Path dependence in hierarchical organizations: The influence of environmental dynamics

Arne Petermann
Institute for Quality and Management, BAGSS
Konrad-Zuse-Str 3a, 66115 Saarbrücken, Germany
E-mail: arne.petermann@iqm-bagss.de

Alexander Simon
Berlin University of Professional Studies
Katharinenstraße 17-18, 10711 Berlin, Germany
E-mail: alexandersimon90@googlemail.com

KEYWORDS

agent based modelling, social simulation, path dependence, path breaking, organizational studies, business strategy, technology strategy

ABSTRACT

The following paper will describe how path dependent hierarchical organizations are affected by a changing environment. The results of current 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 produced for stable environments only. Agent based simulation was applied as research method. In order to examine how this process evolves when the organizational environment is changing, the existing model will be enhanced. The objective is to simulate the impact of external influences to the emergence of norms within an organization.

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. If an organization fails to do so, it may fall back or even be eliminated from the competition. This comes with a high risk, especially 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 technological change on the TV market from the CRT displays to the new LCD-based flat screen technologies. In fact, Loewe still builds CRT displays. The result is an imbalance of supply and demand, because most customers are not interested in those TV's any more. 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 the investor Stargate Capital bought Loewe and made some serious changes. But their previous ignorance almost led them into bankruptcy.

Nokia on the other hand 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 and Samsung captured the market applying the latest technologies. By now the mobile phone division of Nokia has been bought by Microsoft. 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) which for reasons of simplicity was built on the assumption of a stable environment will be extended with a new variable one or the other 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. In that time this new technology was clearly a superior solution than the incumbent. These keyboards, however, were not able to become a serious competitor to "QWERTY"- keyboards. David examined in detail the self-reinforcing mechanisms that led to the domination of the established keyboards by the inferior QWERTY solution.
Based on David's findings, Arthur (1989) used a polya urn model to analyze the self reinforcing mechanisms discovered by David in a more formal way. In his model two technologies (A and B) are entering the market at the same time and compete for the adoption by customers called agents. At the beginning both technologies have the same chances 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.

Proceedings 30th European Conference on Modelling and Simulation ©ECMS Thorsten Claus, Frank Herrmann, Michael Manitz, Oliver Rose (Editors)
ISBN: 978-0-9932440-2-5 / ISBN: 978-0-9932440-3-2 (CD)

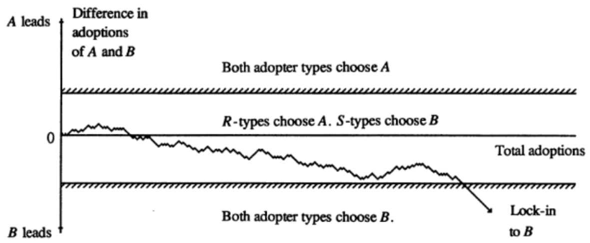


Figure 1: Increasing returns adoption: a random walk with absorbing barriers

David and Arthur stress that a technology can become dominant even when it is inferior in terms of its long term value to the system.

Transform path dependence to an 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 developed a model which describes this advanced concept of path dependence. In this model the path is split into three different phases. Figure 2 (Sydow et al., 2009: 692) shows the concept of this model.

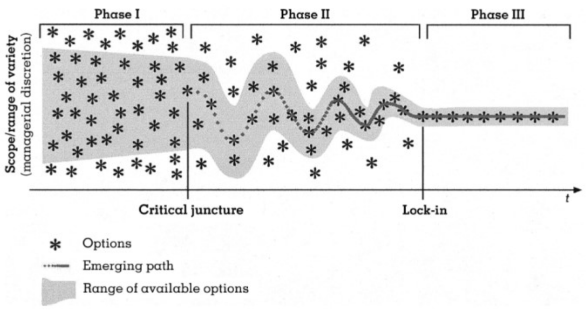


Figure 2: The Constitution of an Organizational Path

Phase 1: Preformation Phase

In this phase the decisions the participants are able to make are relatively open. Influences at this point can 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". 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". The self-reinforcing effects that are triggered by these small events narrow the path and limit future choices within the organization.

Phase3: Lock-In Phase

The reinforcing effects have now taken the lead and reduced the scope of choices drastically. 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, 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 organizations that undergo path depended processes. In historical analysis scholars have shown many examples of organizations that were able to adapt in the light of changing environment, while others are stuck in a lock-in state, unable to change, even when the necessity to change became obvious from an outside perspective. Our model aims at describing hierarchical organizations, that undergo a path depended 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 (Harrison 2007: 1232). When complexity and non-linearity of social systems make it hard or impossible to develop mathematical equations, 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 insights and first assumptions for other social research methods.

