MATRIX-TYPE MODEL TO CONTROL THE BUSINESS PROCESSES

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The aim of this paper is to introduce a matrix model to be used for business process management. The process control matrix is applied in the case of the Romanian Farm Land Register (cadastre services) – which is a premiere and an original contribution. The Key Performance Indicators (KPI) and control matrix were developed using statistical methods while six sigma methodology and lean production systems were used to select the relevant factors. The results are positive and managerial implications are associated to the advantages of the model – mainly a higher stability of the process outputs – for the benefit of the whole organization, which is transiting from unstructured activities to a process-focused organization.

Keywords: business process management, KPI (Key Performance Indicators), KPI control matrix, transfer matrix, lean six sigma, Romanian Farm Land Register

1. Introduction to process-oriented business organizations

Innovative companies manage their business processes in a systemic manner, in order to achieve their ambitious objectives, allocating efficiently their resources. Continuous improvement, and innovative concepts and systems for product quality or for new product development as Kaizen ([1], [2], [3]) and Total Quality Management (TQM) ([4], [5], [6]) – supported by applied statistics – namely Six Sigma ([6], [7], [8], [9]) – were solid approaches to achieve operational and business excellence.

New concepts as lean production ([10], [11], [12], [13]) have completed the managerial arsenal. They are applied as such or in more complex models as Lean Six Sigma or Design for Six Sigma ([14], [15]).

Top global companies such as Motorola [8], General Electric [16] or Toyota ([11], [17], [18]) have discovered that most of the troubles appear in the modulation points of the processes, precisely at the limit of functional areas. They all understood that managers must get ready for a process-based approach: the final result is all it counts and mastering the entire process ("end to end") by all people involved is critical in order to perform.

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These studies are related to goods manufacturing industries, and off Romanian companies [19]*. Our study is concerned by Romanian service firms.*

Madison defines organizations as people, processes, control, and structure mechanisms [20]. Hayler and Nichols [21] analyze business organizations as process-based: the business process is defined by input vector X (resources), set of activities (i.e. transfer function F), and output vector Y (goods and/or services); output vector and input vector should be strongly correlated through activities. The general model of the transfer function, presented in Figure 1, is:

$$Y = F(X) \tag{1}$$

or

$$Y[Y_1, Y_2, ..., Y_m] = F(X[X_1, X_2, ..., X_n]) \tag{2}$$

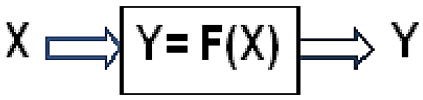


Fig.1. The general model for the transfer function

In order to better match the critical customer demands, each factor should have set clearly defined specification limits – as described by Breyfogle [8]. This means that managers have to focus on X inputs to keep their values within specified limits in order to obtain the quality of the outputs Y at the level corresponding to the customer requirements [22].

The transfer matrix (TM) is a strategic tool which leverages the rolling down of the strategic objectives in the entire organization (setting measurable limits for relevant factors). TM is enhancing the Balance Score Card (BSC) model – that is used to control the Key Performance Indicators (KPI) as described by Kaplan and Norton [23]. For process-oriented organizations, TM represents a conveyance to stabilize the process outputs.

For the purpose of the current study TM was also used to shorten the time required to structure the current activities within organization.

The significant stages of the process (in order of the process evolution) are: Stage Zero (Idea Stage) → Unstructured activities → Stable process → Mature and profitable process. *This paper presents the results related to the evolution of the organization from "unstructured activities" to the "stable process" stage.*

As studies presented in the literature are related to goods production, in global companies, the purpose of this paper is to present some of the results of a larger study, which is focused on a service provider organization from Romania – specifically cadastre services (Farm Land Register) – which is an original

contribution. The main objective is to develop a transfer matrix for this cadastre service company, using statistical methods, while six sigma methodology and lean production systems were used to select the relevant factors. The transfer matrix is subsequently used to develop a KPI control matrix – supporting the organization [i.e. its management] to control the business process and to evolve from unstructured activities to stable process.

