

The Influence of Management for breaking organizational paths - A Simulation Study

Felix Obschonka
Department of Management
Free University of Berlin
Garystrasse 21, 14195 Berlin, Germany
E-Mail: felix.obschonka@fu-berlin.de

Arne Petermann
Department of Management
Berlin University for Professional Studies
Katharinenstraße 17-18, 10711 Berlin, Germany
E-Mail: arne.petermann@duw-berlin.de

KEYWORDS

social simulation, agent based modelling, path dependence, path breaking, organization studies

ABSTRACT

We examine how means of management affect the breaking of organizational paths. Prior studies on the interplay between management and organizational path dependence explored the self-assertion of increasing returns in hierarchies, path dependence in management teams, influence of rigid cognitive maps on organizational change or the short-term thinking in strategic planning (Petermann, 2010; Beckman & Burton, 2008; Tripsas & Gavetti, 2000; Holtmann, 2008). But up to now there is only little known about how management affects breaking of organizational paths. As the strategic inflexibility of path dependence may result in inefficiencies for an organization, means for breaking paths are of interest not only for the theoretical concept of path dependence but also for practitioners. We contribute to close this research gap by developing an intraorganizational learning model of path constitution in a narrow sense and then examine the influence of integration, restructuring and turnover on their ability to break paths. In doing so we focus on an information and balance rule on micro level and observe emerging properties on system level.

Our findings indicate that the proposed means could potentially break paths with the probability of path break depending on the micro behaviour of actors. We further found that turnover on management level is the most effective approach and hint to difficulties in breaking paths.

INTRODUCTION

The notion of path dependence recently gained momentum in the field of management studies and especially in organization science (Sydow, 2009). Defined as a process where an initial contingent decision leads to a potentially inefficient lock-in

situation due to increasing returns, path dependence emerges in organizations from interactions between actors.

Prior literature highlights the influence of management on organizational path dependencies. Recently by taking an institutional view on organizations it was shown that self-reinforcing complementary effects could prevail against hierarchies (Petermann et al., 2012). In a similar direction the case on the Bertelsmann Book Club underlined that short-term profit targets set by the top management undermined the search for new opportunities (Holtmann, 2008: 211). Lock-in because of cognitive rigidity on the top management team impeded Polaroid to adapt, although knowledge for coping with environmental change locally existed in the organization (Tripsas & Gavetti, 2000).

While we already have knowledge about the constitution of path dependence in organizations and the influence of management on organizational paths, the literature is inconclusive regarding the process of breaking paths. As most organizations ground on the principle of command and control it could be argued that escaping a lock-in is possible simply by the top management team setting a new strategy and aligning subunits or individuals in the organization through incentive systems. But as control over processes in an organization is limited by ambiguities, uncertainties or cognitive capabilities of actors, an effective alignment might prove difficult (Simon & March, 1954, Sydow et al., 2009). This ambiguity is reflected in empirical research: Whereas some studies suggest that the top level of an organization may restore the external fit of an organization (Siggelkow, 2001) others emphasize the difficulties inherent in breaking path dependencies through interventions from the management (Holtmann, 2008; Tripsas & Gavetti, 2000). Although the concept of path dependence includes the notion of deliberately breaking paths or unintentionally dissolving paths, studies of breaking path dependencies are still scarce (Sydow et al., 2009; Castaldi & Dosi, 2006; Tolbert, 1988; Siggelkow, 2001). Because of severe consequences stemming from path dependence it is a

worthwhile endeavor to take a closer look at the interplay between path dependence and approaches the management could pursue to break organizational paths.

