Adjusting Business Processes by the Means of an Autoregressive Model Using BPMN 2.0

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Abstract. Process approach in the management of modern business entity activities opens a wide range of opportunities, ways and methods of activity reorganization, improving the quality of customer interaction, optimization of internal and external business processes. An effective tool in analyzing business processes as a central category of the process approach is modeling that increases their adaptability and mobility. We propose approach to improve and adjust business process to time and profit increasing by the means of autoregressive model using BPMN 2.0 in contrast existing approaches without econometrics analysis of experimental data for BPMN.

Keywords. Business process, regression, BPMN, profit

Key terms. BusinessProcess, EconometricModel, DynamicModel

1 Introduction

When we construct a business process by means of BPMN 2.0 we will set the initial conditions of the operation, such as execution time and the cost of resources (e.g., human resources in cost per hour or piece wage). During operating of a business process such timing and costs of the resources are chosen as would satisfy the restrictions of a customer or designer of the business process. To support decision-making in which direction should change the initial parameters of the business process, it is proposed to use dynamic distributive-lag and autoregressive econometric models. These models allow to take into account the impact of previous indices' values of business process on its succeeding values to assess short-run and long-run impact on the efficiency of a business process as a whole according to specific criteria.

The goal of the paper is to develop a procedure of business processes adaptation according to cost and profitability criteria by means of autoregressive model using BPMN 2.0.

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Paper has following structure: section 2 is devoted to related works, section 3 demonstrates designing and adjustment of business processes, section 4 concludes.

2 Related Work

2.1 Dialectical Essence of the Process Approach

The paradigm of the functional approach, which has long been used for organization and management of companies, appeared to be unable flexibly and effectively to address current challenges faced by each business entity. Focus on the functional approach has led to the isolation of the top management from the current economic situation that caused information asymmetries, bureaucratization of companies, leveling of the system of incentives and reward schemes for human capital assets, excessive localization of functions within individual units, distortion of control and analysis system. The next stage of the management concept evolution was marked by the emergence of process management approach that provides for a high degree of mobility and adaptability in highly turbulent current market conditions (table 1).

Table 1. Invariant character of the "business process" definition

Criterion of classification	U. Deming	J. E. Short.	T. Davenport	I. Fedorov	O. Volkov	V. Repin, V. Yelifyorov	ISO-9000:2001	L. Frolova	Y. Zinder	J Martin	B. Nemurivskiy	V. Yevdokiyenko	V. Ponomarenko
Any types of activity													
A logic range of interfacing													
Distribution of working operations in the space													
Human engineering													
Getting the results at the output based on resources at the input													
Customization													
Method of solution of the business target													
Technology													

This approach allows a company to easily integrate into the concept of the client-oriented market that meets the actual needs of society and economy (fig. 1).

Finally, the analysis of the previous scientific researches demonstrated that the process approach is the mainstream of the "business process" definition which is considered as the logic range of interfacing in the field of customization of the company activity for the purpose of convergence customers and producers targets.

2.2 Business Process as a Central Category of the Process Approach

The object of the process management concept is a "process" in which the activity of a company is a combination of business processes, management of which allows to significantly increase the transparency and manageability of business and to improve its effectiveness as per specified criteria. The process is described by the parameters

❖ taking into account the structural features of business processes ❖ customer-oriented strategy ❖ continuous optimization of cross business processes ❖ delegation of authority and responsibility ❖ high qualification required ❖ specialization of administrative personnel in the strategies development ❖ simplification of multilevel hierarchical organizational structures ❖ simplified exchange of information ❖ time saving ❖ reduction of overhead costs ❖ simplified coordination, organization and control systems ❖ vertical integration of resource flows ❖ high flexibility and adaptability of the management system ❖ high degree of transparency in relations ❖ priority of processes with a high degree of added value ❖ risks leveling	❖ strict social requirements ❖ complex design of management system for the account of detailing and formalization
Opportunities ❖ change of organization functioning logic and mechanism of its control ❖ competitive growth ❖ comprehensive effectiveness evaluation of functioning ❖ possibility to create systems to monitor the quality of company activities ❖ preparing for benchmarking ❖ process approach as a reserve for enhancement of efficiency ❖ resources optimization ❖ high staff motivation ❖ the possibility of team-working ❖ possibility of integrated automation	**Threats** ❖ delegation of authority and responsibility ❖ serious requirements for qualification of contractors

Fig. 1. SWOT- analysis of the process approach in a company management

of time, sequence, transformation of object states during its movement to the final state [2], which helps the company to flexibly respond to the dynamic changes, to switch from one process to another, to comprehensively analyze the entire operational cycle. Business process, as a part of the process approach, has its "input" and "output" in the form of production of resources and products (goods, services or works), respectively (fig. 2).

