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ERROR CORRECTION MODEL FOR THE SERVICE COMPANY

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Abstract:
Purpose of this applicative project research was the identification and analysis of the key performance indicators (KPIs') which significantly contribute to the benefits of the business processes exploitation in the Port of Luka Koper, d. d. With this case study we attempted to get deeper understanding, and to clarify and evaluate the causalities between enablers and results. For this purpose we developed a single equation microeconomic Error Correction Model (ECM) with the Engle–Granger (1987) two step method. With the ECM approach we performed application on the KPIs and estimated short and long term effects between them. Final ECM indicates that that there is a lot of nonlinearity at the microeconomic level between KPIs and that a two step method should be used for the time series (KPIs) analyses at the microeconomic level and for forecasting. From the literature review is evident that this kind of approach is not used very often with exception for the macroeconomic level. Long-term framed qualitative and quantitative analyses indicate the benefit of the identificated KPIs' and their influence on the fulfilment of the strategic directions.

Keywords: microeconomic level, error correction model, cointegration, error correction term, KPIs.

1. INTRODUCTION

The Luka Koper, d. d. is recognized as a significant port and logistic system in the Adriatic maritime market. The company introduced their first balanced scorecard (BSC) system in 2006. Beside that the company entered the competition for the most prestigious European Business Excellence Award, and becomes an Excellence Award Finalist in 2006.

System of performance measures or BSC, when used in practice, shows that is difficult to determine transparent relations between perspectives. However, the implemented model doesn't enable the identification of all information on the relations (i.e. correlations, causalities) between process Key Performance Indicators (KPIs). In this manner company doesn't have transparent evaluation of resource inputs in efficiency of the implemented model in the management system (Janeš & Dolinšek, 2010). Diagnostic activities, in this context, are usually "too expensive" to the company and it's usually overworked employees. Because of the latter's outlook, diagnostic is regarded as being time-consuming activity. With the development and application of a model for identification of the influential KPIs' which gives important contribution to the business results, company can perform its own diagnostic activities and focus on improvements of the key processes in a short and long-time period.

Many authors, such as Kaplan and Norton (1992), Bititci (1994), Bititci et al. (2006), Olve et al., (1999) and Robson (2004), argue that the establishment of a system of performance measurement must begin with the review of the strategy and not the actual outcome of business processes. Therefore, measures must be directly related to the strategies of the organization and should be selected on the basis of the strategic objectives of the organization. Knowledge about the relations and causality between the KPIs in the selection and composition of balanced scorecard is essential for efficient and effective management of the organizations. Studies of many authors in the field of performance measurement systems show the actuality of this scientific field and the selected methodology provides support to decision-making process in organizations.

2. REVIEW OF THE LITERATURE AND RESEARCHES

The origins of the Balanced Scorecard (BSC) date back to the time when the management of organizations generally relied on a short-term perspective and only considered the historical data, which mainly represented the financial performance indicators (PIs) (Johnson & Kaplan, 1987; Modell, 2009).

Gradually, the need has arisen to take into account new perspectives, such as the customer satisfaction, the internal process perspective and the perspective of learning and growth. In the 1990's, the role of various business-related perspectives and the associated financial and non-financial performance indicators have become an important topic for practitioners, experts and researchers.

The cause and effect relations among the different business perspectives are underlying for accomplishing the long term strategic goals of the organization. This can be achieved by a decomposition of the vision and strategic objectives of an organization into a set of causally related KPI's, which represent the financial perspective, the customers and internal processes, and the learning and growth perspective. Such a set of indicators should be cascaded across all levels of management so as to promote the understanding of the organization's objectives

from the perspective of managers and all employees (Kaplan & Norton, 2000; Modell, 2009; Poister, 1982; Wisniewski & Dickson, 2001).

As a rule, the KPIs are determined based on the past experience and by regular reviewing. Where appropriate, an expanded range of KPI's may be confirmed or some of them may also be phased out.