The basic model

The basics of this research is the simulation model M1 Petermann et al. (2012) developed in their 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).

$$\mathbf{FTA_j = E_j * V_j = E_j * \left[\sum_{k=1}^{m} (V_k * I_{j,k})\right]}$$

(1)

Vj describes the connection of individual and organizational goals according to Vrooms (1964) expectancy theory. Ej ϵ [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

$$\mathbf{f_{M,c(x)} = e^{m*c*x*1,5} + i(y) * li}$$

(2)

is used in the simulation to determine V according to equation (1) with M ϵ {A, B}, m = 1 for fA,c(x) and m= -1 for fB,c(x). The variable c represents the reinforcing effects and is generated by the actual spread ϵ [-1, 1] which is a variable that characterizes the state of the system, which 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 cases (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 his supervisor prefers.

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

$$\mathbf{FTA_A(x) = E_1 * f_{A,c}(x) > FTA_B(x) = E_2 * f_{B,c}(x)}$$

(3)

and otherwise B if $FTA_B > FTA_A$.

Simulation of an external impact

Enhancing this model further, we now implement an external impact into 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.

$$\mathbf{FTA_M(x,y,z) = E_1 * f_{M,c}(x) + i(y) * li + s(z) * ei}$$

(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 other variables in the equation are generated by the simulated organization itself, ei is triggered from an external source. When there is no external impact, ei is equal to 1 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. Is 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.

SIMULATION

To simulate the described external impact, we need to specify in what way and when the variable ei should change. The first condition, we need to break the path and the path must be locked-in. That means that a dominant norm exists in the simulation model. The lock-in state in model M1 is defined by Petermann et al. (2012: 195) as minimum 500 of ticks with a spread > 0.9 if B is dominant (spread < -0.9 if A is dominant). Furthermore, a definition for breaking a path is also needed. The model M1 defines no values for that, so we assume a path is broken when spread < 0.5, when B was the current norm in the company and a spread > -0.5 when A was the current norm. This means that less than 75% of all company members adopted a norm. The last variable is the leadership impact. This is set to 1, to have an impact from that side. The defined values for lock-in and leadership impact are assumption and not empirical researched values.

The variation of the external impact is possible in two ways. Either the intensity can be variated or the amount of time (number of ticks) the impact is present in the system. To get usable data from the simulation model, only datasets with a lock-in at B before the external impact is triggered are used for analysis purposes. Otherwise it is not possible to see a behavior for one norm. A simulation for each parameter-set will run 100 times according to the Monte-Carlo method (Law et al. 1991:113).

Run of the 1. Simulation

The change of the external impacts must be further clarified to run the first approach. During the enhancement of the model the following parameters seemed to be valid for a first run. After the first simulation an optimization of the parameters is needed. Maybe a closer look at several parameter areas is interesting.

		intensity (int)				
		1	3	5	7	10
continuity (ticks)	10	10/1	10/3	10/5	10/7	10/10
	40	40/1	40/3	40/5	40/7	40/10
	70	70/1	70/3	70/5	70/7	70/10
	100	100/1	100/3	100/5	100/7	100/10
	130	130/1	130/3	130/5	130/7	130/10

Figure 3: 1. Simulation parameter Setup

The lock-in behavior with leadership impact of 1 and 2 is at 6000 ticks (Petermann et al. 2012:195). This means, that each simulation must run at least 6000 ticks, before the external impact can be triggered. A complete run will last 8500 ticks, and then the system has enough time to reconfigure itself after the external impact. It is not possible to define a number of ticks after the impact, when the system has locked-in again. This basic setup is used for all simulations in this paper; otherwise it is not possible to compare the results properly.

Results of the 1st Simulation

The result of this run is a huge amount of data, which needs to be analyzed. The first intensity parameters from 1 to 3 will not be visualized in this paper, because the maximum possible spread change is from 1 to 0,992 at a random point of time, so with a parameter combination of 130 for continuity and 3 for intensity no connection to the external impact can be identified. The effects that occur at the intensity of 10 are also not visualized they are similar to the graphics that depict the intensity of 7.

Results for Intensity of 1 and 3

No valid differences could be detected, that change the system normal behavior. It is not possible, to force a path break with all combinations containing the parameter 1 for intensity.
The most interesting effect occurs at the parameter intensity between 5 and 7.

