The influence of changing environment for path dependence in hierarchical organizations

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ABSTRACT
The following paper aims at describing how path dependent hierarchical organizations are affected by a changing environment. The results of the latest research in this field (Petermann et al. 2012) analyzed path dependency of norms and institutions in different kinds of hierarchical organizations and the impact of leadership within this process. The results were produces for stable environments only. Agent based simulation was applied as research method. In order to examine how this process evolves when the organizational environment in changing the model M1 (Petermann et al. 2012) will be enhanced. The goal is to simulate the impact of external influences to the norms emerging within the organization. The research described is not yet completed so this paper characterizes first thoughts and possible simulation approaches to tackle the problem at hand.

INTRODUCTION
Nowadays most organizations have to deal with a changing environment. From the organizational point of view a changing environment can be seen as disturbances from outside that forces the organization to adapt very fast. If the organization fails to do so, it may fall back or even be eliminated from the competition. This is especially risky when new technologies flood the market and companies have to react. Examples may be found by taking a closer look at companies like Loewe or Nokia. Loewe missed the technology change on the TV market from the CRT displays to the new LCD-based flat screen technologies. In fact, Loewe builds first rate CRT displays even today, but the market is no longer asking for TVs of this category anymore. Thus Loewe appears ignorant of market realities. The high technical level of their obsolete skills is disguising the internal view of the environment, in this case innovations on the TV market. In the end they were bought by some investors just in time, but their previous ignorance almost led them into bankruptcy.

Comparably to Loewe is Nokia and their behavior on the smartphone market. Nokia was one of the pioneer companies on the mobile phone market, but they did not react adequately to new mobile trends. Just like Loewe, Nokia suffered immensely when other suppliers like Apple (trendsetter of the smartphone trend) and Samsung captured the market. By now the mobile phone division of Nokia has been bought by Microsoft and they slowly get back on track. The questions that arise are: why do companies sometimes need to get hit so hard from external influences until they see that they have to change? How fierce do these influences need to be?

In the following research the model M1 (Petermann et al. 2012) that for reasons of simplicity was build on the assumption of a stable environment will be extended with a new variable, that will include environmental change into the model.

LITERATURE REVIEW AND RESEARCH QUESTION
The theoretical concept for the behavioral analysis described above is called theory of path dependence. The concept of that theory was first described by David (1985). He dug into the history of the “QWERTY”- keyboards from their first steps in the 19th century until 1985. This alignment of characters has been dominant till today for nearly 100 years. In the early 1930s the alternative “DVORAK” keyboard layout was developed. This at the time new technology was clearly a better and more efficient solution for keyboard layout than the incumbent. These keyboards, however, were not able to become a serious competitor to “QWERTY”- keyboards. David wanted to know why this was so, i.e. what kinds of effects were responsible for the domination of the established keyboards. Based on David's findings, Arthur (1989) described this market behavior with a model of two technologies (A and B) coming to the market at the same time and fighting for the adoption of the customers, called agents. At the beginning both technologies have the same possibility to get adopted. For the first time in the history of the path dependence debate, Arthur coined the definition of the historical small events increasing returns and contingency. These events are responsible for the start of the path process and lead to a lock-in of
the technologies A or B. Figure 1 (Arthur 1989: 120) illustrates this behavior. When B is locked in, A is completely eliminated from the market.

![Figure 1: Increasing returns adoption: a random walk with absorbing barriers](image)

**Path dependence in the organizational context**

To transfer the theory of path dependence to an organizational context a different view of Arthur’s description is needed. In organizations and social systems, history always matters, and due to the ongoing variations in behavior, the lock-in on markets has peculiar characteristics. There is less adoption behavior, hence development phases deviate from purely technological path dependence. To capture organizational path dependence, Sydow et al. (2009) developed a model which describes this advanced concept of organizational path dependence. In this model the path development is split into three different phases. Figure 2 (Sydow et al., 2009: 692) shows the concept of this model.

![Figure 2: The Constitution of an Organizational Path](image)

**Phase 1: Preformation Phase**

In this phase the decision the participants are able to make are relatively open. Influences at this time could be historical events, “history matters”, routines, and the existing culture of the organization. In the beginning the participants already have an idea of thinking and behaving in their daily environments. Koch (2007: 286) described imprinting circumstances of an organizational culture in this context. Therefore the decisions that will be made in the future are already not completely open. In figure 2 all options are symbolized by the black stars, but only the stars in the grey zone are available options for the organization.

**Phase 2: Formation Phase**

In this phase the path begins to emerge. The step from phase 1 to phase 2 is called “critical juncture”. At this point an unknown or virtually unrecognizable event from the past leads to the organizational path formation (Sydow et al., 2009: 693). These events are described as “small events”. Furthermore self-reinforcing effects triggered by these small events narrow the path. Not every small event is able to trigger such a process, but some will do so.

**Phase 3: Lock-In Phase**

The reinforcing effects have now taken the lead and reduce the scope of choices. In this phase the organizational path has become locked in. The lock-in state may, in an unfortunate case, be an inefficient one which disables the organization’s ability to change and adopt more efficient solutions to the problems at hand. As described above, Loewe appeared locked-in to such an unfortunate state. At first the state was very efficient, but when the market changed Loewe’s technology was not needed anymore and thus the state lost its efficiency causing severe problems for the organization.

**RESEARCH QUESTIONS**

We are interested in the impact of a changing environment to organization that undergo path dependent processes. In historical analysis scholars have shown many examples of organizations that were able to adapt in the light of changing environment while other are stuck in a lock-in state, unable to change even when the necessity to change was obvious. Our model aims at describing hierarchical organizations that undergo a path dependent development in a changing environment. Will they be able to adapt or do they stick to the path? What can we learn about this process applying simulation methods? How should an organization be structured to be able to adapt in the light of dramatic changes in the environment?