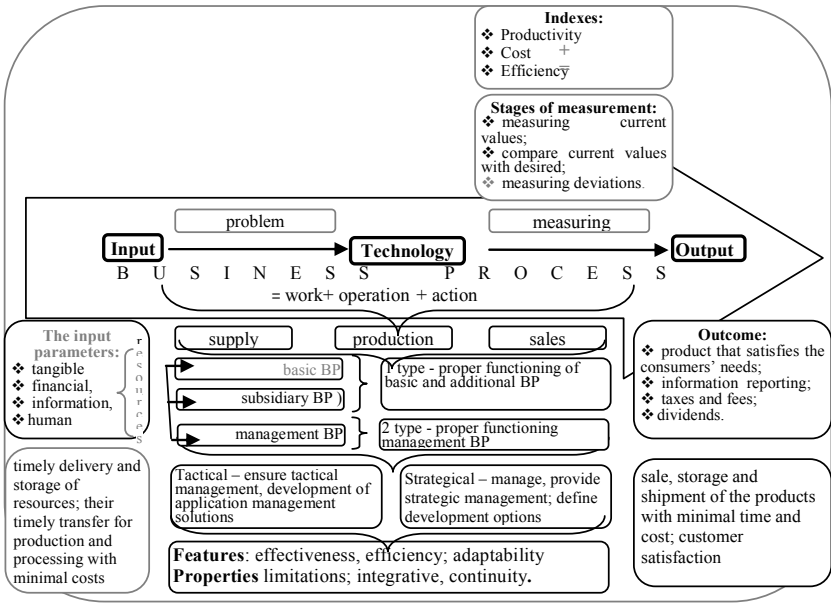

Fig. 2. Components of Business Process, [1, 2, 5]

Technology, mechanism of interaction between functions and control system are additional components of the process approach (fig. 3) [6].

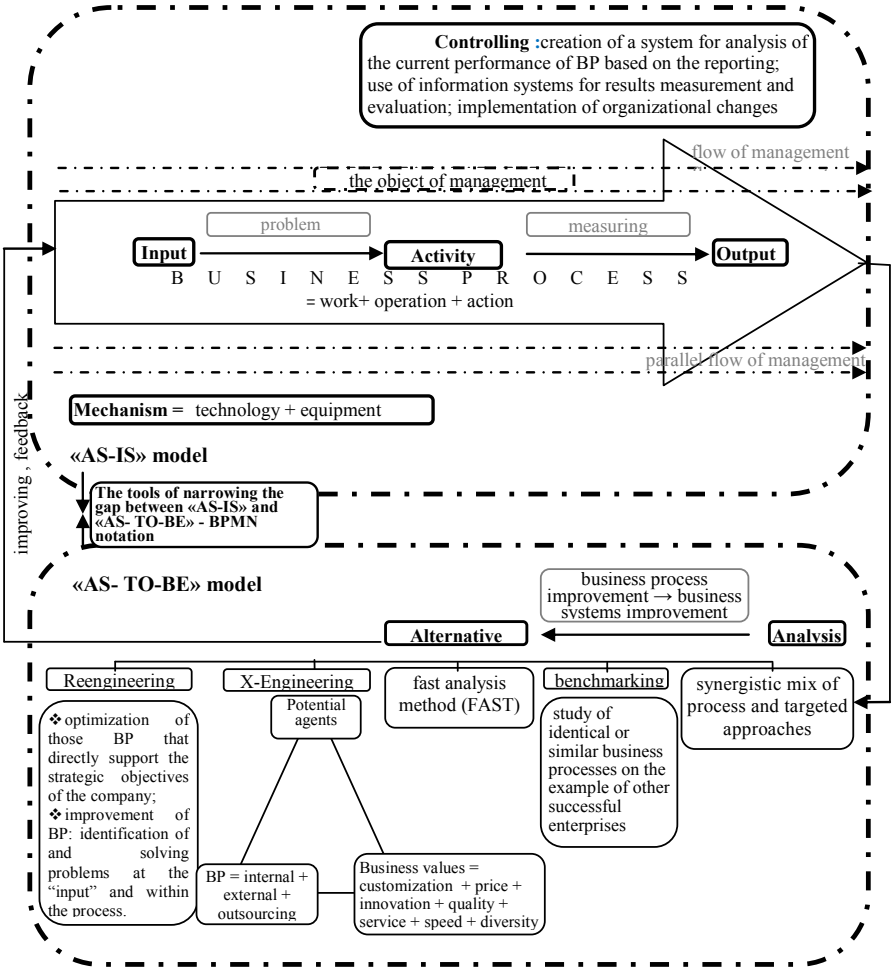

Fig. 3. Model of process management concept [1, 2, 4, 6-10]

2.3 Correspondence of Business Processes with the Strategic Objective of the Business Entity

The mechanism of leveling the differences between "AS-IS" and "AS-TO-BE" models is the "Road map" that sets benchmarks for optimization of business processes. "Input" resources during the process of transformation into goods, services and works at the "output" form "AS-IS" model, the main purpose of which, according to L. Dryuchenko, is aimed at identifying of "bottlenecks" in business process: current problems, differences, inconsistencies, threats that can be overcome subject to radical modernization of existing organizational and administrative decisions and procedures.