Results for Intensity of 5

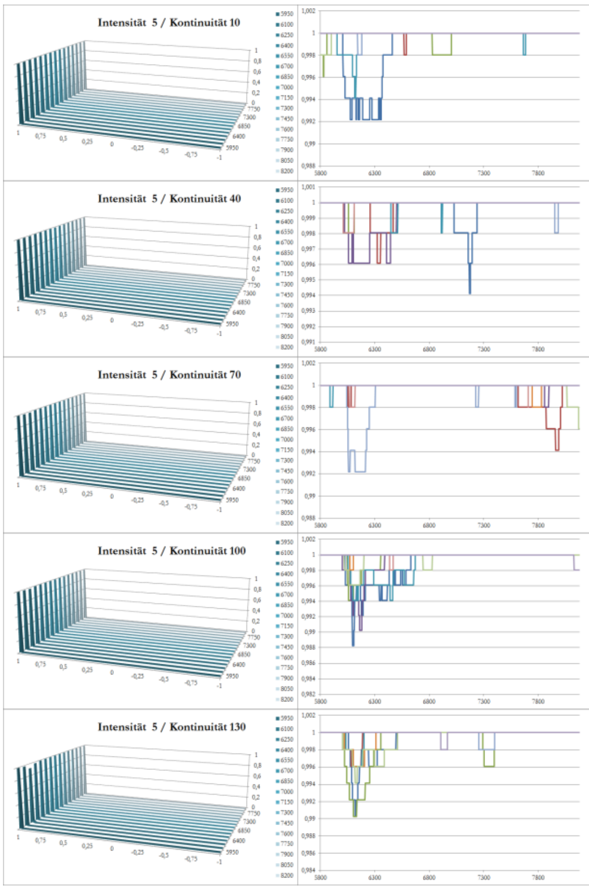
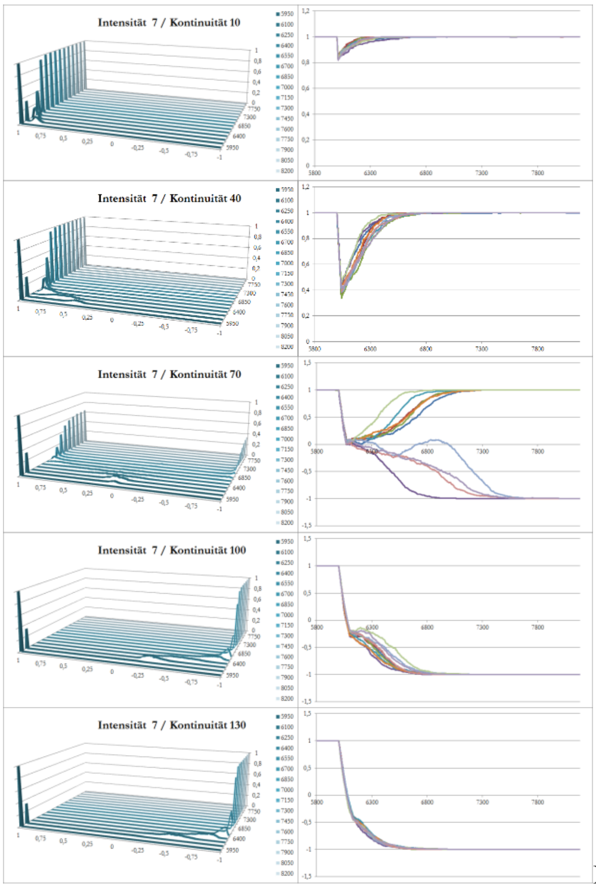


Figure 4: Left: Histograpchical view: probability density, 150 ticks summarized. X axis: spread, Y axis: probability from 0-1, z-Axis: time in ticks, starts counting at 5800 ticks. Right: exemplary first 10 runs. X Axis: ticks, Y-Axis: spread.

At this parameter setup the system started to react. With the combination of continuity of 10 until continuity of 70 no valuable reactions are noticeable. However, at a continuity of 100 the system starts to change. The spread is forced to the path breaking direction. Of course, it is only a spread of 0.992, but the events occur exactly at the starting point of the external impact.
With this first result it is maybe useful, to increase the continuity over 130 with an intensity of 5 to generate a path break.

Results for Intensity of 7



F

Figure 5: Left: Histograpchical view: probability density, 150 ticks summarized. X axis: spread, Y axis: probability from 0-1, z-Axis: time in ticks, starts counting at 5800 ticks. Right: exemplary first 10 runs. X Axis: ticks, Y-Axis: spread.

An intensity of 7 forces the system to break the path for the first time even with low continuities. With a continuity of 10 a significant system behavior is detected, but there is still no path break. This happens for the first time with a continuity of 40 (spread < 0.4). Higher continuities with values of 70, 100 and 130 forced the system to establish new norms.

Results for Intensity of 10

The intensity of 10 behaves nearly like the intensity of 7. With higher amount of continuity path breaks and new path formations are results of the simulation.

Summary of the 1st Simulation

The first simulation run gave first insights to the system behavior of the described model M1. In the following three figures all parameter combinations described in figure 3 are being compared.

The effect at the path is listed in figure 6. As described above, the interesting area is between the intensities of 5 and 7. The probability of a path breaking behavior increases rapidly at this interval. This parameter field will be investigated more closely.

continuity (ticks)	intensity (int)				
	1	3	5	7	10
10	0%	0%	0%	0%	0%
40	0%	0%	0%	99%	100%
70	0%	0%	0%	100%	100%
100	0%	0%	0%	100%	100%
130	0%	0%	0%	100%	100%

Figure 6: Pathbreaking probability

Figure 7 describes the probability of new path directions. With a continuity of 70 at an intensity of 7 the probability is 3% higher compared to an intensity of 10. There is, however, a small probability at 100 simulation runs that the result differs from one's expectations. That the system behaves unexpectedly at this point could also be an assumption. A deeper analysis about this could be an interesting question for upcoming research, but it will not find place in this paper.

