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MONITORING THE SOCIAL BEHAVIOUR OF PARTICIPANTS IN NON-HIERARCHICAL PRODUCTION NETWORKS

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Abstract: *Beyond doubt the application of technologies and materials is significant for the industrial production of goods. However, besides those factors, also the human being needs to be included in the production management as a resource. The actor human plays an important role especially from the point of view of the quality and productivity management as well as the resource planning. This paper focuses on the actor human as well as on the supervision of special behaviour patterns during value-added processes in networked production structures. That procedure is called „Social Monitoring". In that connection, a framework for the fulfilment of that task is introduced.*
Key words: Production Network, Network Management, Social Monitoring, Soft-facts.

1. INTRODUCTION

The current economic situation in most countries is characterised by recession. There are various reasons for that development. That problem in combination with the trend for globalisation as well as the intensive application of the modern information and communication technology (ICT) is a big challenge especially for small and medium-sized enterprises (SME). Those try to face that challenge in different ways. The formation of enterprise networks is one possibility. Enterprise networks are bounds of enterprises, especially SME, that are generated for a special purpose. This paper is focused on production networks. Thereby enterprises unite for the purpose of manufacturing products. By forming production networks, enterprises try to face the growing competition pressure, producing internationally competitive products and thus remaining competitive in comparison to the big companies.
It is to mention that problems arise during the production in networked structures which would not occur in single enterprises. For that reason the implementation of monitoring mechanisms is a recommendable measure for guaranteeing the maximisation of the success for the entire network. Besides the monitoring based on qualitative variables of the production process, also the monitoring of the behaviour of the actors participating in a production network is of great significance. This paper introduces an approach for the supervision and the management of the social behaviour of actors in networked cooperation structures. That model is called „Social Monitoring for Production Networks" (SMPN) and introduces an innovative concept in the field of network organisation.

2. MONITORING AS A TOPIC OF RESEARCH

2.1 The Term Monitoring

For a better comprehension, first of all a definition is to be formulated for the term monitoring. Monitoring is the continuous oversight of an activity to assist in its supervision and to see that the monitored objects proceed according to a plan. Thereby, monitoring involves the specification of methods to measure activity, use of resources and response to services against agreed criteria. The balancing of actual and target-data thus stands in the centre of interest. The monitoring-activities can be focussed on several objects. Usually target and actual data are balanced from the field of production or manufacture, for example times and capacities. Because normally these values are only available in a quantified form, a comparison of target and actual values of those parameters does not cause problems. However the implementation of monitoring mechanisms for segments with information which is not available in a quantified form is much more difficult. This for example also includes social aspects in cooperation networks. In such cases, the balancing of target and actual data is not possible based on quantitative values. An approach for managing qualitative data needs to be implemented for making possible a monitoring of social aspects. This paper introduces one possible approach for the integration of social monitoring into the network controlling.

2.2 Literature Research

At the moment, the research of social structures in networks is very popular. Two approaches will exemplarily be mentioned. However, those rather deal with the analysis of structures than with the supervision of those structures. The structural hole theory (Burt, 1997) investigates the social connections of interacting actors in networks as well as eventually occurring breaks of contacts. The combination of the Repertory Grid-methodology and the Polyhedral Analysis (Teich et al., 2003), went another way. In that approach, the information concerning existing features of network actors are efficiently analysed and used for the generation of production networks.
Approaches for monitoring the social behaviour are introduced in literature for various application fields. However, those often restrict to a balancing of data which are already available in a quantified form. For the monitoring of qualitatively available parameters, suitable approaches are often missing. Especially suggestions concerning monitoring in production networks are not widely spread so far and in most cases rudimentarily formulated. For the monitoring and performance measurement of supply chain structures, which under certain pre-conditions are related to the production networks, the application of the Analytic Hierarchy Process (AHP) and the Balancing Scorecard are suggested for the comparison of the targets (Miller, 2001). That approach however is based on the application of qualitative parameters.
An approach for a network monitoring of educational and industrial needs is presented by *Riives et al.* (Riives et al., 2003). The proposed model can be used for monitoring human resources quality in networks. These networks are focused on the mechanical engineering sector. That approach is orientated towards social sciences, but nevertheless it focuses on another point. Basically, the monitoring-architecture is presented between several institutions involved in the network.
After the aforementioned points, it gets clear that the term Social Monitoring describes the field of research in a very ambiguous way. For that reason, an exact definition of that term is to be introduced.