Instead, the "AS-TO-BE" model is aimed at improving the existing practice of business process implementation [6]. Improving the effectiveness of business processes and transition of "AS-IS" model to "AS-TO-BE" model are achieved by correlation of current business processes with strategic installations and objectives of the business entity, that leads to a radical rethinking of business philosophy. The theoretical basis for the implementation of this process involves multiple possible scenarios: reengineering, X-engineering, FAST technique, benchmarking and synergistic combination of process and target-oriented approaches. Simulation modeling and economic analysis are technical tools to achieve this objective.

The most popular of these scenarios is the concept of reengineering, which, according to the definition of the founders of the concept, namely M. Hammer and J. Champy, is treated as a fundamental rethinking and radical reconstruction of business processes. Reengineering should not be identified only with the processes of reorganization or automation. It shall be considered in the context of a component of a larger category – Total Quality Management (TQM) since its main function is the fundamental transformation of the essence of processes implementation and performance of operations at the stages of "input" and direct process, but not only increase in efficiency or profitability of the "output". However, in our opinion, X-engineering theory of J. Champy is a more progressive one. This theory, unlike reengineering, provides for a comprehensive restructuring of not only internal operations and relations between internal staff, but also the transformation of external relations, including not only consumers, but also other stakeholders – competitors, contact groups, state, global economy entities [10], that will make it possible to adequately meet the urgent needs of the economic system as a whole.

2.4 Business Processes in the Coordinates of Evolutionary Economics

In the context of complicating of the forms and types interfacing between counterparties and market indeterminacy economic systems are able to self-organization and reach the temporary equilibrium, which transforms the system from the chaotic state to the equilibrium within the sphere of evolutionary economics, which identifies stochastic development script.

Given the actualization of the key tenets of the evolutionary economics of J. Schumpeter, the analysis of business processes through the prism of the theory of jokers is an interesting one. According to this analysis, some parallels can be drawn between a business process and economic and physical method of "channels" and "jokers" that simplifies the model, highlighting the main parameters and discarding irrelevant ones [11]. "Input" of a business process can be compared with the "source" from jokers theory, similarly, "Output" – the "mouth". Conditional distinction of parameters and processes in this area is performed for the account of determining the degree of dynamism: the system in "sources" and "mouths" is slow, which can be explained by the relatively stable partnership relations that are often built on long-term cooperative basis; while the "jokers" are characterized by high dynamism and unpredictability as production operations and actions tend to increasing volatility because of strengthening of scientific and technical progress development (fig. 4).

Riverbeds are the methods of simplification the complicates systems or processes.

Riverbeds separate the unite to the various parts and also, determine the possibility of development process forecasting. Diverse fields of the space which are characterized by the high level of the time rate of change and unpredictability are called jokers (specific bifurcations) in which the system is tested for sustainability.

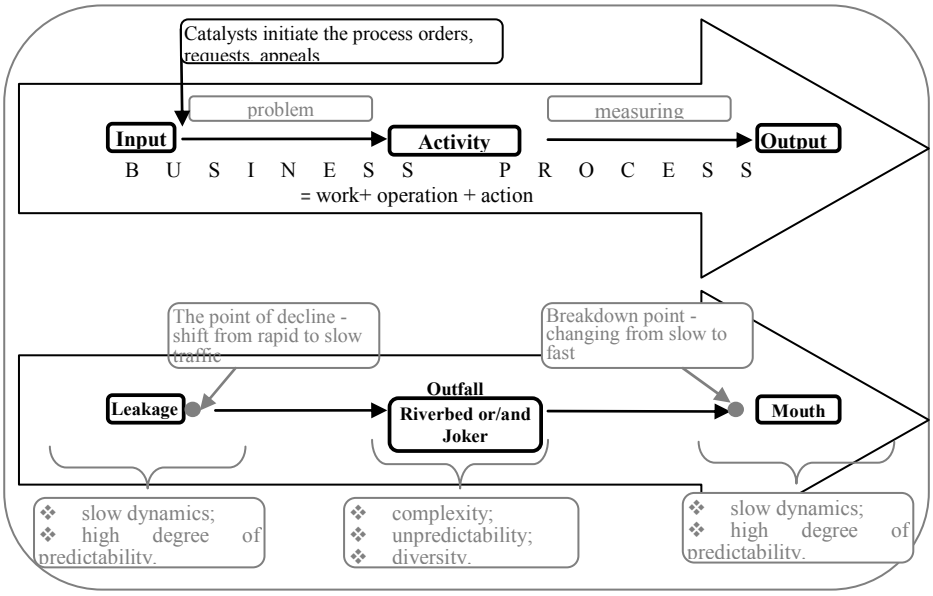

Fig. 4. Overlapping between business process and jokers theory in evolutionary economics, [4, 11]

The mechanism of decision-making in the process approach can be represented by the following algorithm (fig. 5).

