MODELLING OF DECISION MAKING PROCESSES BY THE METHOD OF PETRI-NETS

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Abstract

Managerial work and performance of managers includes activities which come from basic managerial functions – planning, leading, organizing, control and last but not least – decision making. This paper deals with the last mentioned function – decision making. We have tried to present application of decision making methods on concrete wood processing company in order to optimize supply chain and decisions in this supply chain. Decision making process should be not only optimize but also the most objective. And because of that, it is necessary to use some methods, models and patterns.

Introduction

Decision making methods and models are necessary for the optimization of logistics performances. Analyses of value chain should be focused on specification of so called bottle necks which mention those activities that disable to increase business margin. At the same time, these analyses show the inefficiency caused by oversized of some activities regarding to lower level of assurance and lower performance of other business activities [3].

Importance of multicriterion decision-making methods for evaluation of alternatives doesn´t lie in definite increasing of results objectivity although it should lead to that. Priority of this method lies mainly in simplification of manager´s decision making. It allows managers to arrange alternatives according to extensive file of criterions, it describes particular steps of solution and its logical sequence, this methodology also requires from managers to express their understanding of various criterions importance. This process of solution is transparent, repeatable and there are evident starting assumptions and also how these assumptions, situations, criterions and incidents affect reached results [9].

Real managerial work from particular companies shows the subjective evaluation of particular criterion importance. This importance depends on value patterns of particular decision-maker (manager) or particular company´s value system.

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Just below mentioned methods should help to minimise subjective evaluation and thus subjective results from decision-making process within managerial work [2, 7].

Dynamic monitoring of production processes

Complexity, extensiveness and variability of contemporary technical, social respectively combined objects requires application of such a methods that allow explicitly and objectively to handel, to project and further to manage those features which characterise synthesis of functional parts into one unit.

Requirements on systemic model can be gathered into the following items. So, for the systemic model it is necessary [5, 10]:

- to reflect systemic features of an object, so it means to take into account all parts, events and processes of an object which share on the generation of these features
- to simplify primary complexity of an objectin order to be technically managed
- to unify model heterogeneity of particular parts of an object and by that to allow application of formalised tools
- that the form of a model could allow quantification and metrics of monitored parameters.

Systemic features are universal features of the objects from real life. This term contains the following features of the objects:

- interaction the parts of a unit among themselves
- interaction of the object with an environment
- dynamics and goal focus of the object behaviour
- adaptability of the object on environmental changes and inside the particular object
- ability to save and to utilise experiences.

In order to detailed investigation of features result from system dynamics, there is established term “status” of a system or “dynamics“. It is mentioned as the goal oriented behaviour represented by the sequence of statuses by which the development of a system comes through.

A choice of the process is managed by input setting and by internal assumptions. Petri Nets (PN) are suitable tools which can be characterised by the following [10, 11] :

- **net** is created by two kinds of peaks:
  - traditional set of peaks which describes status parameters – it means elements (situations) of a system

- untraditional set of peaks which describes transitions between various statuses of two near-by elements, respectively it causes the change of a status in the following element caused by the impact in the previous element.

- **transition** (element from the non-standard set of elements) differs from situations. It is not associated as a one element feature but it is independent element like virtual item which initiates situation. It is also presentation of dynamic feature of a connection within the system structure. Transition is real holder of the element ability to change its status.

Report of the system structure is completed by modification of incident function [10]:

- connections which describe relation from the element to the transition – "transition" incident functions
- connections in oposite direction, it means coming from element back to transition (to that which caused the change of given element) – "feedback" incident functions.

On the base of the above mentioned process, Petri Nets can be described:

$$PN = \{P, T, F, B, M_o\} \qquad P \cap T = 0 \qquad (1)$$

where: P, T - related sets of elements and transitions

F, B - incident transition and feedback functions

M_o - initial system line-up

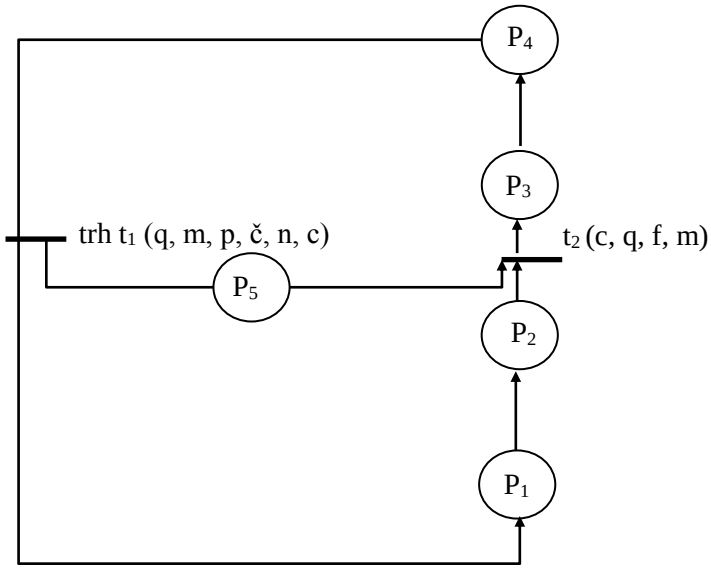
Implementation of transition and feedback incident functions allow to divide investigation of how elements are prepared for the realisation of transitions (matrix F) or how elements are prepared to accept incidents of transitions (matrix B). Both matrixes can be joined into one matrix E.

$$E \subseteq (PxT) \cup (TxP) \qquad (2)$$

Logistics systems in woodprocessing manufacturing are dynamic, with permanent adaptation to turbulent market environment and they integrate all functions of material management, starting with assessment of material and resources demands and ending with selling of final products [10, 11].

Supply chain model on the division of wood raw manufacturing

We had decided to solve supply chain by the model of Petri Nets. This tool is suitable because it perfectly expresses decision situations, describes the whole material flow and because of parametrisation and quantification of criterions expressed by transitions and elements (situations). We could use also other appropriate methods as CPM, PERT, Gantt chart and histogram for the capacity optimization. These methods could be used for the planning, co-ordination and time spending description of particular processes.



P = {P1, P2, P3, P4, P5} P4 - timber warehouse
T = {t1, t2} P3 -saw
P2 - manipulation and debarking
P1 - warehouse of logs
P5 - supplier of logs

Figure 1 Model of logistics (supply) chain within the division of timber production [1]

Knot P1, place – warehouse of logs

The first knot of the chain is warehouse of logs. There is no decision making process here. We can see that there is no transition "t" before this knot. Inputs must be bought in the market from external supplier. Of course, it is necessary to make choice among suppliers what has further impact on the quality of production and final product, but this decision making is not under

competence of ”place“- warehouse of logs. Selection of suppliers is the business of Logistics and Sales department which find, monitor and select the most suitable suppliers for all departments. Is is necessary to assess some specific demanded parameters on inputs (wood raw or logs) in order to monitor and evaluate this process of warehousing.

Table 1 Criterions for the monitoring of knot “Warehouse of logs“ [1]

Criterion	**Agree**	**Disagree**
Volume	over X m³	below X m³
Time of order	X days	less or more than X days
Safety stock	X m³	below X m³
Qualitative requirements	given by the standard	other than in standard
Inventory costs	over X Eur	over X Eur

Knot P2, place – manipulation and debarking

Every log which is moved to saw mill has to go through this place. Again, it must be assessed parameters of the process in order to monitor it, to evaluate it and to control it. Proposal is given in the following Table 2.

Table 2 Criterions for the monitoring of manipulation and debarking process [1]

Criterion	**Agree**	**Disagree**
Diameter ø	between X-Y cm	Out of interval X-Y cm
Time of the process	X min	X min
Length of a log	between X-Y m	Out of interval X-Y m
Costs	below X Eur	Over X Eur

Knot P3, place – saw mill

Before the entry of logs into saw mill, it is a transition „t2 “ where it is necessary to decide about the choice of logs. It is possible to take them from own capacity after the flow through the previous two operations or to buy debarked logs from external supplier. This choice depends on the meeting particular technological and economic criterions.