LITERATURE REVIEW AND RESEARCH QUESTION

Originally the concept of path dependence stems from a market perspective. Brian Arthur (1989) proved with a poly-urn model that if increasing return technologies compete for adoption in a market, chance may lead to a situation where a technology corners this same market and locks-out other alternatives. Thus, even under rational choice, sub-optimal technologies could dominate the market when there are increasing returns at play, due for example to external economies of scale or learning effects. This however is in sharp contrast to the view of neoclassical theory of markets stating that market forces will under certain conditions select the most efficient solution. David's (1990) historical analysis of the typewriter market is a vivid empirical example of such path dependence. A small event was responsible for the QWERTY keyboard design prevailing against other designs, although with the DVORAK keyboard a more efficient alternative was known. Other examples include the market penetration of the video home system, modern gasoline engines or light-weight nuclear reactors (Cusumano, Mylonadis, & Rosenbloom, 1992; Cowan, 1990). Despite its critics, path dependence is nowadays a widely acknowledged phenomenon in the market penetration of technologies and the evolution of technologies (Liebowitz & Margolis, 1995; Dosi, 2006; Kauffmann, 1993; Arthur et al., 1987; Arthur, 2009; Rosenberg, 1994).

Apart from path dependencies in technologies Nelson & Winter (1982), March (1991), Levinthal (1997), Carrol & Harrison (1994), Cohen & Levinthal (1990) and Kogut & Zander (1992) highlight the occurrence of path dependence in organizations. But deviating from the original definition the notion of path dependence in current organization research is mostly a broad label that merely emphasizes that "*history matters*". Defining mechanisms proposed by Arthur (1989) for a process to be called path dependent like contingency, increasing returns or lock-in are mostly not reflected in current research on path dependence in organizations (Mahoney, 2000; Sydow et al., 2009). But as using the term path dependence to state that history matters will bring us close to a truism, a more narrow definition is appropriate when we want path dependence to be more than an ubiquitous history matters argument (Sydow et al., 2005; Teece et al. 1997; Antonelli, 1999). Sydow et al. (2009) therefore suggested a more distinct framework for organizational path dependence left ajar on Arthur's definition of technological path dependence.

A framework for organizational path dependence

To account for the peculiarities of social systems, the market model has to be adjusted towards an

organizational context. One implication is that history always matters in organizations and social systems don't exhibit the same characteristics as a lock-in on markets because of the ongoing variation in behaviours. Development phases are hence deviating from path dependence of technology adoption and are less strict. Sydow et al. (2009) developed a model of organizational paths describing organizational path dependence as a process consisting of three development phases. The *first phase* is characterized by a relative open situation where a range of choices are possible. Nevertheless because of imprinting effects, history matters from the beginning on and therefore is already limiting the scope of action. Instead of looking for new distant solutions, search is carried out locally in the proximity of the organizations domain. This is also in line with the notion of bounded rationality, which states that cognitive limitations of actors impede rational choice decisions and may therefore lead to suboptimal outcomes (Simon & March, 1963). Transition to the next phase is caused by an initially contingent choice serving as a triggering event or bifurcation (Kauffmann, 1993). One can refer to this bifurcation as a critical juncture because from there on it becomes more difficult to go back to prior alternatives. In *phase two* self-reinforcing effects lead to the emergence of a dominant solution in the organization. Repetition of choices with increasing returns crowd out other choices hence progressively restricting the capacity to act. Still, different choices are possible. Eventually in the *third phase* the self-reinforcing dynamics further reduce the scope of choice and lock the organization into a single potentially inefficient state. Even when the external environment changes, the pattern is reproduced and the organization is unable to adapt. One can think of this lock-in as an "underlying core pattern with some variation of practicing it" (Sydow et al., 2009: 695). Figure 1 aggregates the remarks on path constitution in a narrow sense:

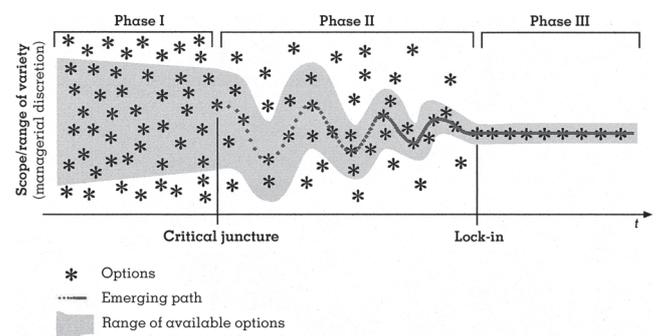


FIGURE 1: Constitution process of an organizational path in the Berlin Model (Sydow et al., 2009)