continuity (ticks)	intensity (int)				
	1	3	5	7	10
10	0%	0%	0%	0%	0%
40	0%	0%	0%	0%	0%
70	0%	0%	0%	35%	32%
100	0%	0%	0%	100%	100%
130	0%	0%	0%	100%	100%

Figure 7: new path direction probability

Finally the average spread over all combinations is shown in figure 8. The average was calculated at the last tick of the impact. As expected, the spread changes in the intensity fields of 1 and 3 are out of scope. It's interesting to see that with an intensity of 5 differs with 3%, but that is not according to its continuity.

continuity (ticks)	intensity (int)				
	1	3	5	7	10
10	1,00	1,00	1,00	0,84	0,82
40	1,00	1,00	1,00	0,40	0,37
70	1,00	1,00	0,98	0,05	0,02
100	1,00	1,00	0,97	-0,23	-0,25
130	1,00	1,00	1,00	-0,43	-0,45

Figure 8: Average spread, calculated at the last external impact tick

The expected behavior was successfully created in the first simulation run. The path was broken, and new path directions emerged in the system. It is also a validation of the external impact implementation of the model M1. Furthermore interesting results came out of the first run. A second and third simulation run are recommend at this point. In the second simulation a closer look is taken at the system behavior with very high intensities. As described above, the intensities 7 and 10 seem to behave almost equally. To clarify this interpretation, a second simulation was done. The third simulation takes a closer look at the intensity area between 5 and 7. Here the system seems to react very sensitively.

Run of the 2nd Simulation

The finding of the first simulation: “the intensities of 7 and 10 behave almost equally” should be clarified in this simulation. Therefore a simulation with highly overdriven intensities was performed. We assume here that there are no significant different system-behaviors observables, with intensities of 10 or more. To break the path with a continuity of 10 is also part of this simulation. The path was influenced in the first simulation with this continuity, but there was no sustainable effect, like breaking or new formation, at the path. Figure 9 shows the parameter setup for the second simulation.

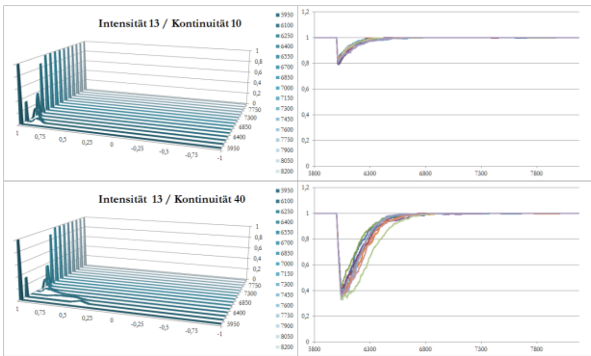
		intensity (int)		
		13	**16**	**19**
continuity (ticks)	**10**	10/13	10/16	10/19
	40	40/13	40/16	40/19
	70	70/13	70/16	70/19
	100	100/13	100/16	100/19
	130	130/13	130/16	130/19

Figure 9: 2. Simulation parameter Setup

Results of the 2nd Simulation

The figures 10 – 12 show the visualized result of the simulation.

Results for Intensity of 13



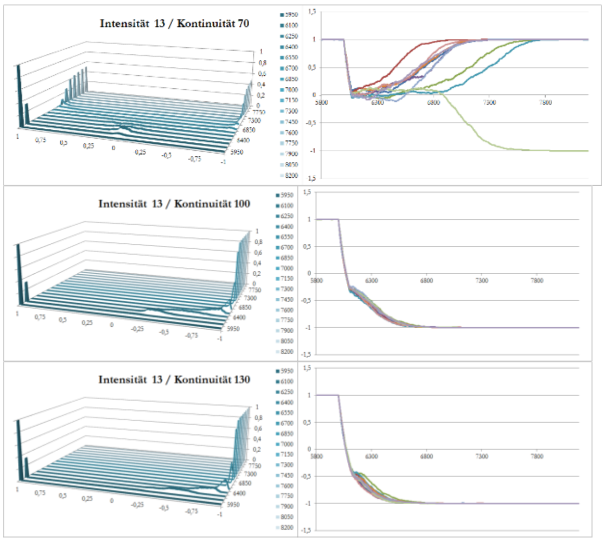


Figure 10: Left: Histograpchical view: probability density, 150 ticks summarized. X axis: spread, Y axis: probability from 0-1, z-Axis: time in ticks, starts counting at 5800 ticks. Right: exemplary first 10 runs. X Axis: ticks, Y-Axis: spread.