It is necessary to clarify why, what and how often we need to measure before we decide how to measure (Jones, 2009). Managers should be first asked the questions about what they want to achieve, what their objectives are and how they can describe them. Therefore, we begin to set up the system of performance indicators by the consensus of managers regarding the description of their goals in the four perspectives. This will facilitate the determination of measurement, as well as defining and changing the KPIs themselves and the sources of data (Kaplan & Norton, 2004; Ittner et al., 2003; Poister, 1982). Historically, the processes in the organizations were investigated mainly as qualitative, verbal and linguistic. Previous research in the field of business processes and performance measurement systems was predominantly performed with the data within a short period of time.

Meanwhile, the longitudinal and dynamic researches for developing theories in this area are very rare. An example for updating the research methodology could be the theoretical physicists (e.g. Einstein or Hawkings), who think in the context of mathematical equations. Thus, the mathematical tools are appropriate to increase the exactness of the conceptual and empirical research. A completion of qualitative research of business processes with statistical tools holds great potential in this area. Namely, the inclusion of a process-based approach and the methodology of longitudinal treatment of business processes makes a very important addition to the conceptual thinking of researchers (Brock & Durlauf, 2001; Fritz & Fritz, 1985; Monge, 1990).

Given the framework of the strategy map, which consists of four perspectives, and within them a large number of related strategic objectives, it is considered that the added value to business processes is increased by direct and indirect mutual relations. The added value in business processes is manifested in the form of chains of cause and effect relations ranging from nonfinancial and quantifiable KPIs in the learning and growth perspective to the results in the customers' perspective (Ittner & Larcker, 1998) and in the financial perspective. Kaplan and Norton's Balanced Scorecard provides a comprehensive framework that translates the strategic goals of the organization into a coherent set of measures. The biggest advantage of the Balanced Scorecard, as compared to other approaches or models, is its ability to integrate the capabilities of the various perspectives of the company - financial and non-financial, as well as internal and external (Kaplan & Norton, 2006).

Since we do not know the exact principles between the observed variables, which were taken into account in addition to the available literature, researches, documents and records, we especially applied the information contained in the time series of observed variables (i.e. PIs). Already through the observation of linear regression between pairs of variables or PIs, we can presume the causality which is then confirmed by the Granger causality test (Smith, 1993). It should be noted that from or literature review to date, we have not found any similar case study. The knowledge about the correlations and causalities between the KPIs in the selection and composition of balanced scorecard is essential for efficient and effective management of organizations (Janeš & Dolinšek, 2010). Studies of many authors in the field of Balanced

Scorecard show how topical this scientific field is and the selected methodology provides the support to organizations' decision-making process in real time.

3. METHODOLOGY

The purpose of our research is to explore and clarify the cause and effect relations between KPIs. This will give us a basis for understanding these relations and understanding about the relations between business strategy and operations at all levels. This quantitative oriented research deals with the influence of the measured process KPI's on the company's strategy fulfillment. As a research method we have chosen the case study (Yin, 1994) of the Luka Koper, d. d. Company, based on the following criteria:

- First BSC system has been introduced in 2006,
- Luka Koper, d.d. entered the competition for the most prestigious European Business Excellence Award, and has become an Excellence Award Finalist in 2006, and
- The project of identification of the KPI in collaboration with the UP Faculty of Management Koper has formally started in 2009.

Data for the model testing, application and analyses were gathered in period between September and November 2010. From the collected data we constructed time series of KPIs' for one of the terminals for maritime throughput in the period from January 2003 to September 2010. In previous years of the project we already ascertained correlations between KPIs (Janeš & Dolinšek, 2010). But the research question about causality still remains: For which relations between the KPIs can we statistically (quantitative) and practically (qualitative) ascertain causal relations? For this purpose we developed a single equation microeconomic Error Correction Model (ECM) with the Engle–Granger (1987) two step method.