Breaking organizational paths

In contrast to physical or biological systems, in social systems individuals may recognise and act strategically to counter emergent processes (Gilbert, 1995). If path

dependence results in an inefficient system state an organization needs to recognize this and change in order to survive. This is easier said than done since self-reinforcing patterns on the micro level are still at work and make adaptation difficult.

In general one can think of two possibilities to overcome path dependence: unintentional dissolution of a path or intentional breaking a path. A well-known example for path dissolution is Intels switch from the memory business towards microprocessors (Burgelman, 1991). Although the top management team of Intel favored the memory business, consisting routines allowed the middle management to redirect resources towards microprocessor manufacturing. While the dissolution of a path happens accidentally path breaking requires awareness and purpose. As a path can be fatal waiting for path dissolution may not be appropriate.

Specific means to break paths are conceivable. For example, Sydow et al. (2005) propose discursive, behavioral and systemic approaches to break organizational paths but also highlight, *"that none of these approaches deals explicitly with issues of path dependencies, not to mention provides a theory of unlocking paths that builds upon a theory of path constitution and specifies the conditions under which a once chosen path may be unlocked"* (Sydow et al., 2005: 22). While they explicitly name approaches to break paths, they also admit that these approaches, although carefully derived from the literature, can only serve as a suggestion and need further research. Adopting an evolutionary economics point of view, Castaldi & Dosi (2006) propose the (purposeful) loss of organizational memory, restructuring of the organization, increasing cognitive dissonance between beliefs held in the organization and labour respectively management turnover as means to overcome the lock-in. But evidence on the effectiveness of these approaches is missing. To close this gap, we here pick means derived from literature of organizational change namely integration, restructuring and turnover. To give evidence of the effectiveness we later test these approaches with a computer simulation.

Integration

Partitioning of organizations in different subunits according to different tasks can locally maintain diversity and may break organizational paths through the integration of beliefs from formerly isolated subunits (March, 2004). For example, Fang et al. (2010) argue that semi-isolation of subunits enables an organization to achieve ambidexterity and examine the optimal degree to which the subunits need to be interconnected. In their model selected actors serve as boundary spanners searching for new ideas in other subunits, when no satisfying solution can be found in the local neighborhood. Through this process new ideas spread through the organization, questioning the status-quo in the organization. This diffusion of beliefs among

subunits could also break path dependencies. In practice, managers of organizations achieve semi-isolation of a subunits by setting up a skunkwork group, corporate venturing programs or working in a network organization (Fosfuri & Ronde, 2009; Block & MacMillan, 1995; Phelps, 2010). One empirical example of successfully breaking an organizational path in a broader sense through integration of ideas from a corporate venturing subgroup is the development of bioterials at DSM (Vanhaverbeke & Peeters, 2005). To what extent integration can be used to escape lock-ins arising from path dependence in a narrow sense still has to be answered.

Restructuring

In literature on organizational renewal restructuring is seen as a mean to overcome inertia, which is related to the concept of path dependence (Zajac & Kraatz, 2007; Carley & Svoboda, 1996; Burgelman, 1991; Bowman & Singh, 2007). For example, research on moving organizational members across subunits suggests that member rotation can be an instrument for stimulating the formation of new beliefs in groups if they share some common practices (Kane et al., 2005). While this may hint to a potential candidate for breaking a path, one has to bear in mind the differences between the formal and informal structure of an organization. Managers have the ability to set a formal structure in organizations by assigning actors to certain tasks. More precise, the formal structure is defined through job roles, responsibilities and communication structures between actors in an organization. Managers may change this composition in their role as organizational architects (Jacobides, 2006). Resulting recombinations facilitate flow of information and may stop disfunctional routines hence allowing the formation of new beliefs (Simon, 1962; Jacobides, 2006). But affected by the formal structure an informal structure is emerging through unintended patterns of interactions between actors. While managers could rapidly alter the formal organization, the informal organization may not be affected by the same extent (Miller and Friesen 1984, Nickerson and Zenger 2002). Interactions within an organization may perpetuate informally although the formal structure has been changed. This is in line with the argument brought forward by Sydow et al. (2009) that a path is developing behind the backs of actors and is governed by hidden rules. To examine the possibility to break path dependence by restructuring through the moving of members we focus on informal interaction processes in the organization.