The remaining of the paper is structured as follows: description of cadastre process and transfer matrix format; research methodology and data; results and recommendations; managerial implications – completed with overall conclusions.

2. Developing the transfer matrix in case of cadastre services

This section describes the essentials of the cadastre process (as a business process) and format of the transfer matrix.

Description of the cadastre process

For developing the Transfer Matrix it is vital to understand the national land registration "challenges" and the current issues related to the cadastre process. It is critically important to highlight the activities rolled during the process, step-by-step, and to emphasize the importance of human resources skills, clarity of the work instructions, the impact of the public agencies' policies and the criticality of current client requirements [24].

Logics of the process: Registering of the agriculture plots in the National Land Registry (end to end process).

Process input: Collecting primary information – i.e. documents that show the history of the ownership rights over the land (as property titles, heir certificates, legatee certificates, court orders, documents of voluntary separation, sale or donation contracts, real estate exchange contracts, and similar others).

Main steps of the process:

Step 1: Land identification
Step 2: On-site measurement of the land coordinates (GIS technology: Appendix)
Step 3: Collecting necessary information from the National Office for Cadastre and Real Estate Information (in Romanian: OCPI) and respective Town/Village Hall
Step 4: Completion of cadastral location and delimitation plan (in Romanian: PAD) and cadastral framing plan (in Romanian: PIT)
Step 5: Document validation (by OCPI and Town/Village Hall)
End of the Process

Process output (deliverables): Documents delivered to the land owner.

Transfer matrix format

According to Yang and El Haik [14], the main drivers to design the Transfer Matrix are both customers and business needs. The transfer matrix format (m x n; m=5, n=13) was developed by the team involved in the process using the Quality Function Deployment (QFD) matrix (Lean Six Sigma initiative). The team members are highly experienced in either research methods or cadastre process, or both. The design parameters (inputs and the outputs) are listed below – as they were agreed by the research team [25].

Five design parameters (outputs) were acknowledged:

Y_1 = Number of [sets of] documents (for the registered piece of land)
Y_2 = Lead time
Y_3 = Quality
Y_4 = Skilled workforce
Y_5 = Productivity

The input factors (process variables) are the following:

X_1 = Human resources training
X_2 = Work instruction
X_3 = Human resource level of knowledge
X_4 = Number of [successful] contacts at Town/Village Hall
X_5 = Number of [successful] contacts at OCPI
X_6 = Internal quality
X_7 = Number of documents delivered (which were needed and requested)
X_8 = Full-time employment (available)
X_9 = Frequency of OCPI visits
X_{10} = Frequency of OCPI calls
X_{11} = Workforce morale
X_{12} = Frequency of visits at the Town/Village Hall
X_{13} = Backlog

Thus, in case of cadastre services, mathematical model (2) becomes (3):

$$Y[Y_1, Y_2, Y_3, Y_4, Y_5] = F(X[X_1, X_2, ..., X_{13}]) \tag{3}$$

Further deeper analysis of the transfer matrix – as it was conducted by the research team – has led to the interdependencies depicted in Table 1 [25]. According to these, the top output indicator Y_1 depends on seven input factors only: X_1, X_2, ..., X_{10} (4):

$$Y_1 = F_1[X_4, X_5, X_6, X_7, X_8, X_9, X_{10}] \tag{4}$$

Table 1

The transfer matrix for the cadastre service company

Design parameters	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}
Y_1				√	√	√	√	√	√	√			
Y_2							√					√	√
Y_3	√	√				√							
Y_4	√		√								√		
Y_5			√			√					√		

Comparing the two perspectives of the mathematical model, practical versus statistical, it could be stated that the Y_1 model (4) comprises some correlated terms which show abnormal behaviour from a practical point of view. The process of land registration has been revised by specialists and, based on their experience, the project team decided to conduct further analysis. Consequently, each effect factor involved in the process has been studied according to two perspectives: individual and group interactions. However, due to the general conditions of the business, it was difficult to plan a balanced experiment in order to obtain the direct influence of the factor interaction effects. Therefore, the process survey plan has been managed in order to prioritize the importance of the involved factors.