2.3 A new Approach for Social Monitoring

It has to be stressed that this contribution results from works which are in a theoretically orientated phase. For that reason it is necessary also to formulate a theoretic definition: Social monitoring refers to the continuous supervision of the behaviour of actors in production networks during the process of adding value as well as in the phase of the dissolution of the network under the aspect of the maximisation of utility for the entire network. The decision makers of the organisation units involved (SME) are the actors in production networks. Social monitoring might record qualitative as well as quantitative variables. An evaluation of the data accompanying the monitoring process can be used for correcting the course in case of misconduct.

For carrying through social monitoring in production networks, first of all the critical comparable values need to be identified. After that, the values are normalised via a value benefit analysis (scoring-procedure). At the end the user gets an actor-related measure, the so-called „network-compliancy", which allows the comparison with other actors. Here it is imaginable also to consult the method Balanced Scorecard. Besides the possibility of a comparison for single actors, there is also a point of approach for the efficient implementation of penalty mechanisms if the actors do not notice a network-compliant behaviour.

In that sense, the approach introduced in section 4 is different from other approaches basically because of the application field „regional non-hierarchical production network" (cf. paragraph 3.2) as well as because of the consideration and analysis of qualitative as well as quantitative variables. For the better comprehension, the application field as well as the theoretic basis are taken a closer look on in the following section.

3. FRAMEWORK FOR SOCIAL MONITORING IN PRODUCTION NETWORKS

3.1 Theoretical Basis: New Institutional Economics

The assumptions of an economically orientated approach called New Institutional Economics (NIE) (Furubotn & Richter, 2000) are a basis for the works about social monitoring in production networks. As oppose to the neo-classical theory, which starts from the assumption of a complete transparency of the market (equally distributed information), the NIE is based on more realistic assumptions. Three assumptions for the behaviour of actors in economic relationships are the basis of that approach: limited rationality, individual maximisation of utility and opportunistic behaviour (Williamson, 1985). Thereby, the least two interact. A further characteristic is asymmetrically distributed information among the actors. In the following, those assumptions will be described more detailed.

While the limited rationality results from the amount of data and information that cannot be fully managed by human beings or ICT, the drive towards an individual maximisation of utility in connection with opportunism refers to the behaviour of (economically) operating actors. Thus, the drive towards success and profit and its expansion can be considered the mainspring of economy (Danner, 1996). That drive towards a local maximisation of utility does not necessarily have to be related to the target of the global maximisation of utility. The least is a desire within the scope of the network management. For that reason it is a task to implement efficient incentive mechanisms such as approaches for the distribution of profit in the network controlling.

The NIE starts from an asymmetric distribution of information between the actors. The actors are subdivided into an employer (principal) and a contractor (agent) by the means of the Principal Agent Theory (PAT), a field of research of the NIE. Thereby, the contractor in most cases is better informed. The employer cannot supervise or evaluate the stresses. That problem just occurs after the conclusion of a contract and might lead to the problem of Moral Hazard. The contractor here profits from his information advantage opportunistically and at the expense of the employer. Monitoring can be applied as one possibility for the reduction of the information asymmetries (Picot et al., 2002) and can for example be realised by the application of planning and control systems as well as by a reporting system in enterprises or networks.

3.2 The Field of Application: Non-hierarchical regional Production Networks

Regional non-hierarchical production networks are the conceptual vision of a bound of economically autonomous organisation units investigated by the collaborative research centre (CRC) 457 established at Chemnitz University of Technology. The preferable small enterprises thereby are called competence cells (CCs). Although the condition non-hierarchical exists, a network management is necessary. For the model of the CRC 457, the Extended Value Chain Management (EVCM) is responsible for that task (Teich 2002). EVCM is an automated management concept, which guarantees that the actors (CCs) in the network are non-hierarchical organised. In the sense of the PAT, the EVCM is the principal whereas the CCs are the agents. Now, the application field of the social monitoring has to be defined for a conceptual life cycle of a production network for that employer-contractor-relationship.