**METHOD**

In modern social and management sciences the method of simulation modeling has been accepted since the early 1990s, like Harrison (2007: 1232) figured out. When complexity and non-linearity of social systems makes it hard or impossible to develop mathematical solutions, simulation models are a good choice to describe the whole system and its development (Gilbert et al 2005: 16). “Simulation is particularly useful when the theoretical focus is longitudinal, nonlinear, or processual, or when empirical data are challenging to obtain” (Davis et al, 2007: 481). On the other hand it is important to know that the method of simulation cannot replace empirical or analytic methods, but it can provide
first insights for other social research methods to be applied later on.

The basic model

The basic of this research is the simulation model M1 Petermann et al. (2012) developed in his simulation study about the competing powers of self-reinforcing dynamics and hierarchy in organizations. The theory of that model is the simulation of a norm A and a norm B in an organizational hierarchy structure and to answer the question which norm will be adopted by most of its members. Every member of the organization is represented as an agent. These agents are able to decide whether to adopt norm A or norm B.

Agents decision algorithm to adopt A or B

To implement this technically, the agents need to be forced to adopt a norm. Therefore the force-to-act variable FTA is defined (Petermann et al. 2012: 726).

\[ \text{FTA}_j = E_j \cdot V_j = E_j \cdot \left( \sum_{k=1}^{m} (V_k \cdot I_{jk}) \right) \]  

(1)

Vj describes the connection of individual and organizational goals according to Vroom’s (1964) expectancy theory. Ej \( \epsilon [0,1] \) represents the subjective probability of each agent’s decision. This variable represents the “small events” of the organizational path dependence theory. To implement this in the algorithm, the strictly monotonously increasing function

\[ f_{\text{M}(x)} = e^{m \cdot c \cdot x^{1.5}} + i(y) \cdot l_i + s(z) \cdot e_i \]  

(2)

is used in the simulation to determine V according to equation (1) with M \( \epsilon \{A, B\} \), m = 1 for \( f_{\text{A}(x)} \) and m = -1 for \( f_{\text{B}(x)} \). The variable c represents the reinforcing effects and is generated by the actual spread \( \epsilon [-1, 1] \) which is a variable that characterizes the state of the system that is either dominated by agents who all choose A (spread =-1) or agents who all choose B (spread=1) or at some state between these extreme case (spread between -1 and 1). The factor i(y) sets the value of li in the correction path direction. This could be 1 or -1. At the beginning of the simulation the spread is 0 (meaning there are equally large groups of agents choosing A and B in the beginning of the simulation). The lock-in state is nearly 1 for A or nearly -1 for B after a defined amount of time (measured in ticks). The misfit costs are described by x. The leadership impact variable li, which makes the simulation of a hierarchy organizational structure possible, is affecting every agent according to what norm this agents supervisor prefers.

Under these conditions the agents choose an adoption for A, when

\[ \text{FTA}_A(x) = E_1 \cdot f_{\text{A}(x)} > \text{FTA}_B(x) = E_2 \cdot f_{\text{B}(x)} \]  

(3)

and otherwise B if \( \text{FTA}_B > \text{FTA}_A \).

Simulation of an external impact

Now an external impact has to be implemented in the FTA function to see whether or not this will have an effect of breaking the organizational path. Therefore, equation (2) needs to be extended with an additional value.

\[ f_{\text{M}(x)} = e^{m \cdot c \cdot x^{1.5}} + i(y) \cdot l_i + s(z) \cdot e_i \]  

(4)

The variable ei represents the external impact from the changing environment. The factor s(z) is only used to set the correct direction, which depends on the actual path. The value generation of that variable needs to be clarified in the next step. While all variables in the equation are generated by the simulated organization itself, ei is triggered from an external mechanism. When there is no external impact, ei is equal to 0 and behaves neutrally. The question of how the model reacts after the lock-in has occurred is highly interesting. Are there any options to “reset” the norm distribution of the organization? The goal here is to find out about the behavior of the organization regarding the external impact. Are its intensity, its continuity, or a mix of both able to break the path? Every agent in the system is subject to the same external impacts. We assume that environmental influences have the same strength throughout the organization.

Expected Results

With the variable of the external impact, a path breaking effect should be realized. Figure 3 shows a possible behavior during the path formation phase as inferred from first simulation attempts. The path was prompted by an external impact to “reset” the building process.

![Figure 3: Impacts during path formation phase](image-url)
become locked in. Figure 4 shows some possible path directions similar to figure 3 from first simulation attempts.

![Figure 4: Impact after lock-in](image)

Another interesting part could be the behavior of an organization in cases where the external impact is present right from the beginning on, so before the system eventually becomes locked-in. The question here is, whether the organization is able to properly focus on a norm under such conditions at all.

REFERENCES


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**Dr. Arne Petermann** was MBA Program Director at the Berlin University for Professional Studies from 2011 until 2013. As a visiting scholar, he is currently teaching organization science and scientific simulation methods in the PhD-program at the School for Business and Economics at Freie Universität Berlin. He is founding President and CEO of Linara GmbH, an international HR agency specialized in the transnational European healthcare sector. His research focuses on organization science, path-dependence theory, entrepreneurship, and social simulation, especially agent-based modeling. His research results have been presented at the leading international science conferences in his field, including the Academy of Management and the American Marketing Association Educators Conference where, moreover, his work was recognized with a best paper award. His work is published in books and peer-reviewed journals.

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