Results for Intensity of 16

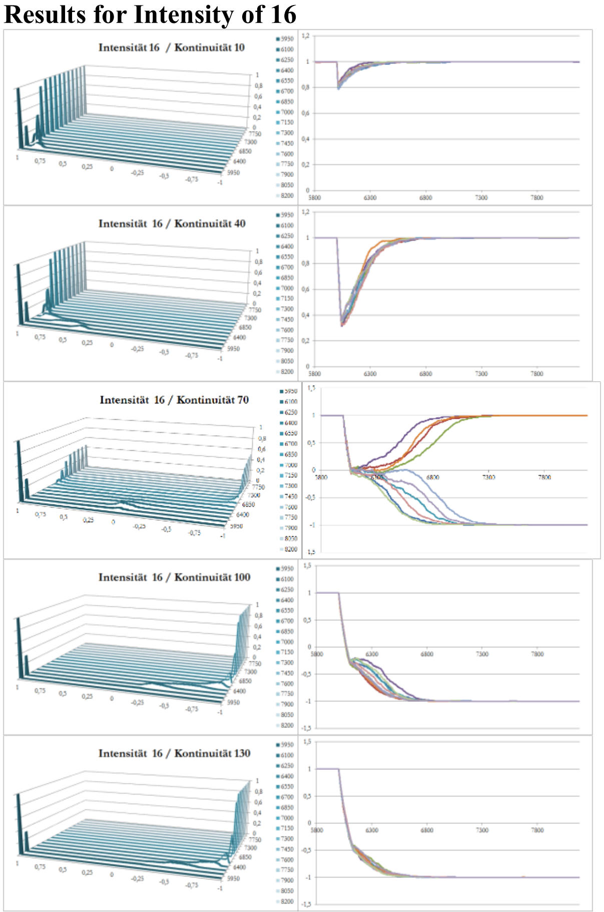


Figure 11: Left: Histograpchical view: probability density, 150 ticks summarized. X axis: spread, Y axis: probability from 0-1, z-Axis: time in ticks, starts counting at 5800 ticks. Right: exemplary first 10 runs. X Axis: ticks, Y-Axis: spread.

Results for Intensity of 19

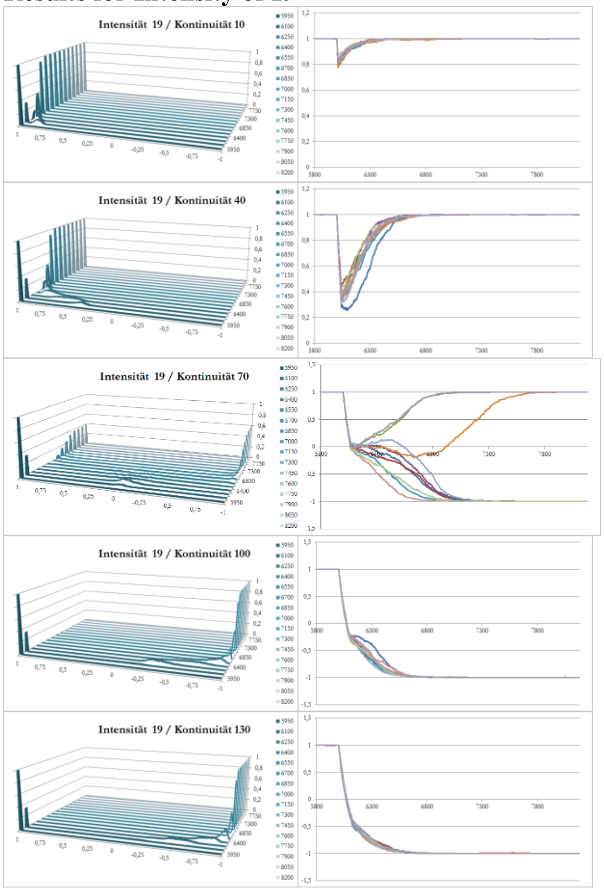


Figure 12: Left: Histograpchical view: probability density, 150 ticks summarized. X axis: spread, Y axis: probability from -1, z-Axis: time in ticks, starts counting at 5800 ticks. Right: exemplary first 10 runs. X Axis: ticks, Y-Axis: spread.

The average spreads shall verify the assumption of a constant changing behavior with increasing intensities. The detailed results are shown in figure 13 to 15.

continuity (ticks)	intensity (int) 7	10	13	16	19
10	0%	0%	0%	0%	0%
40	99%	100%	100%	100%	100%
70	100%	100%	100%	100%	100%
100	100%	100%	100%	100%	100%
130	100%	100%	100%	100%	100%

Figure 13: Pathbreaking probability

continuity (ticks)	intensity (int) 7	10	13	16	19
10	0%	0%	0%	0%	0%
40	0%	0%	0%	0%	0%
70	35%	32%	49%	51%	60%
100	100%	100%	100%	100%	100%
130	100%	100%	100%	100%	100%

Figure 14: new path direction probability

continuity (ticks)	intensity (int) 7	10	13	16	19
10	0,84	0,82	0,81	0,81	0,81
40	0,40	0,37	0,35	0,35	0,35
70	0,05	0,02	0,01	0	0
100	-0,23	-0,25	-0,25	-0,25	-0,26
130	-0,43	-0,45	-0,45	-0,45	-0,45

Figure 15: Average spread, calculated at the last external impact tick

Figure 13 shows the pathbreaking probability for the second simulation. All intensities have similar values, except the parameter combination intensity of 7 and continuity of 30 with 99%. The average spread, which is shown in figure 15, only varies from the intensity from 7 to 10. For an intensity of 13 or more the average spread is constant. This result validates the assumption that a continuity of 10 can not trigger a pathbreak in the system, regardless the height of intensity. The most interesting outcomes of this simulation are the values of the new path direction probability (figure 14). The continuities have the same behaviors, except 70. With a higher intensity the new path direction probability increases. Even if the average spread is 0 at a continuity of 70 and intensity of 16 and continuity of 70 and intensity of 19, that means a total balance between the adopted norms A and B is present, the new path direction probability increases about 9% between this two combinations.