Despite the benefits of process management, empirical implementation of this approach is characterized by a number of difficulties, including those identified by J. Rilley: fragmentarity of processes that adversely affects the flexibility and adaptability of business; low level of automation of processes resulting in increased operating costs; the basis of enterprise motivation is maximization of its own profits, but not satisfaction of customers' needs; lack of evidence-based research on the advantages and disadvantages of modeling and optimization of business processes; rejection of modeling and optimization through formal introduction of process management [12].

Technical leveling tool for these shortcomings and limitations of the process approach is a mechanism for predicting and adapting business processes through modeling.

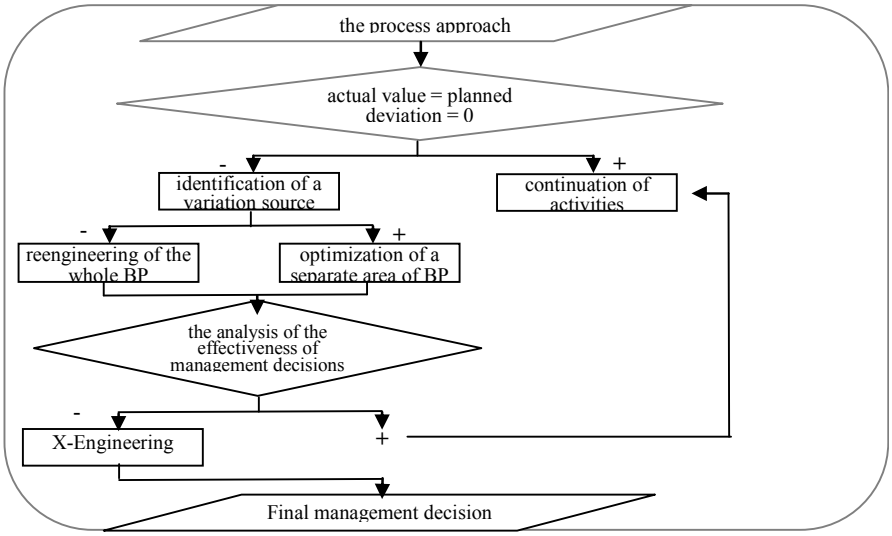

Fig. 5. Logic of the process approach

3 Modeling of Business Processes

We believe that business process modeling is a tool for reflecting the aggregate of logically related operations or processes to improve the quality of business processes through improving their forecasting, optimization, and adaptation (fig. 6).

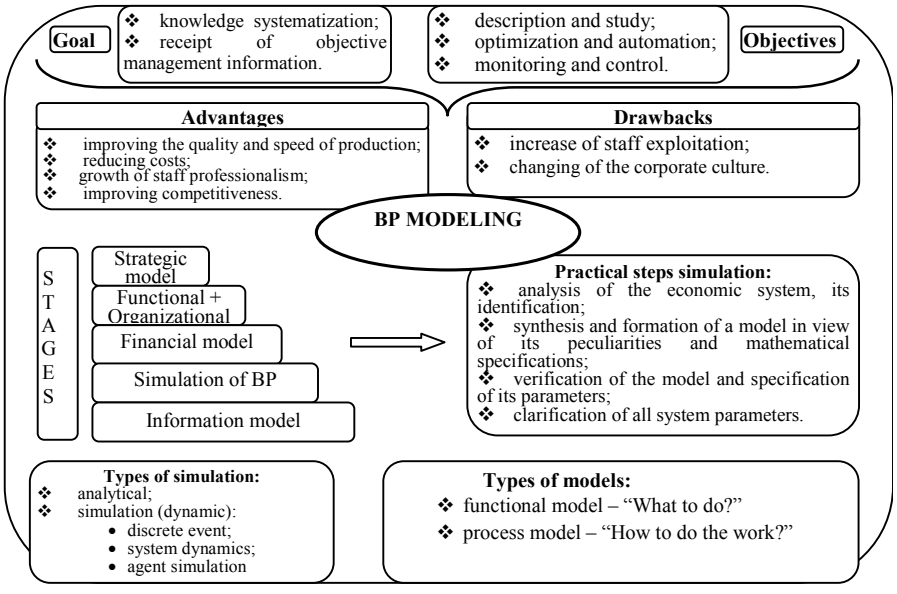

Fig. 6. Essence of the "Business Process Modeling" category, [4, 11, 13 - 16]

We should note that under the optimization of business processes, the interpretation of J. Harrington, a pioneer in the field, is meant. Under the specified category J. Harrington understands improvements aimed at increasing productivity, efficiency and adaptability of business processes [3].

According to D. Kozenkov, the modern management concept reduces the formalization of business process modeling to the process of building of enterprise architecture with a three-level structure (fig. 7) [2].