4. EMPIRICAL FINDINGS AND DISCUSSION

We have chosen KPIs by which the company executes monitoring of its business performance in the four perspectives. Among the indicators that were available, we were opting for those who are monitored in general cargo terminal (GT). All variables represent indicators which are monitored in the company's BSC system. We used six indicators which are: operating revenue OR1, revenue per unit of maritime throughput RU1, maritime throughput MT2, electricity consumption EC3, fossil fuel consumption FC3, and water consumption WACN3. From the previous analyses in 2010 and 2011 we ascertained that selected KPIs are stationary, cointegrated between pairs and causal related (see Janeš & Dolinšek, 2010; Janeš & Dolinšek 2011).

4.1. Error Correction Model

In the first step, we estimated cointegration in accordance with the Engle-Granger procedure. To this end, we set the initial model of performance indicators, calculated regression by the least squares (LS) method and saved the residual value of the potential cointegration vector. Residual values were tested for stationarity which was ascertained by the Phillips-Peron test.

In the second step, we built a model to correct these errors by using the seasonal differences of the indicators, and different time lags of KPIs' and residuals. When the KPIs are cointegrated, then according to the Engle-Granger procedure (1987), there must be an ECM

model, which coordinates short-term changes of cointegrated KPIs' with their long-term changes (Gujarati 1995, p. 730). In the following error correction model (see Table 1 and eq 1) the value of RESID11(-11) represents the error correction term u_{t-i}. The latter represents the residuals from the cointegration regression equation, which measures the speed of adjustment to long-term equilibrium.

In order to restore equilibrium, the sign of the coefficient of the EC_{t-1} is expected to be negative (Engle & Granger, 1987; Gujarati, 1995, pp. 730; Alkhathlan, 2011). Since we had monthly data available we included 12 time lags for the initial model (Gujarati, 1995, pp. 728–729). We evaluated the structure of the lags with the criteria for determining the order of lags and correlograms. In our case, 11th order of lags proved to be suitable. This was approved on the basis of five criteria, at the 5 % level of statistical significance (i.e. Sequential modified LR test statistic, FPE - Final Prediction Error, AIC - Akaike information criteria, SC - Schwarz information Criterion and HQ - Hannan-Quinn information criterion).

$$\Delta OR1_t = \alpha_0 + \Sigma_{i=1}^{n} \alpha_1 \Delta OR1_{t-i} + \Sigma_{i=1}^{n} \alpha_2 \Delta MT2_t + \Sigma_{i=1}^{n} \alpha_3 \Delta EC3_t + \Sigma_{i=1}^{n} \alpha_4 \Delta FC3_t + \Sigma_{i=1}^{n} \alpha_5 \Delta WACN3_t + \Sigma_{i=1}^{n} \alpha_6 \Delta RU1_t + \alpha_7 u_{t-i} + \varepsilon_t \quad \text{(eq 1)}$$

In activity of excluding lags we performed the visual analysis of time series and residuals with correlograms (Gujarati 1995, pp. 739–742). The number of lags was then gradually reduced on the basis of Wald test for exclusion of lags (excluding lags 2, 4, 7, 8, 10 and 12). By testing different KPIs time lags on the right side of the equation and decreasing of autocorrelation and serial correlation we have come to the final error correction model (ECM) (Table 1).

The results of the final ECM model show that the operating revenue OR1 is dependent on several indicators. First and foremost, the causal indicators of the OR1 are maritime throughput MT2 and revenue per unit of maritime throughput RU1.

The statistically significant causal relationship is contributed also by electricity consumption EC3, fossil fuel consumption FC3 and water consumption WACN3, which are exploited for the handling of all types of maritime throughput.

The final model has a high adjusted determination coefficient which is $Adj.R^2 = 0.9890$. For the cointegration regressions is generally recommended to choose the solutions that have the highest coefficient of determination R^2, because the latter reduces bias in the estimated cointegration parameters (Banerjee, Dolado, Hendry & Smith, 1986; Hall, 1986 by Jiha & Orphee, 1995, pp. 106–107).