All CCs which are willing to participate in a value-added process are united in a so-called pool of resources. For the completion of a customer order, a regional non-hierarchical production network is generated automatically according to pre-defined rules and algorithms (Teich, 2002). The actual value-added process, that means the operation of the network, happens subsequently. After the product has been manufactured, the network dissolves. The CCs involved return to the pool of resources. Now, it has to be clarified in which phase(s) the monitoring of social processes should happen.

3.3 The Domain of Application: During and after the Process of adding Value

Social monitoring is imaginable for the whole network as well as for every single CC. However, only the least alternative is considered. The reason for that is that the single CCs leave a scope of action while the network represented by the EVCM is obliged to the value-added process. Social monitoring does take place during the phase of the operation of the network. Thereby the EVCM collects data.

The biggest problem concerning the evaluation of performances and contributions of CCs results from the fact that the information for the ascertainment of the performances must be kept secret. This issue however is supported by the non-hierarchical management of the network. The automated network management (EVCM) is responsible for the coordination of all those tasks. This administers the confidential data and controls the exchange of data. The access to the sensitive data is secured and only made possible for authorised users having special access rights to fixed data. Thus, the possibility arises to keep and evaluate all the data from the network without supporting an abuse by single value chain units. Those are only equipped with the data based on their pretexts which are necessary for production.

During the network dissolution phase, important data concerning the whole added value process are finally collected and stored. Subsequently, these data have to be evaluated. That part is very important for future cooperation. CCs, which did not behave network-compliant, need to bargain for sanctions. Those sanctions might be contractual penalties if the delivery is delayed, a low probability to be considered in future networks or an exclusion from the pool of resources. It has to be stressed, that the monitoring of the EVCM does aim at the maximisation of the utility of the whole network. This needs to be fixed in the consciousness of the actors of the CCs.

4. SOCIAL MONITORING IN NETWORKS

4.1 Procedure

This section introduces a model for social monitoring in regional non-hierarchical production networks (SMPN). Thereby the social monitoring activity (SMA) includes the procedure of the supervision. It describes the actual intention. Thereby, the supervision of the activity structures of the CCs in the regional non-hierarchical production networks is in the centre of interest. The focus is on the target of the maximisation of utility of the whole network. This is an intention of the principal, and thus the EVCM. It is realised by social monitoring instruments (SMI). Those instruments are tools, algorithms and aids which make possible the supervision. In the ideal case, the SMI are automated and can be implemented in the EVCM. The SMI supervises the social monitoring objects (SMO). Those SMO include the CCs in the production network. If demand arises, suitable counter-measures can be taken resulting from the ascertainments about the behaviour of the SMO for achieving the planned targets. Those for example include penalty mechanisms. Finally, the „network-conformity" is ascertained as a parameter. That variable can then be further interpreted and evaluated.

4.2 Modelling

In a first step, a scoring-model is suggested as SMI. There are parameters which make possible an evaluation need to be distinguished. Those are different in two demarcations: parameters which have already been bailed with numbers and thus exist in a quantitative form and those, which are only available in a qualitative form. The qualitative variables need to be transferred to the quantitative form. If finally all variables are available in a quantitative form, the analysis can be started. In that connection it has to be stressed that the analysis might also be carried through already during the production process, but then without the data which are not fixed until the end of the value-adding process.

It is assumed that n parameters K_i ,$i=1,...,n$ are available in a quantified form. Furthermore, it is assumed that m CCs CC_j, $j=1,...,m$ take part in an value-added process in a network. In a next step, the parameters are weighted for the social monitoring according to their significance. Therefore, the variable g_i is introduced. In order to achieve a standardisation, it is valid: $\Sigma g_i=1$. Subsequently, the credits of the parameters are evaluated for every CC by the means of suitable points (cf. section 4.3). This is termed r_{ij} and in an ideal case it is in the value interval between 0 (very bad performance) and 10 (very good performance). A weighted credit value, the so-called actual value $AV_{i,j}$ results from the multiplication of the credit evaluation for every parameter K_i and every CC CCj for every parameter K_i and CCj, cf. equation (1)

$$AV_{i,j} = g_i * r_{ij} \quad (1)$$

Subsequently, the actual value can be ascertained for every CC_j by adding up the $AV_{i,j}$ for all the parameters K_i i=1,…,n, cf. equation (2).