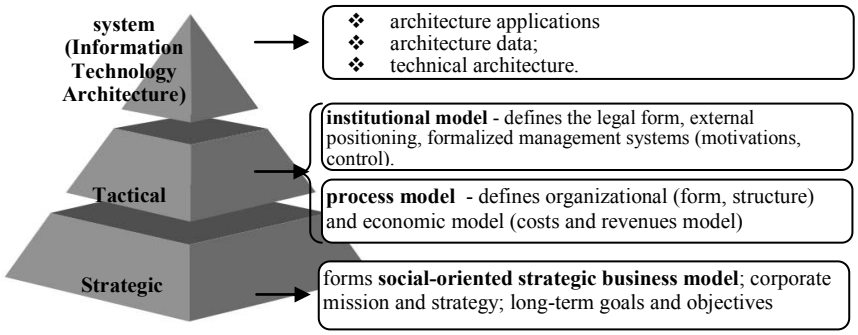

Fig. 7. Levels of enterprise architecture

3.1 Designing of business processes

Consider the business process, which describes the manufacture of soft drink (Fig. 8).

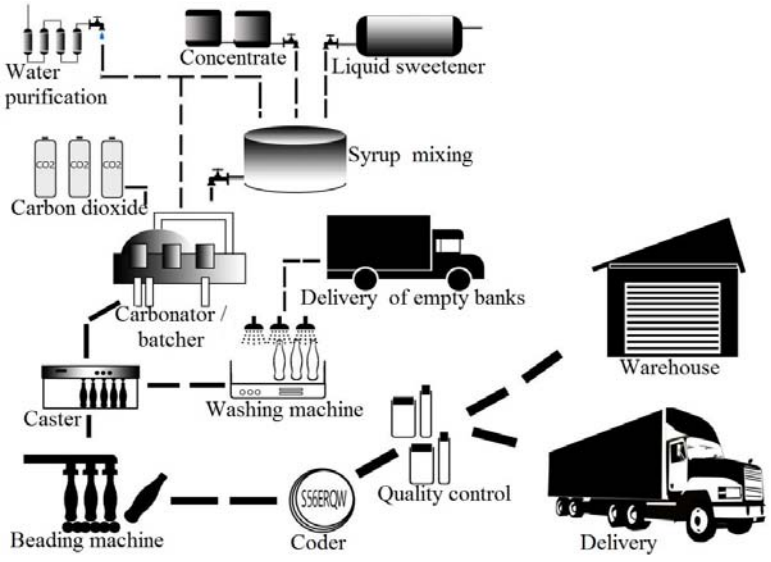

Fig. 8. Preserving cycle of bottling on the manufacturing of soft drink

Positions of workers performing all business process operations and in-payment forms are described in Table 2.

Table 2. Staff categories of business process

Resource	Total fixed cost	Total unit cost
worker		+
driver	+	
loader		+
dishwasher		+
quality tester		+
storekeeper		+

In the menu Resources in tab Availability a maximum number of employees available to perform business process is determined (fig. 9), and in tab Costs – piece (fixed cost) or hourly (cost per hour) wage (fig.10).

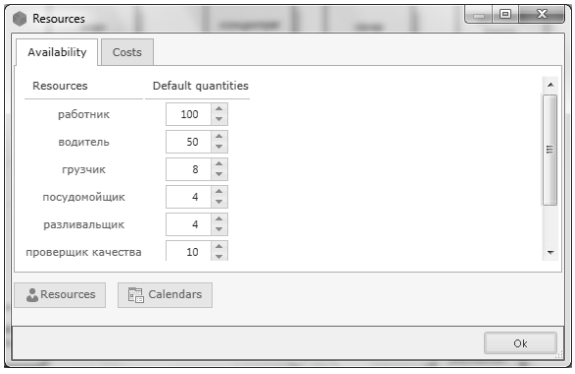

Fig. 9. Determining the employees' number for all positions

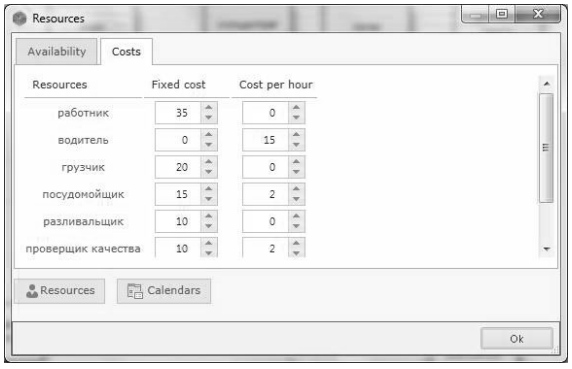

Fig. 10. Setting in-payment forms for each category of employees

In BPM notation business process will look like (fig. 11)