This paper is focused on Y_1 - related calculations and results mainly.

3. Research methodology and data collection

The overall research objective is to identify the relation between input factors and output factors, to establish levels/limits for these factors, and to finally find an *adequate model* and a *stable process.*

The research team was assembled of experts either in specific research methods and methodologies (as six sigma, lean production) or cadastre process and topography, or both of them. The company the team works for is a cadastre service provider in Romania, and its clients are landowners across all country.

The data were collected and analyzed for a past period of 50 weeks (year 2012) in order to match the research objective.

The task of the research team was to set a minimum level for low impact factors and to maximize the effect of the most important factors. As X_{10} was not included for further analysis as considered less important, the model was constructed using only six factors out of original thirteen (3) funnelled then to seven (Table 1): Successful number of contacts at Village Hall (X_4), Successful number of contacts at OCPI (X_5), Internal quality (X_6); Number of the documents

delivered (X_7); Full-time available employment (X_8); Frequency of OCPI visits (X_9) – i.e. (5):

$$Y_1 = F_1[X_4, X_5, X_6, X_7, X_8, X_9] \tag{5}$$

4. Research results, discussion and recommendations

The regression analysis (Figure 2) highlights X_7 among the other five as the most correlated factor. During the analysis, the project team observed that X_7 is correlated with Y_1 *only if time is considered to be an additional factor*.

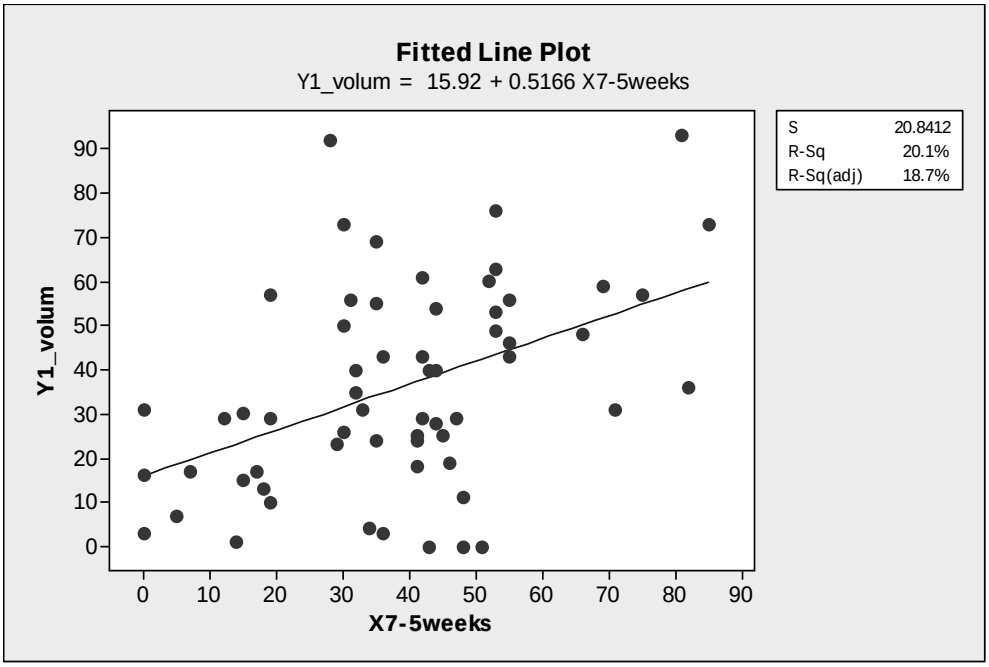


Fig.2. Regression equation (Minitab): $Y_1(X_7)$

Therefore, the research team took into consideration the volume variation delivered over the most recent 8 weeks. From a mathematical perspective, in order to emphasize the time variation of the X_7 factor (a 50 [weeks] – dimension column vector), the research team used a transformation matrix aiming to understand the statistical effect of the delays generated by the national agency processing (Lead-Time Variation). Specifically, X_7 was decomposed in nine column vectors respectively: first column is "$X_{7\ \text{current week}}$" (number of documents