$$AV_j = \Sigma AV_{i,j} \quad (2)$$

For being able to carry through a target-actual value-comparison, the maximally achievable evaluation number (target value, TV) as well as the actually achieved evaluation number (actual value) per CC additionally needs to be ascertained. The maximally achievable evaluation number for every parameter K_i results from the product of the maximally achievable credit $r_{i,max}$ and the weight cf. equation (3).

$$TV_i = g_i * r_{i,max} \quad (3)$$

Subsequently, the target value can be ascertained by adding up the TV_i for all the parameters K_i i=1,…,n, confer equation (4).

$$TV = \Sigma TV_i \quad (4)$$

Finally, the measure for the behaviour of a CC can be calculated by comparing the actual value AV_j for every CC with the target value TV. The calculation rule is represented by equation (5).

$$NC_j = \frac{AV_j}{TV} \cdot 100 \quad (5)$$

The variable NC_j refers to the degree of network-conformity and concludes the degree of the behaviour of a CC in the production network in one value. Thus, it is guaranteed that the CC can be compared with other CCs

4.3 Extraction of Data

While the calculation scheme for the value NC is relatively simple, the actual ascertainment of the data is more difficult. Therefore, this paper will in the following take a closer look at the procedure of the analysis and the problems. The relevant parameters need to be ascertained for the SMPN in a one-time work step. This has to be carried through in a pre-investigation. Results concerning influential parameters with regard to the behaviour of the actors in a network are the consequence of that investigation. Those parameters are hard or soft factors. The hard (quantified) factors are for example stability of the price, adherence to delivery dates and quality assurance. Soft factors are not available quantitatively and thus first of all need to be ascertained numerically in a preceding step. The soft factors for example include the satisfaction of the customers, the confidence culture or the behaviour towards other network actors. Evaluation measures (EM), which include the degree of the evaluation, can be identified for soft as well as for hard facts. Finally, a measure can be allocated for every kind of factors (parameters).

4.4 Quantification of Data

Concerning the quantification of data of the soft parameters, a rating-procedure is to be used. During a rating, which is compliant to the scoring-model (thus e.g. value between 0 and 10), those values can be taken over. All CCs should be involved in the evaluation for parameters which require an evaluation of other CCs, such as the behaviour towards other CCs or the confidence culture. Other parameters such as the satisfaction of the customers require the opinion of the customer. However, it is very difficult here to make a differentiated statement concerning single CCs.

Evaluation formula can be formulated for the quantitative evaluation of the hard parameters. Here, it is exemplarily traced back on the parameter date of delivery. The adherence to the agreed date of delivery can already be supervised during the production process. That process however does not belong to social monitoring. After finishing the value-adding process in the network, the realised date of delivery can be compared with the planned one. Both parameters are available in a quantified form. According to equation (6), the adherence on delivery date of a CC j (add_j) can be determined and quantitatively evaluated. The parameter $t_{j,p}$ represents the time from the arrival of the order until the planned date of delivery of CC j as a

$$add_j = \frac{t_{j,p}}{t_{j,r}} \quad (6)$$

target value, while $t_{j,r}$ refers to the time between the arrivals of the order until the realised date of delivery, the actual value. If the date of delivery is fallen below or kept, equation (6) results in a value for add_j that is bigger than or equal to 1. For missed date of deliveries a value of smaller than 1 result. For a delay of 2 days and a delivery time of 20 days, the value add_j for example amounts to 0,91. That value, which can be interpreted as 91%, can for example lead to a credit distribution of 9,1. However, it is a problem that even big delays still lead to relatively high evaluations. Therefore, a detailed calculation rule needs to be formulated for the credit value r_j, that enters the evaluation of the scoring-model as the adherence on delivery date of a CC. It has to be considered that the credit evaluations need to be in an interval (usually [0, 10]). Therefore, a credit distribution dependent on the degree of adherence on delivery date seems plausible. The degree of adherence on delivery date d_j refers to the deviation from the planned and realised time of delivery in relation to the planned time of delivery. Thereby, it has to be mentioned that d_j becomes smaller the smaller the delay is. The same is valid the other way. Therefore, cf. equation (7).