Run of the 3rd simulation

This simulation researches the area of the intensities between 5 and 7 as described above. The following table shows the parameter setup for this run.

continuity (ticks)	intensity (int) 5,5	6	6,5
10	10/5.5	10/6	10/6.5
40	40/5.5	40/6	40/6.5
70	70/5.5	70/6	70/6.5
100	100/5.5	100/6	100/6.5
130	130/5.5	130/6	130/6.5

Figure 16: 3. Simulation parameter setup

Results of the 3rd Simulation

The figures 17 and 18 show the visualized results of the simulation.

Results for Intensity of 5.5

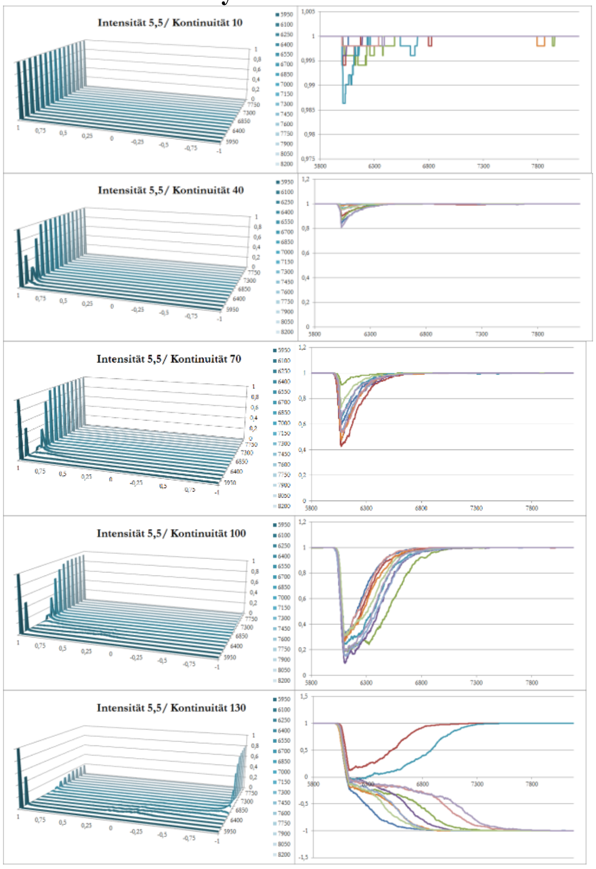
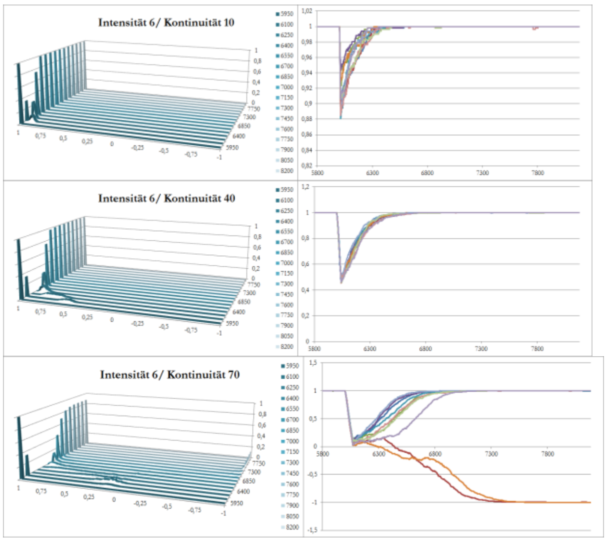


Figure 17: Left: Histograpchical view: probability density, 150 ticks summarized. X axis: spread, Y axis: probability from 0-1, z-Axis: time in ticks, starts counting at 5800 ticks. Right: exemplary first 10 runs. X Axis: ticks, Y-Axis: spread.

Results for Intensity 6



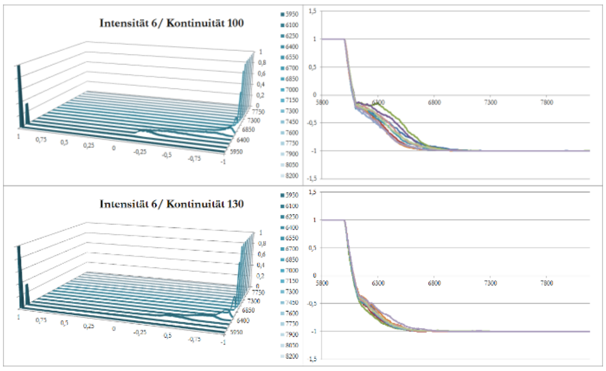


Figure 18: Left: Histograpchical view: probability density, 150 ticks summarized. X axis: spread, Y axis: probability from 0-1, z-Axis: time in ticks, starts counting at 5800 ticks. Right: exemplary first 10 runs. X Axis: ticks, Y-Axis: spread.