delivered to the national agency in the "current week"); second column is "$X_{7\text{-}1week}$" (number of documents delivered to the national agency one week before); …; ninth column is "$X_{7\text{-}8weeks}$" (number of documents delivered to the national agency eight weeks before). The mathematical model (5) becomes (6):

$$Y_1 = X_4 + X_5 + X_6 + X_{7\,currentwek} + X_{7-1\,week} + ... + X_{7-8\,weeks} + X_8 + X_9 \tag{6}$$

The transformation matrix for the factor $X_{7\text{-}1week}$ is (7):

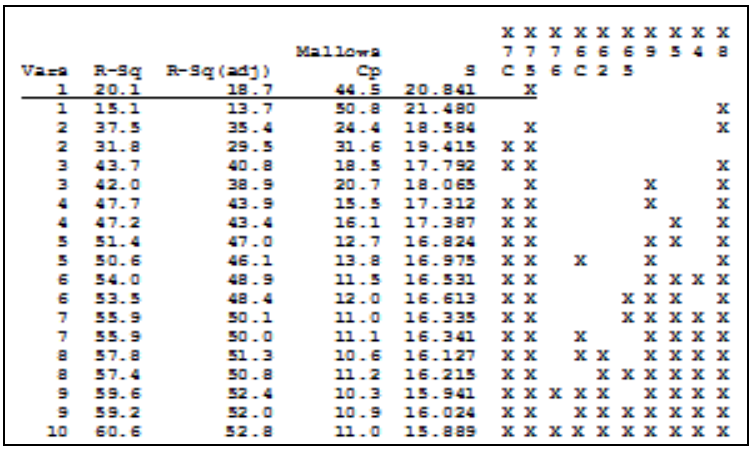
$$\begin{pmatrix} 0 & 0 & ... & 0 & 0 \\ 1 & 0 & ... & 0 & 0 \\ ... & ... & ... & ... & ... \\ 0 & 0 & ... & 1 & 0 \\ 0 & 0 & ... & 0 & 1 \end{pmatrix}_{kk} * \begin{pmatrix} X_{7,1} \\ X_{7,2} \\ ... \\ X_{7,k} \end{pmatrix}_{k1} = \begin{pmatrix} 0 \\ X_{7,1} \\ ... \\ X_{7,k-1} \end{pmatrix}_{k1} \tag{7}$$

Therefore the relation between Y_1 and $X_{7\text{-}1week}$ is (8):

$$\begin{pmatrix} Y_{1,1} \\ Y_{1,2} \\ ... \\ Y_{1,k} \end{pmatrix} = C \begin{pmatrix} 0 \\ X_{7,1} \\ ... \\ X_{7,k-1} \end{pmatrix} \tag{8}$$

where: $Y_{1,1} = 0$.

The X_6 factor (Internal quality) behaves similarly to X_7 and it is decomposed accordingly. The remaining modified input factors X were obtained using the same procedure. Hence, each combination of factors was interpreted from practical perspective. The Minitab best subset combination (Figure 3) shows that the most relevant factor from the process is $X_{7-5weeks} = X_{7,6}$ ("Number of needed and requested documents which were delivered, minus five weeks / before") and it alone could explain almost 19% of the variation.