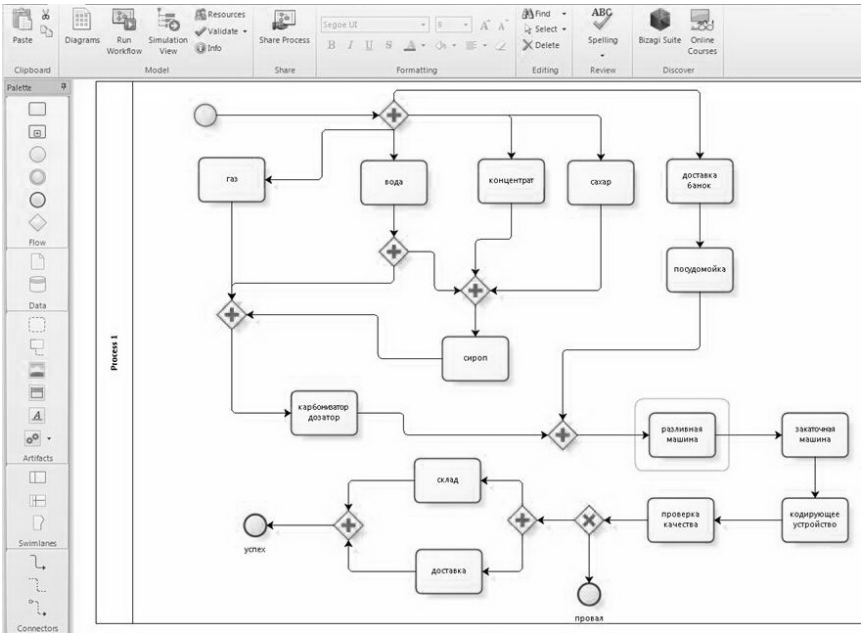

Fig. 11. Business process of soft drinks production in BPM notation

Standard activity time, the number of performers and activity cost are defined for each business process operation (Fig. 12).

Fig. 12. Determining time, executors and activity costs for a business process operation

The number of actually executed orders that are shipped to the end customer; average time of each operation; delay time in operations; a share of time during which the employee performs his work (on a scale from 0 to 100%) (fig. 13) is obtained as a result of the business process (fig.13).

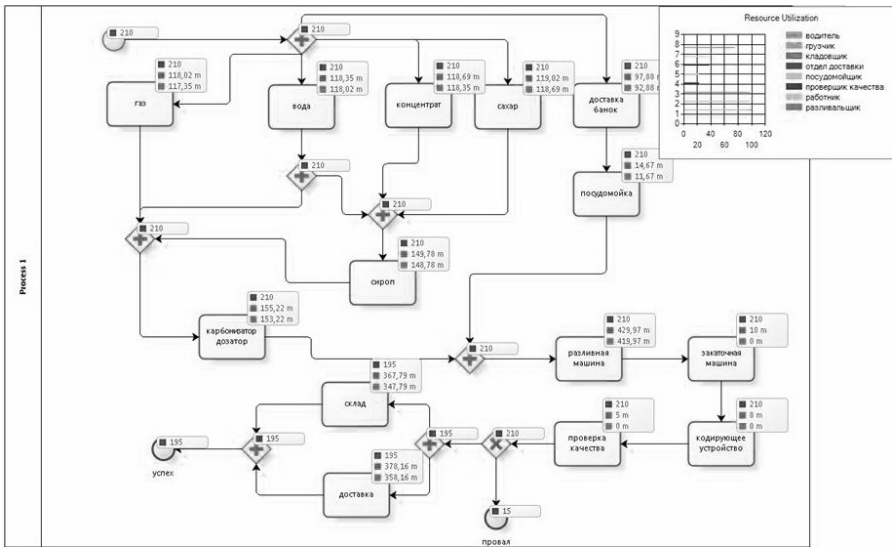

Fig. 13. The results of the business process in BPMN

Export of experimental data concerning staff costs (Fig. 14) provides an econometric estimation of payroll costs on cost per unit (average cost) of soft drink parties.

Resource	Utilization	Total fixed cost	Total unit cost	Total cost
работник	35,32 %	44 100	0	44 100
водитель	100,00 %	0	34 687,5	34 687,5
грузчик	98,02 %	2 720	0	2 720
посудомойщик	22,70 %	3 150	84	3 234
разливальщик	75,68 %	2 100	0	2 100
проверщик качества	37,84 %	2 100	350	2 450
кладовщик	98,02 %	4 080	0	4 080
отдел доставки	22,88 %	1 270	529,17	1 799,17
	Total	59 520	35 650,67	95 170,67

Fig. 14. Experimental data for payroll staff

Export of business process activity costs (Fig. 15) from Bizagi Modeler in MS Excel makes it possible to build an econometric model for estimating the impact of total time of work performed on the profit of business process owner.