Turnover

A considerable amount of organizational knowledge exists in the beliefs of individual members. Labour turnover can therefore hamper the retention of knowledge in an organization (Hollenbeck, Ilgen, Sego, Hedlund, Major & Philips, 1995). If knowledge rests solely in individuals, organizational lock-in could be

overcome by selecting individuals with obsolete knowledge and replace them with individuals bringing in new beliefs. However knowledge is not only embedded in individuals but also in the interactions between them. Knowledge embedded in interactions is less likely to depreciate as knowledge embedded in individuals (Cohen & Bacdayan, 1994; Argote, Beckman & Epple, 1990; Argote, 1999). Retention of knowledge embedded in interactions is hence more likely to survive turnover. Nevertheless labour turnover may provide a reframing of current views in the organization eventually leading to change.

Besides initiating labour turnover changes of the composition in the management team are likely to result in modifications of the cognitive structure. As in a hierarchy the interpretation of the environment is influenced by management, bringing in new members could break paths. An empirical study on Liz Claiborne, a retailer and manufacturer of apparel, revealed that changes in the composition of the management team lead to the breaking of an organizational path in a broader sense (Siggelkow, 2001).

Research questions

Derived from the three approaches described above we want to contribute to the literature on organizational path dependence by answering the following research questions:

RQ1: Does the integration of isolated subunits affect an organizational path?

RQ2: Does restructuring of the organization affect an organizational path?

RQ3: Does (1) labour turnover or (2) turnover of management affect an organizational path?

In the subsequent section we present a model to answer the research questions at hand.

METHOD

Empirically examining path dependent processes is afflicted with methodological difficulties (Dobusch, 2012; Dosi & Castaldi, 2006). Vergne and Durand (2010) stress that evidence on the contingency condition inherent in the concept of path dependence is impossible to produce using field studies and that long run suboptimality is hard to show because outcomes are sensitive to the choice of time frames. Along the same line Pentland et al. (2012) argue that it is not possible to reconstruct the development of a path if not being involved as an insider to the group and even then the memory of participants could be faulty and conclusions drawn may be wrong. To overcome these methodological problems, Vergne and Durand (2010) recommend the application of controlled laboratory experiments or computer simulations. We follow this

argument by conducting computer simulation experiments to answer the research questions at hand. First we create a formal intraorganizational learning model of path dependence, second the model is extended by the three approaches mentioned above and third experiments are conducted by transferring the model into a numeric computer simulation.

An intra-organizational learning model

In general we regard organizations as complex adaptive systems where local interactions between individuals take place in order to achieve individual or organizational goals. In particular, individuals possess beliefs about an exogenous environment and may adopt beliefs of other individuals through interacting with them. Such change of beliefs presupposes besides the existence of multiple individuals the presence of different beliefs. Referring to this representation of an organization, the question arises *how* an individual selects another individual to interact with and *how* the updating of beliefs takes place.