Vars	R-Sq	R-Sq(adj)	Mallows Cp	S	X7 C	X7 5	X7 6	X6 C	X6 2	X6 5	X9	X5	X4	X8
1	20.1	18.7	44.5	20.841		X								
1	15.1	13.7	50.8	21.480										X
2	37.5	35.4	24.4	18.584		X								X
2	31.8	29.5	31.6	19.415	X	X								
3	43.7	40.8	18.5	17.792	X	X								X
3	42.0	38.9	20.7	18.065		X					X			X
4	47.7	43.9	15.5	17.312	X	X					X			X
4	47.2	43.4	16.1	17.387	X	X						X		X
5	51.4	47.0	12.7	16.824	X	X					X	X		X
5	50.6	46.1	13.8	16.975	X	X		X			X			X
6	54.0	48.9	11.5	16.531	X	X					X	X	X	X
6	53.5	48.4	12.0	16.613	X	X				X	X	X		X
7	55.9	50.1	11.0	16.335	X	X				X	X	X	X	X
7	55.9	50.0	11.1	16.341	X	X		X			X	X	X	X
8	57.8	51.3	10.6	16.127	X	X		X	X		X	X	X	X
8	57.4	50.8	11.2	16.215	X	X			X	X	X	X	X	X
9	59.6	52.4	10.3	15.941	X	X	X	X	X		X	X	X	X
9	59.2	52.0	10.9	16.024	X	X		X	X	X	X	X	X	X
10	60.6	52.8	11.0	15.889	X	X	X	X	X	X	X	X	X	X

Fig.3. Best subset multiple regression analysis (Minitab)

The best subset analysis shows, from statistical perspective, that the seven factor combination with adjusted coefficient of multiple determinations at 50.1% (adjusted R2) is the recommended model. When considering the Cp coefficient (lower the coefficient, better), the minimum value is 10.3. Per Montgomery and Runger [26], Cp coefficient is a measure of prediction quality. For Cp = 10.3, the variation due to the number of nine factors (adjusted R2 = 52.4) does not justify to consider the combination with two more factors. Nevertheless, the research has to consider the abnormal negative coefficients' values and, accordingly, to make the proper decision in factor analysis. In this case, the model comprises two statistically significant factors that do not make sense from practical perspective: $X_{7\text{-}2weeks}$ ("additional request 2 weeks before") coefficient -0.779 and X_5 ("Successful number of contacts at OCPI agency") coefficient -2.233 (Figure 4) have introduced an important challenge for the entire research team.

Direct survey did not explain entirely the inverse correlation for number of visits. The most likely explanation is that number of visits could add success (new validated documents, received by agents) only if the agent is not "pressing" the national office. It seems that the agency clerks try to serve in small batches as many entities as they can. Therefore, the agent is not effective while maximizing the visits to the agency. Thus, the research team decided to implement a new system to schedule the OCPI visits. The team learnt that it is more important to increase the relative number of specialists/week involved in delivering documents in smaller batches instead of increasing the number of visits of field agents. It was decided to keep the number of field agents' visits at a minimum level (using the scheduling system) and to monitor the completion of documents' batches (per certified specialist, per week) sent to OCPI.

This finding is an opportunity to monitor batches instead of number of field agents involved.

As far as transformed factor $X_{7\text{-}2weeks}$, the negative coefficient might be explained based on the fact that the documents are returned by national agency to the firm in order to be rectified and consequently, the initial volume is diminished. However, not all these documents are related to the surveyed period and sometimes they could have a positive coefficient influence on Y_1. This issue can be addressed by training the people and increasing the quality of the output.

Coefficients

Term	Coef	SE Coef	T	P
Constant	-24.1106	8.36549	-2.88215	0.006
X7_saptamana_curenta	0.3438	0.11356	3.02790	0.004
X7-5saptamani	0.3912	0.11545	3.38887	0.001
X7-6saptamani	0.1537	0.11230	1.36832	0.177
Completari_saptamana_curenta	0.6837	0.45145	1.51436	0.136
Completari -2 saptamani	*-0.7791*	*0.43020*	*-1.81099*	*0.076*
Completari -5 saptamani	0.5045	0.43670	1.15528	0.253
X9_vizite_OCPI_SME	3.4915	1.23571	2.82547	0.007
X5_nr vizite_OCPI_agenti	*-2.2339*	*1.14823*	*-1.94549*	*0.057*
X4_nr vizite_primarii_agenti	0.8408	0.43527	1.93173	0.059
X8_nr agenti_finalizare	2.6582	0.94450	2.81442	0.007