$$d_j = \frac{t_{j,r} - t_{j,p}}{t_{j,p}} \quad (7)$$

The degree of the adherence to delivery promises is characterised by a delay of a punctual delivery or an early delivery. It is assumed that only the delay of the date of delivery needs to be sanctioned. For that reason, equation (7) is only applied for those cases where $t_{j,r} > t_{j,p}$. Therefore, only values in the interval (0, ∞] result for d_j. Thereby, it has to be considered that the smaller d_j is, the bigger the credit evaluation r_j has to be. Now, the task is to find a relation of the values of d_j and r_j by a calculation rule. Thereby, it is to be valid that the values of r_j have to be in the interval [0,10]. For a punctual or early delivery ($t_r \leq t_p$), the CC_j is always given the maximum credit value for r_j, thus for example 10 credits. It becomes clear that the coherence is non-linear. An inverse dependence of the credit value r_j and the adherence to delivery d_j can be recognised and needs to be modelled.
In case of a simple inverse dependence 1/x for r_j, values in the interval (0, ∞], result for a domain of d_j in the interval (0, ∞]. Therefore, a scaling is necessary for values in the interval [0,10] for the use as a credit value r_j in the scoring-model. For that reason, the application domain of d_j is reduced to values of 1% delay (e.g. $t_{j,r,}$=101 days and $t_{j,p}$ =100 days) and 100% delay (e.g. $t_{j,r}$=200 days and $t_{j,p}$=100 days). The values of d_j are then in the interval [0.01; 1] whereby 0.01 is a 1% delay and 1 is a 100% delay. For a delay of less than 1%, the full credit (r_j = 10) is still given and for a delay of more than 100% (more than the double time was necessary), 0 credits (r_j = 0) are given. It becomes obvious that the lower and upper borders can be fixed variably for the modelling.
After the aforementioned modelling (d_j has to be in the interval [0,01; 1]), equation (8) results for the calculation of the credit distribution r_j with regard to that parameter:

$$r_j = \frac{1}{10 \cdot d_j} \quad (8)$$

According to equation (8), now credit values r_j result which are in the interval [0,1; 10]. Also more complex coherences would be imaginable. However, those would need to be included mathematically in the formula for the calculation of r_j. Approaches concerning that are not considered here.
For the better comprehension, a little example is introduced. A delivery time $t_{j,p}$ of 20 days was agreed upon. The delivery $t_{j,r}$ however just takes place after 24 days. According to equation (7), d_j has a value of 0,2. According to equation (9), this leads to an evaluation of r_j=0,5 (out of 10) credits on a scale between 10 (punctual delivery) and 0 (very unpunctual delivery).
During further calculations, it becomes very clear that already small deviations from the date of delivery (in the sense of delays) lead to a massive devaluation. That means loss of credits. If this is aimed at in the single case remains situation-dependent. Should the occasion arise, a modification of the equation (8) should be aimed at. For the general relation that modelling is sufficient. The calculation scheme showed that the credit evaluation of the delivery reliability can also be applied for most of the parameters existing in a quantified form, as it is applied here or in an adapted form. For that reason, detailed descriptions will be dispensed with in that paper.

4.5 The Significance of NC for the Network Controlling
Besides the quantitative ascertainment of the parameters as well as, if necessary, their quantification, the choice of the weights in the scoring-model is a further task. New weights need not to be fixed for every monitoring process. The weightings need to be changed as rarely as possible for the purpose of keeping a continuous comparability of the evaluation. In the ideal case, the selection of the weights is carried through by the network management (EVCM) in the beginning of the SMPN-activities. Thereby, rankings or empirical studies can be used.
The CC-specific parameter NC_j is ascertained for every CC for every value-added process. To make sure that the preceding information is not lost, the current with the existing information should be combined. Thereby, the current information should have a higher weighting. The CC-specific values NC_j can then be used with the claim of an efficient network-controlling by the EVCM. Information concerning the behaviour of CCs during the value-adding process can be especially important during the selection process for future networks. If several CCs are equally suitable for one part of added value from a technological point of view, the demarcation of the parameter NC_j can be used as a decision aid.

5. CONCLUSION

The paper introduced a framework for social monitoring in non-hierarchical production networks. If the implementation into the network management is successful, the introduced approach can be a very efficient and expressive controlling-instrument in a automated management-system EVCM. In that connection, the quality of the accomplishment of added value processes in non-hierarchical production networks is increased. Thereby, production processes in networked structures can be further established in the economic life which leads to the fact that also small and medium-sized enterprises can offer competitive products on the world-wide market.

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