Selection

Economic and behavioural models highlight the utility maximizing behaviour of individuals, where selection of information sources takes place according to an expected benefit. Organizational learning models take for example the performance, defined as the match between the environment and the individual set of beliefs, as the decision criteria for whom to learn from and update their beliefs according to the beliefs of superior organizational actors (Siggelkow, 2002; Levinthal, 1998; Lazer & Friedman, 2007; Miller, 2006; March, 1991). Reasons for individuals to update their beliefs according to a performance measure are that actors want to achieve their ends through superior beliefs (Katz and Kahn, 1978), reduce uncertainty (Radner, 1986), conserve or attain power (Pfeffer & Salancik, 1978; Burns and Stalker, 1961) or just out of pure curiosity (Freedman, 1965).

Differently to a performance maximizing view a stream of literature in social psychology argues that individuals are maximizing their utility by learning from individuals similar to them (Byrne, 1971; Friedkin, 1994; McPherson, Smith-Lovin and Cook, 2002). Actors actively seek for information endorsing their decisions and avoid contradicting information sources. Choosing individuals who are similar is preferred as it is reducing cognitive dissonance (Festinger, 1950, 1957, 1967). Literature on absorptive capacity gives as further explanation that learning is facilitated if individuals possess similar knowledge bases (Cohen & Levinthal, 1990). Another emphasize that growing cognitive distance between individuals impedes learning hence individuals prefer to update their beliefs from individuals with a small cognitive distance (Nooteboom et al., 2007).

In our intra-organizational model we integrate both views in one selection rule. Systems where actors update their beliefs in accordance with these competing processes are defined as balance and information systems (Frank & Fahrbach, 1999). Equation 1 describes such a simple selection rule:

$$selection = inf \left\{ \begin{pmatrix} m_{1,I_N} \\ \vdots \\ m_{m,I_N} \end{pmatrix} \times \begin{pmatrix} m_{1,E} \\ \vdots \\ m_{m,E} \end{pmatrix} \right\} + sim \left\{ \begin{pmatrix} m_{1,I_0} \\ \vdots \\ m_{m,I_0} \end{pmatrix} \times \begin{pmatrix} m_{1,I_N} \\ \vdots \\ m_{m,I_N} \end{pmatrix} \right\} \quad (1)$$

The parameter *inf* describes the weight actors put on gathering new *information* and the parameter *sim* describes the weight actors put on updating beliefs from *similar* individuals. To account for organizational distance and local search processes individuals can only select direct neighbours to update their beliefs (Nooteboom, 2007; Lazer & Friedman, 2007).

Updating

After selection the updating of beliefs takes place. Updating describes the process of adopting beliefs of other actors. Commonly behavioural learning models set learning rates to characterize the speed with which beliefs are updated (March, 1991; Miller, 2006). We follow this notion, but instead of setting the rate as exogenous parameter we adjust the learning rate with regard to the similarity of actors. The more beliefs are shared among actors the easier learning takes place, emphasizing the importance of similarity for the acquaintance of beliefs (Cohen & Levinthal, 1990). Equation 2 delinates the updating rule:

$$updating = \left\{ \begin{pmatrix} m_{1,I_0} \\ \vdots \\ m_{m,I_0} \end{pmatrix} \times \begin{pmatrix} m_{1,I_N} \\ \vdots \\ m_{m,I_N} \end{pmatrix} \right\} \quad (2)$$

Basic simulation model of path constitution

Following a building-block approach we base our model on an intra-organizational learning model of Miller et al. (2006). Basicall the model of Miller is extending March's (1991) organizational learning model by allowing for direct interactions instead of exchanging beliefs through an organizational code. As in the original model our basic model consists of an *environment* and *individuals* interacting within an *organization*.

Environment: Organizations operate in a broader environment and need to adapt to changes in order to survive in the long term. It is assumed, that the environment is external and is not influenced through actions of the organization. In particular, actors are not enacting their beliefs on the environment (Weick, 1979). Similar to March (1991) the environment consists of *m* independent dimensions where a random value of 1 or -1 is assigned to each dimension with equal probability. We fix the number of dimensions to $m=75$.

Individuals: Individuals hold beliefs about the environment by assigning a value of -1 or 1 to a particular dimension. If an individual is not sure or does not know about a specific attribute of the environment a value of 0 is assigned.