Name	Type	Instances completed	Instances started	Min. time	Max. time	Av
Process 1	Process	210	210	1h 13m	1d 15h 17m	20h 2
NoneStart	Start event	210				
газ	Task	210	210	40s	3h 57m	1h 58
вода	Task	210	210	1m	3h 57m 19s	1h 58
концентрат	Task	210	210	1m 19s	3h 57m 40s	1h 58
сахар	Task	210	210	1m 40s	3h 58m	1h 59
доставка банок	Task	210	210	5m	3h 39m	1h 37
сироп	Task	210	210	1m	3h 58m	2h 2

Fig. 15. Experimental data concerning timing of business process operations

3.2 Adjustment of Business Processes

We estimate the impact of timing on the efficiency of business processes in the short-run and long-run periods. To assess the effectiveness of business processes consider the following distributive-lagged model where current cost (y_t) depends on the pay-roll of the current and all prior periods ($x_t, ..., x_{t-n}$):

$$y_t = c + b_0 \cdot x_t + b_1 \cdot x_{t-1} + ... + b_n \cdot x_{t-n} + ... \quad (1)$$

where short-run (SR) impact in period t is $b_t = b_0 \cdot \delta^t$, $t = 1, 2, ..., n, ...$. Long-run impact is $LR = \sum_{t=0}^{\infty} b_t$ or after substitution we get: $LR = \frac{b_0}{1-\delta}$. After substitution of SR-impact in equation (1) we get:

$$y_t = c + b_0 \cdot x_t + \delta \cdot y_{t-1} . \quad (2)$$

To determine the regression parameters b_0 and δ conduct a series of experiments for different numbers of orders. The task of the company is to analyze the effectiveness of the wage fund on the average cost of production. For that firm's budget (TC) is determined as sum of payroll and activity costs for each order (q), then we calculate cost per unit of production (AC). After 10 experiments we obtained the following data (table 3):

After construction of regression model using experimental data from table 3 we have:

$$y_t = 14.5 + 0.0007 \cdot x_t + 0.888 \cdot y_{t-1} \ (R^2 = 0.71). \quad (3)$$

The model is adequate to reality according to determination coefficient, i.e. chang-

ing the current wage fund and activity cost and average cost of prior periods explain 71% change in the average cost of a current period. Parameter $b_0 = 0.0007$ indicates how much the cost per unit will increase with the growth of the wage fund and activity cost of the current period to \$ 1. For previous periods the influence of wage fund and activity cost on average cost shrinks rapidly. According to Student test parameter δ is statistically significant ($t(\delta) = 3.4 > 2.45 = t_{kr}$), confirming the impact of per unit cost of the previous period on the next period. That is after decreasing of total cost in previous periods, average cost will reduce in the current period. Long-run effect $LR = \frac{0.0007}{1-0.888} = 0.0058$ describes the impact of reduction of total cost for by \$1 in all previous periods on current average cost. If b_0 is positive then we can gradually decrease total cost (to reduce cost per unit) until b_0 became negative.

The next task of the company is to analyze the impact of the business process duration on the company profits from soft drink production via the model of partial adjustments. It is assumed that profit depends on the expected duration of business process. This profit y_t is observable, and the time duration of employees (x_t^*) is unobservable value; u_t is residual term of the model:

$$y_t = b_0 + b_1 \cdot x_t^* + u_t . \tag{4}$$

Software BPMN allows to simulate the time and resources required to perform business process, but require additional analysis of statistical data for its adaptation by the criterion of profitability. Procedure of determining an adaptive time performance for operations is carried out by the econometric model of partial adjustment. We introduce the hypothesis of adaptive expectations for the leader of the business process, seeking to define the time of operations within which the profit for entire business process reaches its maximum:

$$x_t^* - x_{t-1}^* = \gamma \cdot (x_t - x_{t-1}^*) , \; 0 < \gamma < 1 , \tag{5}$$

where γ shows the speed of adjustment (corrections) of leader's expectations to differences between the actual time of performing the operations and previously expected time. Expression $x_t^* - x_{t-1}^*$ shows how expectations are formed and the expression $x_t - x_{t-1}^*$ explains how expectations are corrected. Rewrite equation (4) as:

$$x_t^* = \gamma \cdot x_t + (1-\gamma) \cdot x_{t-1}^* , \tag{6}$$

where the expected time of performing the operations at time t is a weighted average of its actual value in the current period and its expected value in the previous period with weights γ and $1-\gamma$ respectively.

After the substitution of (6) in (4) we get:

$$y_t = b_0 + \gamma \cdot b_1 \cdot x_t + (1-\gamma) \cdot b_1 \cdot x_{t-1}^* + u_t \tag{7}$$

Then multiply by $1-\gamma$ both sides of equation (1), recorded with a delay of one lag, and find the difference between this equation and equation (7), and then get:

$$y_t = \gamma \cdot b_0 + \gamma \cdot b_1 \cdot x_t + (1-\gamma) \cdot b_1 \cdot y_{t-1} + v_t, \quad (8)$$

where $v_t = u_t - (1-\gamma) \cdot u_{t-1}$

In BPMN environment for simulation data in each experiment we will change the duration of all the company's operations at a fixed time. Then calculate the profit of the company as the difference between its revenue and cost of resources for each time period (t). After 10 experiments we obtain the following data (table 4):

Table 4. Adaptation model where profit depends on time of performance of business process