In addition, the Durbin-Watson's statistic, which is 2.0741, indicates that we significantly reduced the impact of autocorrelation and serial correlation. All regression coefficients and constants of the KPIs' are statistically significant, the error correction term, is negative and also statistically significant $u_{t-11} = -0.9253$. Error correction term shows how fast the model returns to stability at any disturbance or shock. The result in Table 1 can be interpreted as follows: total turnover is increased, by increased maritime throughput. Increasing the maritime throughput means a reduction in electricity consumption per tonne reloaded and increasing consumption of fossil fuels and water.

Table 1: Final ECM

Dependent Variable D11OR1				
KPI	Coefficient	Std. Error	t-Statistic	Prob.
D11MT2	16.91501	0.529441	31.94880	0.0000
D11EC3	-11.54019	1.222652	-9.438652	0.0000
D11FC3	6.149600	1.430026	4.300341	0.0001
D11WACN3	14.08760	2.065849	6.819277	0.0000
D11RU1	897.9722	101.5168	8.845557	0.0000
RESID11(-11)	-0.925361	0.030894	-29.95276	0.0000
OR1	0.836054	0.029701	28.14920	0.0000
MT2	-13.10256	1.049950	-12.47923	0.0000
EC3(-1)	9.172357	1.517075	6.046082	0.0000
FC3(-1)	-5.883652	1.374530	-4.280482	0.0001
RU1	-732.4894	142.9989	-5.122343	0.0000
C	-500897.6	55176.52	-9.078093	0.0000
R^2	0.990579			
Adj. R^2	0.989098			
Akaike info criterion	25.99499			
Schwarz criterion	26.34720			
Hannan-Quinn criter.	26.13640			
Durbin-Watson stat	2.074189			

Revenue per unit of maritime throughput RU1 has a negative regression coefficient, which may lead to an increase in income or increased amount of maritime throughput and simultaneously reducing the cost per tonne reloaded. Results are reflecting the impact of sharp declining in maritime throughput with greatest added value in the years 2007 and 2008. All these results and observations suggest that an error correction mechanism exists and that we set up a stable model, which describes the dynamics of short-term determinants of the long-term service performance.

The final model with an ECM reflect Granger`s causality caused by maritime throughput and energy consumption on the total sales revenue. Results of the analysis are also consistent with the developed procedure and the results of several authors on which we can tie our findings about cointegration between KPIs (Engle & Granger, 1987; Granger, 1983; Mon Miller, 1991, p. 146; Jiha & Orphee, 1995, p. 99; EViews, 2010).

From the methodological point of view it would be interesting to analyse the existence of cointegration and ECM with time series data sample divided into two parts. However, because of the relatively small number of measurements over the entire sample, which is n = 93, statistical analysis of the halved measurements indicates no cointegration between time series. Such a procedure is problematic due to the low number of available measurements and the error correction term that could be misleading. This was identified by the authors of the several studies (Engle & Granger, 1987; Stock & Watson 1988 by Jiha & Orphee 1995, p. 101; Macunovich & Easterlin, 1988; Miller 1991, p. 146).

4.2. Diagnostics of the Error Correction Model

MT2 indicator of maritime throughput, which in this model appears on the right side of the equation, is substantively and statistically (Wald's test of independence) recognized as an independent indicator. Maritime throughput cannot be dependent on other indicators such as consumption of energy and consequently the revenue of maritime throughput. This happens because of the maritime throughput, which is shipped into port of Luka Koper, d. d. A share of throughput is also achieved due to the land transshipment of goods, which was not addressed in this study. The maritime throughput MT2 also includes seasonal component and random errors.

Correlogram of residuals showed that residuals did not induce serial correlation as the Q statistic is not significant (from 0 to 36 lags). Breusch-Godfrey LM serial correlation test showed that between the residuals of the KPIs' there is no serial correlation, since we could not reject the null hypothesis that there is no serial correlation (up to 12th lag).