Organization: An organization consists of *n* individuals with initially random beliefs of the environment. Individuals are positioned on a square grid and are locally interconnected giving them the possibility to directly interact with each other. Interaction happens according to the selection and updating mechanisms described above. Through interaction actors might develop new sets of beliefs that no actor possessed before (Argote, Gruenfeld & Naquin, 2001). We set the length and height of the grid to ten, hence $n=100$ individuals in an organization.

With this model at hand all three phases of a path dependent process are reproduced. *Phase 1* delinates a relatively open situation for an organization. Although each actor is carrier of its own history acquired through prior experiences when entering the organization on an organizational level the scope of choice is fairly open. The model captures this condition by assigning random actors to the organization, each with its own history, but without a socially shared history among the actors in the organization. Beliefs held by the actors in the beginning are conceived as prior experiences of the actors, as for example education or previous working experiences. During the course of time interactions between actors shape individual beliefs and contribute to the emergence of repetitive patterns. Based on the selection criteria actors in the model choose who to update from. When positive feedback effects through the updating of beliefs are occurring, the system will switch to a regime goverend by increasing returns. This commences in *phase 2* where self-reinforcing effects narrow the scope of action through a crowding out of possible choices in the system. Favorable interactions between actors are repeated more often and performed with higher reliability. The model takes this into account by an endogenous learning rate which is increasing according to the updating mechanism. In *phase 3* the self-reinforcing effects narrow the scope of choice to a small corridor, the lock-in. In the model interactions between actors can become locked-in when the updating of beliefs is fixed because self-reinforcing learning effects crowd out alternatives. These stable interaction patterns result in an equilibrium maintained indefinitely if no interventions are conducted.

The computer simulation is building on the JAVA programming language and uses the Eclipse IDE. If not stated differently, we pursue the Monte Carlo Method and iterate 150 simulation runs over a time frame of 300 steps.

Basic Model

As a basic model we take the intra-organizational learning model derived above as a starting point and keep the selection mechanism fixed with $inf=0.9$ and $sim=0.1$. We then subsequently add environmental change, employee rotation as a representation of restructuring, a hierarchy directing orders on individuals and turnover of individuals on two different hierarchical levels.

Basic model with environmental change

Figure 2 reflects the results of the basic model and the model extended with environmental change. In the basic model an equilibrium is achieved in step $t=75$ with a performance¹ of 85 percent. We include in our model a shock in the environment, where the environment vector is randomly renewed. We expect a serious drop in performance for a path dependent organization. Figure 2 confirms this statement: Performance drops to 1% and remains at this level until the run ends.

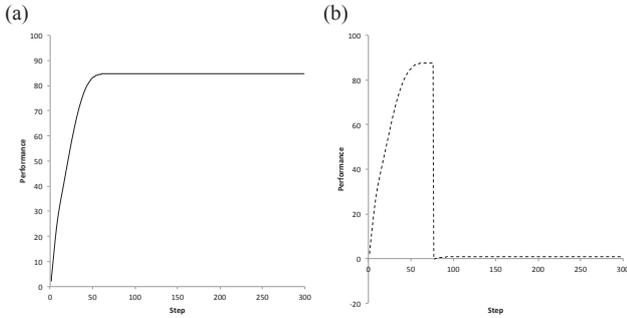


FIGURE 2: (a) Basic Model with $inf=0.9$ & $sim=0.1$ and (b) Model with environmental shock at $t=75$ for $inf=0.9$ & $sim=0.1$

Referring to the concept of aspiration levels, the management initiates interventions when performance falls below a historic aspiration level (Greve, 2003). Approaches to break an organizational path therefore will be conducted after the environmental shock takes place. We now compare the three different approaches with our basic model to draw conclusions about the ability to break organizational paths.