Summary of Model

S = 15.8886 R-Sq = 60.63% R-Sq(adj) = 52.76%
PRESS = 19548.2 R-Sq(pred) = 39.03%

Fig.4. The regression coefficients analysis (Minitab)

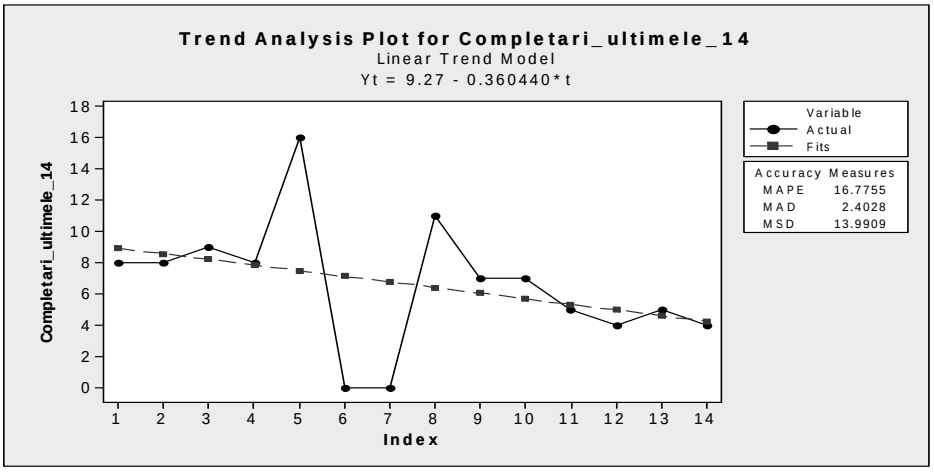


Fig.5. Quality trend analysis (Minitab)

The trend displayed in Figure 5 demonstrates that the quality, for the last 14 weeks surveyed, has been improving.

From the input perspective, the research team recommended to set an optimal level for the critical process variables [7]. For the limit levels set in Table 2, the expected result is 40 units. The confidence interval for mathematical model of this format is CI 95% (43.96, 58.52) and PI (16.08, 86.41).

From management standpoint, these limits are the leading indicators for the business. These values should be communicated to the entire organization and all people should know what their personal objectives are.

Table 2

Y_1 Scorecard Inputs

Y_1 process variables	Description	Limits
X_6	Internal quality	[less than] 5%
X_4	Number of contacts at Town/Village Hall	[higher than] 6 units
X_7	Number of documents which were delivered	[higher than] 53 units
X_8	Number of batches (formerly: FTE available)	[less than] 15 units
X_9	Frequency of OCPI visits	[more than] 1 unit

The procedure presented above for Y_1 was completed for all Y output factors. From process perspective, Ys are functional requirements of the process. In addition, from the scorecard perspective, they are relevant indicators – for both business and customer – and they also represent key performance indicators.

5. Managerial implications: KPI Control Matrix

The results presented are the main gear mechanism for the Key Performance Indicators (KPI) Control Matrix. Figure 6 displays a generic example of KPI control matrix in the case of cadastre service providers. This matrix can be introduced by the top management as comprehensive tool to monitor the process performance and communicate it, at all managerial levels.

The upper side of the matrix contains the main business objectives while the lower part includes the process variables – which are set as lead indicators; periodically their limits are refreshed or even some new factors are added to the matrix.

Leading and lagging indicators

The lag indicators in the downside of the matrix constitute part of the lead indicators for the top side of the matrix (main business objectives).

The upper part of the matrix shows how relationships work between main objectives and lead indicators. For example if Y_1 ("Number of [sets of] registered land documents") is minimum 15 then the customer is satisfied and will increase the demand; hence, the business cost will get lower.