With the Breusch-Pagan-Godfrey, Glejser and White test we rejected the hypothesis of residuals heteroskedasticity. Examination of the stability of the model in breaking year 2006, with the Chow's test showed that we cannot reject the null hypothesis of no breaks at specified breakpoint. In the case of rejection of the null hypothesis, the Chow's test would indicate structural changes. This means that the coefficients of the model equation are stable. Using different tests we confirmed the relative stability of the final ECM. Of course, it is appropriate to test and evaluate the ECM model with the latest actual data and recalculate the error correction term, which will further improve our model. Performed test can be tied to procedures for testing models in studies of various authors (Engle & Granger, 1987; Stock & Watson, 1988; Jiha & Orphee, 1995; Macunovich & Easterlin, 1988; Miller, 1991).

5. CONCLUSIONS

Discussed organization can be a model in terms of demonstrating the achieved level of business performance excellence. Using the model to identify KPI is suitable for classification and assessment of the integration and causality between the performance indicators under the four perspectives of the BSC. Thus, a quantitative approach is useful in combination with a qualitative approach, which is common practice in determining the causal relations resulting in the strategic map of BSC. Whatever the management levels, the simulations of the model are possible by combining the KPI and consecutively acquire new knowledge about their relations, causality, improving the monitoring of strategic guidelines and objectives. Some of the influences of specific factors that affect the unexplained part of the variables analyzed in the study are certainly random, but some may arise from current circumstances in the company and are not included in the model or we did not have available data. A case study of the port and logistic system Luka Koper, d. d. has also some limitations. The first relates to sample size and quality of the data which were available. A second limitation is a quantitative analysis in the four perspectives of the BSC. Since this is the case study which investigates the impact of the KPIs' on the results and causalities between them, we also encountered the data, which are treated as a business secret. We must also consider the impact of external factors, such as changing government regulations, access to public infrastructure such the second rail track to Divača and investment in the railway business, logistic centers, development of maritime passenger terminal and alcohol terminal and competing ports in the Mediterranean (in particular, Rijeka and Trieste). The company has faced sharp decline in maritime throughput in 2007 as a result of the global financial crisis which is reflected

through the KPI in the years 2008, 2009 and 2010. Further research into the impact of introducing the four perspectives of the BSC to monitor the implementation of strategies, organizational culture and business results is definitely recommended. With research of the case studies, as well as benchmarking between them, we contribute to clarify the position of Slovenian organizations among other organizations in the EU and beyond.