Results for Intensity of 6.5

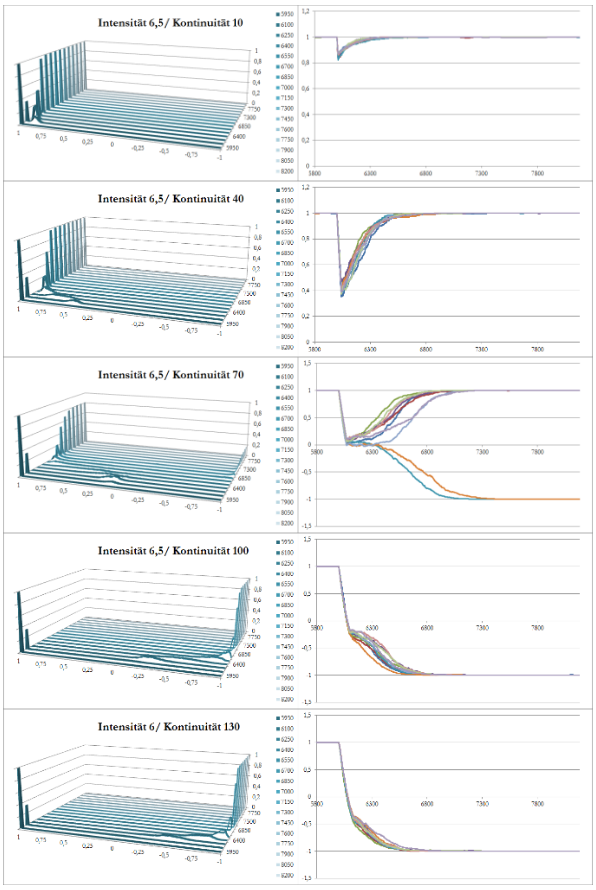


Figure 19: Left: Histograpchical view: probability density, 150 ticks summarized. X axis: spread, Y axis: probability from 0-1, z-Axis: time in ticks, starts counting at 5800 ticks. Right: exemplary first 10 runs. X Axis: ticks, Y-Axis: spread.

In Figure 20 the different pathbreaking probabilities are listed. With an intensity of 6.5 and a continuity of 40 and more the path breaks with a probability of 100%. Compared to the intensity of 7 (figure 6) these two intensities are very close the each other.

		intensity (int)		
		5.5	6	6.5
continuity (ticks)	10	0%	0%	0%
	40	0%	68%	100%
	70	22%	100%	100%
	100	93%	100%	100%
	130	99%	100%	100%

Figure 20: Pathbreaking probability

The new path direction probability increases rapidly from an intensity of 5.5 to 6 with a continuity of 100 from 6% to 98%, shown in figure 21. The highly sensitive area can be bounded between the intensities from 5.5 to 6.

		intensity (int)		
		5,5	6	6,5
continuity (ticks)	10	0%	0%	0%
	40	0%	0%	0%
	70	0%	12%	18%
	100	6%	98%	100%
	130	81%	100%	100%

Figure 21**:** new path direction probability

Also the average spread in figure 22 has a very sensitive reaction in this parameter area. The combination intensity of 5.5 and continuity of 10 has no valuable effect on the spread, but the spread changes with an increasing continuity to the direction of the forced norm.

		intensity (int)		
		5,5	6	6,5
continuity (ticks)	10	1,00	0,91	0,85
	40	0,92	0,48	0,42
	70	0,64	0,11	0,07
	100	0,25	-0,18	-0,21
	130	-0,07	-0,39	-0,41

Figure 22: Average spread, calculated at the last external impact tick

Conclusion

The aim of this research was to examine the behavior of external influences of a path dependent hierarchical organization with the method of computer simulation. The basis of the simulation was the M1 model from Petermann (2012) that simulates a path dependent hierarchical organization. The model was enhanced to simulate an external impact in form of continuity and intensity which were combined and incorporated into the M1 model. For the first simulation a parameter setup that seemed to be valid during the implementation of the external impact was used. With the first results multiple questions arose and two more simulations with adjusted parameter setups were executed. To get an overview of the three simulations figure 23 shows an interesting chart spread versus intensity.

