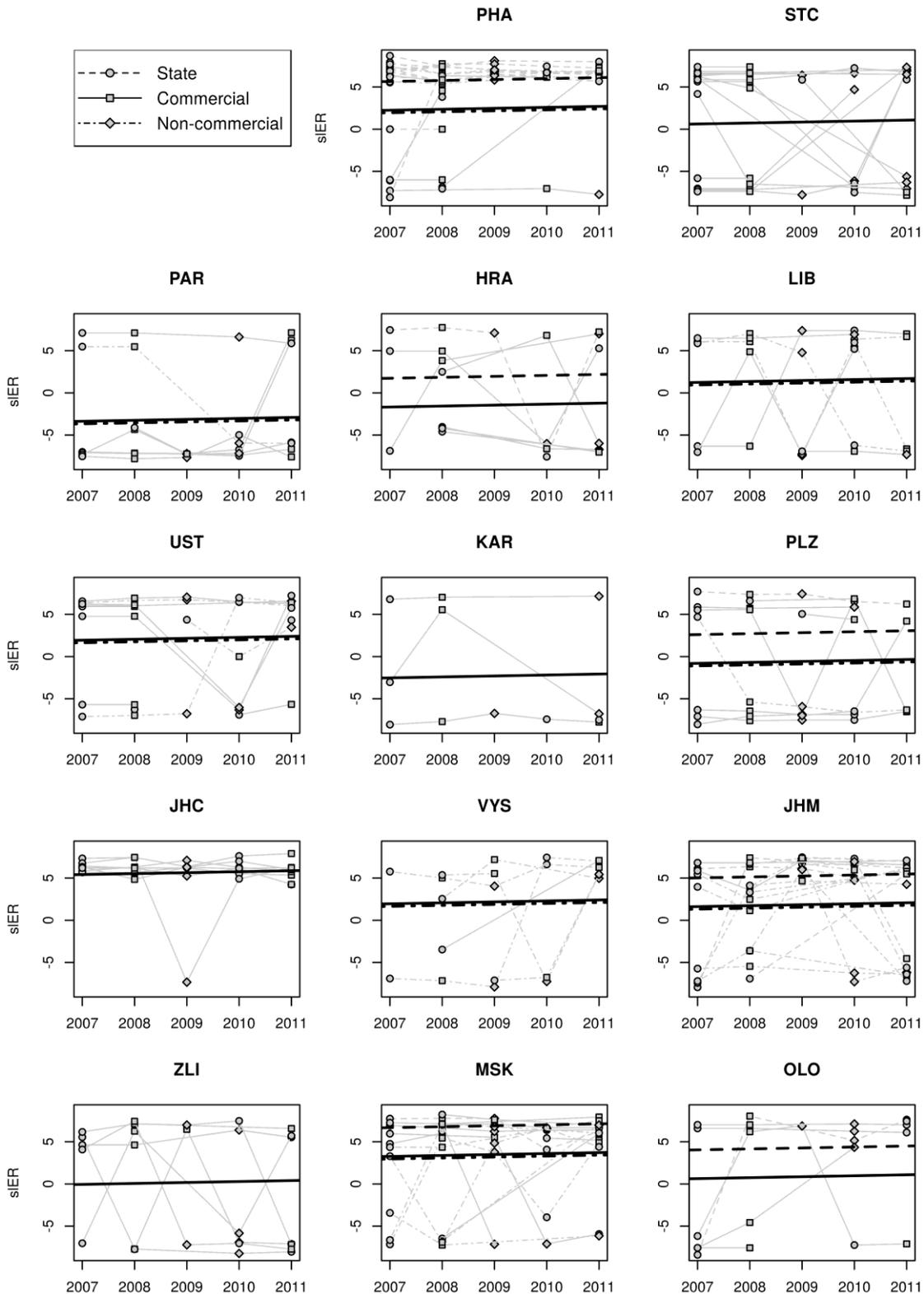


Figure 1. The estimated mean development of the transformed economic result for individual regions and types of hospitals together with the observed sIER values.
 Source: Own research.

Table 9. Estimates of the variance parameters in the model for the development of the sLER.

Parameter	Estimate	95% Confidence Interval
d_0 : Standard deviation – intercept	4.84	(3.65, 5.67)
d_1 : Standard deviation – slope	1.20	(0.74, 1.61)
ρ : Correlation – intercept, slope	-0.68	(-1.00, 1.00)
σ : Standard deviation – random deviation	4.15	(3.81, 4.55)

Source: Own research.

4. Conclusions

This research provides some interesting findings from the hospital financial performance. It turns out that the economic results of hospitals are unstable over time. The question is to what extent is this due to the internal environment of hospitals and the associated managerial decisions and to what extent the instability reflects the influence of the external environment, characterized mainly by administrative authorities and major interest groups, which especially include health insurance companies.

The main purpose of our research was to determine whether the change in the legal status of hospitals was effective or not. Former legislators and especially the representatives of selected regional governments presented the main goal of these changes in the expectation of achieving better financial management of the Czech hospitals. Using a linear mixed model applied on our data, however, we did not prove the relationship between economic results in the period 2007–2011 and the legal form of the hospital. The promised effect of proponents of the transformation of legal form of a hospital into a business company has not been confirmed. On the contrary, the performed analysis proved that the absolute level of economic result is significantly higher for state hospitals than for the other two types of hospitals, confirming, among other things, a specific position of university hospitals, which in addition to health care serve as an educational institution.

The difference in long-term financial performance was proven even regionally. The best economic results during the period considered were achieved by hospitals in the Jihočeský (JHC) region where the economic result also showed a relatively stable level (except for one case in 2009). In this region there are eight hospitals, all owned by the regional government. The legal form of all these hospitals is a joint-stock company. In a subsequent interview with representatives of the management of these hospitals, we have confirmed our findings. In their opinion, an even distribution of hospitals in the region and a different way of managing hospitals help to maintain the positive consolidated economic result. In this region, it led to a personnel interconnection of hospital boards of directors into one holding. Hospitals from this holding share information and logistic processes in the spheres of purchasing medicines and special equipment. Moreover, thanks to the same strategy, they exert pressure on health insurance companies and thereby they achieve uniform and favorable contract terms.

Even if we take into account the possible influence of the type of hospital and operating region, there are significant differences in the financial performance of individual hospitals. It is necessary to attribute these differences to other possible factors that were not included in the research (e.g. staff from internal factors and method of health care financing from external factors) or to other random influences. Although it is not possible to demonstrate population growth or declination of (transformed) economic result during the period 2007–2011, individual hospitals show significant differences in the rate of growth/decline of

(transformed) economic result. In addition to the economic result, we intend to include into the analysis more financial indicators and other hospital activity data in our further research, enabling us to perform a more comprehensive assessment of the efficiency and productivity of the Czech hospitals and their comparison.

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