REFERENCE LIST

1. Alkhathlan, K. A. (2011). Foreign Direct Investment and Export Growth in Saudi Arabia:A Cointegration Analysis. *China-USA Business Review, 10*(2), 137–149.
2. Banerjee, A., Dolado, J. J., Hendry, D. F., & Smith, G. W. (1986). Exploring Equilibrium Relationships in Econometrics through Static Models: Some Monte Carlo Evidence. *Oxford Bulletin of Economics and Statistics*, (August), 253–277.
3. Bititci, U. S. (1994). Measuring your way to profit. *Management Decision, 32*(6), 16–24.
4. Bititci, U. S., Mendibil, K., Nudurupati, S., Garengo, P., & Turner, T. (2006). Dynamics of performance measurement and organisational culture. International *Journal of Operations & Production Management, 26*(12), 1325–1350.
5. Brock, W. A., & Durlauf, S. N. (2001). Growth Empirics and Reality. *The World Bank Economic Review, 15*(2), 229–272.
6. Engle, R. F., & Granger, C. W. J. (1987). Co-integration and Error Correction: Representation, Estimation, and Testing. *Econometrica, 55*(2), 251–276.
7. EViews. 2010. EViews 7, User Software. CD-ROM. Irvine CA: Quantitative Micro Software, LLC.
8. Fritz, R. G., & Fritz, J. M. (1985). Linguistic Structure and Economic Method. *Journal of Economic Issues, 19* (1), 75–101.
9. Gujarati, D. N. (1995). *Basic Econometrics*. New York: McGraw-Hill.
10. Hall, S. G. (1986). An Application of the Granger and Engle Two-Step Estimation Procedure to United Kingdom Aggregate Wage Data. *Oxford Bulletin of Economics and Statistics*, (August), 229–239.
11. Ittner, C. D., & Larcker, D. F. (1998). Indicators of Financial Performance? An Analysis of Customer Satisfaction. *Journal of Accounting Research 36*, 1–35.
12. Ittner, C. D., Larcker, D. F., & Meyer, M. W. (2003). Subjectivity and the Weighting of Performance Measures: Evidence from a Balanced Scorecard. *The Accounting Review, 78*(3), 725–758.
13. Janeš, A., & Dolinšek, S. (2010). Do we need a new compass for the journey through the global crisis? *Journal of Industrial Engineering and Management, 3*(2), 255–293.
14. Janeš, A., & Dolinšek, S. (2011). Knowledge for the right strategy: Leading role in the cluster of supply companies. *Proceedings of the Management, Knowledge and Learning International Conference 2011*, Celje, June, 251–258.
15. Jiha, J., & Orphee, G. (1995). A note on inflation in Haiti: evidence from cointegration analysis. *Social and Economic Studies, 4* (1), 95–115.
16. Johnson, H. T., & Kaplan, R. S. (1987). *Relevance Lost. The Rise and Fall of Management Accounting*. Boston, MA: Harvard Business School Press.
17. Jones, P. (2009). Avoiding problems and predicting recovery during the economic crisis. Retrieved from http://www.excitant.co.uk.
18. Kaplan, R., & Norton, D. (1992). The balanced scorecard - Measures that drive performance. *Harvard Business Review, 70*(1), 71–79.
19. Kaplan, R., & Norton, D. (2000). Having trouble with your strategy? Then map it, *Harvard Business Review, 78*(5), 167–176.

20. Kaplan, R. S., & Norton, D. P. (2004). *Strategy Maps: Converting intangible assets into tangible outcomes*. Boston: Harvard Business School Publishing.
21. Kaplan, R. S., & Norton, D. P. (2006). *Alignment: Using the Balanced Scorecard to create corporate synergies*. Boston: Harvard Business School Publishing.
22. Macunovich, D. J., & Easterlin, R. A. (1988). Application of Granger-Sims Causality Tests to Monthly Fertility Data, 1958-1984. *Journal of Population Economics, 1*(1), 71–88.
23. Miller, S. M. (1991). Monetary Dynamics: An Application of Cointegration and Error-Correction Modeling. *Journal of Money, Credit and Banking, 23*(2), 139–154.
24. Modell, S. (2009). Bundling management control innovations. Accounting, *Auditing & Accountability Journal, 22*(1), 59–90.
25. Monge, P. R. (1990). Theoretical and Analytical Issues in Studying Organizational Processes. *Organization Science, 1*(4), 406–430.
26. Olve, N., Roy, J., & Wetter, M. (1999). *Performance Drivers: A Practical Guide to Using the Balanced Scorecard*. Chichester: John Wiley & Sons.
27. Poister, T. H. (1982). Developing Performance Indicators for the Pennsylvania Department of Transportation. *Public Productivity Review,* (1/2), 51–77.
28. Robson, I. (2004). From process measurement to performance improvement. *Business Process Management Journal, 10*(5), 510–21.
29. Smith, P. K. (1993). Welfare as a Cause of Poverty: A Time Series Analysis. *Public Choice, 75*(2), 157–170.
30. Stock, J. H., & Watson, M. W. (1988). Variable Trends in Economic Time Series. *The Journal of Economic Perspectives, 2*(3), 147–174.
31. Wisniewski, M., & Dickson, A. (2001). Measuring Performance in Dumfries and Galloway Constabulary with the Balanced Scorecard. *The Journal of the Operational Research Society, 5*(10), 1057–1066.
32. Yin, R. K. (1994). *Case study research: design and methods*. Thousand Oaks: Sage.