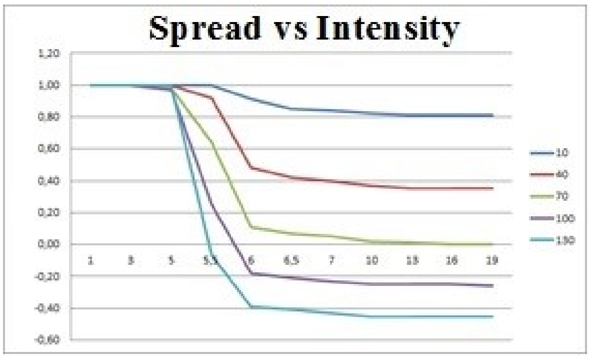


Figure 23: Spread vs intensity. X-axis: intensity. Y-axis: spread. Legend: Continuities from 10-130

To see a reaction on the system a critical intensity is needed. An intensity of 3 and less has no effect on the spread. The system first starts to react at the combination of intensity 3 and continuity of 100. As described in the third simulation, with an intensity of 5 the spread changes dramatically, but the intensive change stops immediately at the intensity of 6 and over. In this intensity field the external impact must last for a defined continuity to adopt a new norm in the whole company. The defined leadership impact of 1 concludes that with an intensity of 5, which is the minimum value to change the spread, the external impact needs to be five times stronger than the leadership impact. To clarify this, further research might show results.

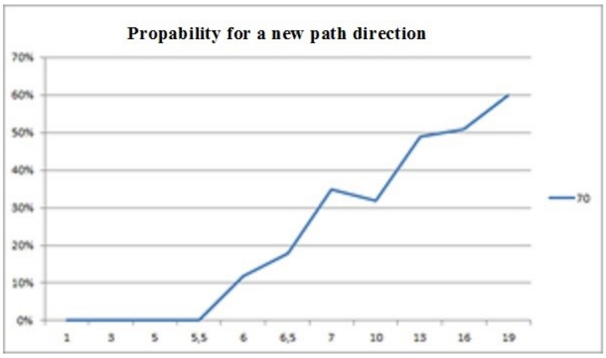


Figure 24: Probability for a new path direction with a continuity of 70. X-axis: intensity, y-axis: new path direction probability. Legend: continuity of 70

Another interesting result of this research is the new path direction probability. It was not in scope at the beginning of this research, but we figured out that we discovered an interesting system behavior at the continuity of 70 that leads the spread to 0 with intensities of 13 and more. This probability increases more and more, the higher the intensity becomes. This unexpected system behavior should be investigated further in the future.

The next interesting point is the fact that path breaking does not necessarily lead to a new path direction. With a continuity of 40 and an intensity of 6.5 the path breaking probability is 100%, but the new path direction probability is 0%. The question that comes up here is: does it make sense to speak about breaking the path without actually changing the path? This might indicate the necessity to adapt the definition of path breaking in this context.

REFERENCES

Arthur, B. 1989. "Competing technologies, increasing returns and lock-in by historical events." The Economic Journal, 99 (March 1989), 116-131.

David, P. 1985. "Clio and the Economics of QWERTY." Economic History, Vol. 75, No. 2, 332-337

Davis, P, Eisenhardt, K. and Bingham, C. 2007. "Developing Theory through Simulation Methods." Academy of Management Review,Vol. 32, No 4, 480-499.

Gilbert, N. and Troitzsch, K 2005. "Developing Theory through Simulation Methods." 2. ed, Berkshire: Open University Press

Harrison, J, Lin, Z. and Carroll, G. 2007. "Simulation Modeling In Organizational And Management Research." Academy of Management Review, Vol. 32, No. 4, S. 1229-1245.

Koch, J 2007: Strategie und Handlungsspielraum: Das Konzept der strategischen Pfade. Zeitschrift Führung + Organisation, 76(5): 283-291

Sydow, J, Schreyögg, G. and Koch, J. 2009. Organizational path dependence: Opening the black box. Adademy of Management Review, Vol. 34, No. 4, 689-709

Petermann, A., Klaußner, S., Senf, N.: Organizational Path Dependence: The Prevalence of Positive Feedback Economics in Hierarchical Organizations, in: Troitzsch, K. G., Möhring, M., Lotzmann, U. (Hrsg.): Proceedings 26th European Conference on Modeling and Simulation, Koblenz 2012, 721-730.

Vroom, V.H. 1964. Work and motivation, New York

Prof. Dr. Arne Petermann is Professor of Management at the Berufsakademie für Gesundheits- und Sozialwesen Saarland (BAGSS). He is also Director of the Institute for Management and Quality at BAGSS. As a visiting scholar, he was teaching organization science and scientific simulation methods in the PhD-program at the School for Business and Economics at Freie Universität Berlin from 2007 to 2014. He is founder and CEO of Linara GmbH, an international HR agency specialized in the transnational European healthcare sector. He is also founder and CEO of 3P Projects GmbH, a consulting and executive education company based in Berlin, Germany. 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.

Alexander Simon, MBA was born in Rheinfelden, Germany and studied electrical engineering at the University of Applied Sciences in St. Augustin, Germany and Business Administration Berlin University of Professional Studies. After first professional experience in the area of software development with focus on the .NET framework in telecommunication and biotech industry, he works in the tax advisory division of Ernst & Young since 2014. During his MBA program at the Berlin University for Professional Studies he became acquainted with path-dependence theory.