№	**Profit** y_t, $	**Time performance** x_t, **min.**	**Previous profit** y_{t-1}, $
1	9611,65	346453,67	
2	22030,50	325469,99	9611,65
3	29940,00	1500015,00	22030,50
4	5940,15	66908,00	29940,00
5	7937,89	172778,00	5940,15
6	8264,50	210119,00	7937,89
7	49822,20	10939490,00	8264,50
8	11346,00	519113,00	49822,20
9	8024,65	257556,00	11346,00
10	8847,80	38597,50	8023,65

Using experimental data of Table 4, we obtain the following regression between the current profit and explanatory variables, such as current time performance and profit of the previous period:

$$y_t = 11098.9 + 0.0037 \cdot x_t + 0.0025 \cdot y_{t-1} \ (R^2 = 0.79). \quad (9)$$

Regression (9) is adequate to reality according to the coefficient of determination, i.e. changing the current performance time and profits in prior periods explain by 79% change in profits in the current period. Taking into account the values of regression parameters, we obtain: $\gamma = 0.9975$, $b_1 = 0.0037$, $b_0 = 11126.6$. Parameter $\gamma = 0.9975$ shows the speed of adjustment of expectations to the profit on the basis of its actual value. The velocity adjustment shows that the business process expected time performance x_t^* almost instantly adapts to the actual time performance x_t. Time performance is expected, but not observable value, whose impact on profits, in view of (9), can be estimated from expression $y_t = b_0 + b_1 \cdot x_t^*$. It means that with increased operation time by 1 minute the margin profit increases to $\$ 0.0037$. Parameter b_1 is statistically significant according to Student's test ($t(b_1) = 4.73 > 2.45 = t_{kr}$), confirming the significant effect of time performance on the profit of the company. Thus, for examined project the company must adjust (increase) standards of time operations,

enabling it to increase the value of the resulting profits until parameter b_1 became negative.

4 Conclusions

Thus, the process approach in the management of modern business entity activities opens a wide range of opportunities, ways and methods of activity reorganization, improving the quality of customer interaction, optimization of internal and external business processes. An effective tool in analyzing business processes as a central category of the process approach is modeling that increases their adaptability and mobility.

Analysis of business process modeling has an analogy with evolutionary economics in the theory of jokers and neurosystem theory. Among the future prospects of business process modeling is the use of ontologies, which, according to T. Gruber's opinion, in business modeling sphere is reduced to a formal specification of conceptualization [16] that involves the use of OWL (Web Ontology Language).

Another promising research vector is the use of neurosystems involving the use of neural networks that can be effectively used in the study and analysis of dynamic processes.

It is demonstrated how we can improve and adjust business process to time and profit increasing by the means of autoregressive model using BPMN 2.0 in contrast existing approaches without econometrics analysis of experimental data for BPMN.

References

1. Bezgin, K. S.: Quality management of business processes in the enterprise. Manuscript (2009)
2. Kozenkov, D.: Business Processes Planning as the Basis of the Creation Enterprise Architecture. The Visnyk of the SSU 3. 126--136 (2011)
3. Harrington, H. J,. Esseling, E. K.C., van Nimwegen. H.: Business Process Improvement Workbook: Documentation, Analysis, Design, and Management of Business Process Improvement. London: McGraw-Hill, 1996
4. Fedorov, I.: Modeling business processes in BPMN 2.0 notation. M., MESI (2013)
5. Davenport, T.: Process Innovation: Reengeneering Work through Information Technology., Boston, MA.: Harvard Business School Press (1993)
6. Druchenko, L.: Implementation of Business Processes Modeling and Optimization in the Local Government. Public Administration: Theory and Practice 1(3) (2010)
7. Ponomarenko, V., Minuhin, S., Znahur, S.: Theory and Practice of Business Process Modeling: Monograph. Simon Kuznets Kharkiv National University of Economics (2013)
8. Manganelli, R., Klein, M.: The Reengineering Handbook: A Step-By-Step Guide to Business Transformation. New York: Amacom (1994)
9. Hammer, M., Champy, J.: Reengeneering the Corporation: A Manifesto for Business Revolution. London : Nicholas Brealey Publishing (1993)
10. Taranyuk, L., Zaporozhchenko, O.: Organizational Principles of Reengineering Business Processes of Enterprises. Mechanism of Economic Regulation 4, 122--131 (2011)

11. Kuzmin, O., Sidorov, Y., Kozik, V.: Achievements and Problems of Evolutionary Economics: Monograph. Publishing House of Lviv Polytechnic National University (2011)
12. Reilly, J. P., Creaner, M. J.: NGOSS Distilled, The Lean Corporation (2005)
13. Kalyanov, G.: Business Processes Modeling, Analysis, Reorganization and Automation. Finance and Statistics (2007)
14. Melnikov, A.: Bases of Business Organization. Center of educational literature (2013)
15. Korzachenko, O.: The concept of business processes modeling and optimization of telecommunications companies. Scientific and theoretical journal Khmelnitsky University of Economics "Science and Economics" 4 (32), 247--253 (2013)
16. Gruber, T.: A Translation Approach to Portable Ontologies. Knowledge Acquisition, 5 (2), 199--220 (1993)