Table 3 Decision making matrix of the transition „t_2“ - Saw mill [1]

Criterion	**Weight (importance) (v)**	**Own supply**	**External supply**
Price (c)	0,30	X €, respectively given as a lower or higher than from external supplier	X €, respectively given as a lower or higher than from internal supplier
Quality (q)	0,30	Standard	Standard
Flexibility of a supply (f)	0,25	Over or below X days, hours	Over or below X days, hours
Volume (m)	0,15	Over or below X m³	Over or below X m³

Table 4 Final decision matrix for the transition “Saw mill“ [1]

Criterion	**Weight (importance) (v)**	**Own supply**	**External supply**
Price	0,30	X points	Y points
Quality	0,30	X points	Y points
Flexibility of a supply	0,25	X points	Y points
Volume	0,15	X points	Y points
Total utility		**∑ X.v**	**∑ Y.v**

Table 5 Decision matrix of transition “Saw mill“ for the choice between external suppliers [1]

Criterion	**Weight (importance) (v)**	**External supplier No.1**	**External supplier No.2**
Price	0,30	X €, respectively given as a lower or higher than from external supplier No.2	X €, respectively given as a lower or higher than from external supplier No.1
Quality	0,30	given by the standard	given by the standard
Flexibility of a supply	0,25	Over or below X days, hours	Over or below X days, hours
Volume	0,15	Over or below X m³	Over or below X m³

Table 6 Final decision matrix of transition "Saw mill" for the choice between external suppliers [1]

Criterion	**Weight (importance) (v)**	**External supplier No.1**	**External supplier No.2**
Price	0,30	X points	Y points
Quality	0,30	X points	Y points
flexibility of a supply	0,25	X points	Y points
Volume	0,15	X points	Y points
Total utility		**∑ X.v**	**∑ Y.v**

The most important operation within the timber manufacturing is operation of cutting. It is very important to deal with the selection, evaluation and monitoring of criterions which have impact the quality of this process. It should be necessary to monitor not only yield of the cutting and quality of a timber, but it is necessary to focus on costs and time of given process because these parameters highly affect satisfaction of a customer.

Table 7 Criterions for the monitoring of cutting process [1]

Criterion	**Agree**	**Disagree**
Yield	X %	less than X %
Time of the process	X mins	more than X mins
Timber quality	given by the standard	deviation from the standard
Costs of the process	Less than X Eur	More than X Eur

Knot P4, place – timber warehouse

The last knot in the logistics chain is timber warehouse. Company uses own warehouses with sufficient free space compared to production capacity. All products are made only for concrete order. So, the warehousing is used only for the drying according to particular timber utilisation or customer´s demand. Every product must meet particular qualitative parameters given by the standard and these should be monitored and controled also in the final products warehouse. Except of qualitative parameters it should be suggested also others like it is given in the following Table 8. Because of the simplification of the timber selection system we had used only 3 qualitative classes. Of course, this simplification did not impact presented results.

Table 8 Criterions for the monitoring of knot "Timber warehouse" and transition t_1 "market" [1]

Criterion	**Class 1**	**Class 2**	**Class 3**
quality (q)	given by the standard	given by the standard	given by the standard
Produced volume (per 1 day, per 1 shift, per 1 order) (m)	m^3	m^3	m^3
% from the total volume (per 1 day, per 1 shift, per 1 order) (p)	X %	X %	X %
Average production time (including idle times) for the 1 m^3 (č)	X hrs		
Average production time (without idle times) for the 1 m^3	X hrs		
Costs (c)	X Eur / Y Eur	X Eur / Y Eur	X Eur / Y Eur

Conclusion and evaluation

Proposed model of logistics chain is the complex of application the various methods. We had used method of decision tree, utility analysis method together with pair comparison and Petri Nets.

Proposed model could be suitable tool for the supply chain management. Management can be described as a sequence of decisions which are made on the base of information about managed system. There are important quality and objectivity of reached information which should support decision-making process. So, the question is not whether to decide or not but how to decide and which criterions are important. An important part of decision making process is methodology and evaluation of information.

Traditional procedure of decision making process was solved only intuitive and on the base of experiences and professional feeling for given situation. But at the same time we can say that intuitive decision making should also lead to very good results but this decision doesn´t take into account feedback from qualitative part of decisions. When a problem occurs it is very hard to choose a particular step where the problem occurred and what did it occur. Intuitive decision making is more subjective and above mentioned methods should decrease this subjectivity. One of the most important assumption for managers in his/her managerial work is to quantify results and to think in alternatives. All these above mentioned methods are helpful for quantification and also for alternative thinking of managers They should also increase objectivity of decision-making in order to decrease wrong, intuitive and only forecasted results.

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