KPI Control Matrix								
	Main business objectives	Customer	Customer satisfaction	+	○			
			OCPI / Town/Village Hall rating			+	●	
			Customer importance (as business share)	+	●			
			New towns/villages entry rate		+	●		
			Time to conform to new customer request	○	+			
		Finance	Unit cost	+				+
			Fixed costs	+				+
			Variable costs	+				+
			Cost of poor quality	+				+
		Internal business processes	Volume of documents delivered	+				
			Service quality		+			
			Rhythm of the process		+			
			Process improvement rate		●		●	
			Productivity					+
			Adaptability to new environment		+	●		
		Learning and growth	Learning curve					+
			Number of training hours					+
			Adaptability in working at any workstation					+
			Number of certified employees					+
			Number of training courses per employee					+
	Transfer Matrix	Design parameters	OUTPUTS →	Y_1 No. of registered land documents	Y_2 Lead time	Y_3 Quality	Y_4 Skilled workforce	Y_5 Productivity
		INPUTS: → Process variables (*Lead Indicators*)	X_1 Human resources training	○	●	+	●	●
			X_2 Work instruction	●	+	●		+
			X_3 Human resource level of knowledge	●	●	○	+	+
			X_4 No. of successful Town/Village Hall contacts	+	●	○		
			X_5 No. of successful contacts at OCPI	+	●	○		
			X_6 Internal quality	+	+	+	●	+
			X_7 Number of requested documents delivered	+	+			+
			X_8 Full Time Employment (available)	+	○			○
			X_9 Frequency of OCPI visits	+	●			
			X_{10} Frequency of OCPI calls	+	●			
			X_{11} Workforce morale	+	+	+	+	+
			X_{12} Frequency of visits at Town/Village Hall	+	+	○		+
			X_{13} Backlog	○	+			
			X_{14} Approved equipment and software	●	+	○	○	○

Fig.6. KPI Control Matrix (example of cadastre service provider)
Legend: + strong relationship; ● average relationship; ○ weak relationship

KPI Control Matrix and Transfer Matrix

The business could be controlled in real time if the transfer matrix is used on a regular basis and it is integrated in the company strategy. The lower side of the KPI Control Matrix is the operational part and that side coincides with the Transfer Matrix [27].

The KPI Control Matrix is the main managerial tool to currently administrate the business operations. For this reason, two individuals are permanently involved in collecting data and reporting this information just in time. Indicators provided by the KPI Control Matrix, in conjunction with visual management, signal any problem, any loss of "velocity" or negative trends. All the graphics and trends are posted and every involved person within organization has the access to the relevant data. People get periodically (daily, weekly, monthly) together to report the main problems, to analyze and solve them.

6. Overall conclusions

This paper presents partial results of an ampler study aiming at developing and applying a new matrix model (based on state-of-the-art techniques as lean six sigma) – in order to better manage the business processes in service industry – cadastre services specifically. The results presented in this paper have successfully addressed its objective: to build an original model (KPI control matrix type) to be used by the cadastre service company and its managers to better manage their business process – which is a breakthrough opening for Romania.

The managerial implications associated with the KPI control matrix are not only short-term (as presented) but also long-term: the control matrix can be used to identify and/or validate additional relevant factors or to find the domain where the actual factors are significantly influencing the output of the process.

On longer run, the use of KPI control matrix will lead to achieving the profitable and mature processes stage [28], based on reengineering or process improvement projects.

Acknowledgements

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Appendix: List of abbreviations

Abbreviation	Stands for:	Explanations
BSC	Balanced Score Card	See more in [23]
FTE	Full Time Employment	
GIS	Geographic Information System	Information technology to capture, store, process, and display geographical data
KPI	Key Performance Indicators	
OCPI	„Oficiul de Cadastru şi Publicitate Imobiliară" (Romanian language)	[Romanian] Office for Cadastre and Real Estate Information
PAD	„Planul de Amplasare şi Delimitare [cadastrală]" (Romanian language)	[Cadastral] Location and Delimitation Plan
PIT	„Planul de Incadrare în Tarla" (Romanain language)	[Cadastral] Framing Plan
QFD	Quality Functions Deployment	Method to transform the user demands into design quality
TQM	Total Quality Management	
TM	Transfer Matrix	