RQ1: Integration

By tuning the weights of the selection rule we can simulate the emergence of different organizational subunit structures. In our model, we define a subunit as an organizational entity where individuals share the same beliefs about the environment. Figure 3 shows the outcome for different values of inf on performance and on the emergence of subunits. The higher an individual puts the weight on *similarity* (sim), the more groups emerge. Similarity hence causes a segregation effect in the organization, leading to homogenous beliefs within a subunit and heterogenous beliefs across subunits.

¹ Performance is here defined as the mean sum of the product of individual beliefs and the according environmental dimension.

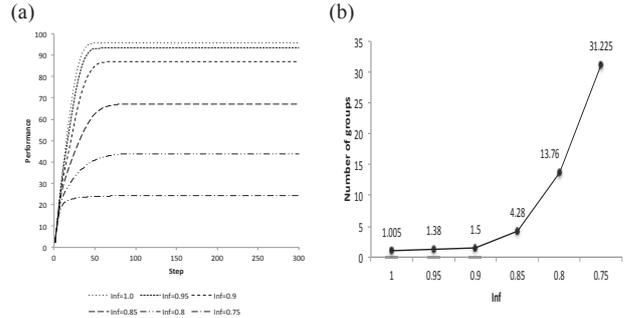


FIGURE 3: (a) Performance and (b) number of subunits for different values of inf

When performance suffers because of an environmental shock, the management may decide to formally integrate subunits. For example, it could integrate a business development or R&D subunit to promote the diffusion of beliefs in the organization (Fang, 2010; Tripsas & Gavetti, 2000). The informal structure of the organization, in our model represented as interactions between the actors, may impede integration because beliefs of other subunits are too dissimilar. Figure 4 shows the results of integration for performance and number of units in the organization.

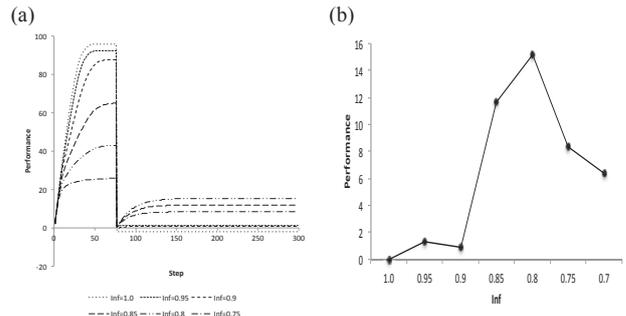


FIGURE 4: (a) Performance before & after environmental shock (b) optimal value of inf for integration

For $inf=0.2$ we found a maximum in performance and for $inf=0$ a minimum. At the maximum the number of groups decreased from 4.28 to 1.98 exhibiting an integration rate of 216%. We consider a path to be broken when the performance after the intervention exceeds a designated threshold value. We then calculate the probability of breaking a path by counting the number of runs exceeding the threshold and divide it by the number of runs. Figure 5 provides an overview of the probability with regard to different threshold levels.

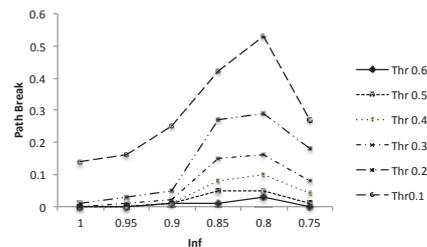


FIGURE 5: Comparison of different performance thresholds for considering an organizational path break

While the trajectories are similar from a qualitative perspective, the probability of breaking a path is decreasing significantly with an increase in threshold. As the concept of path dependence states that at least one superior alternative has to be found in order to consider a path to be broken we here assume that this is the case when the performance value exceeds 10%. In case of integration, we conclude that integration of subunits can break in 5% of the simulation runs an organizational path for $inf=0.1$ confirming RQ1. As management can suppress variety and prevent integration these results may only hold if integration of subunits is supported (Rivkin & Siggelkow, 2006; Greve, 2006).

RQ2: Restructuring

We model restructuring by randomly rotating an actor with another actor of the organization and define a rotation probability of 0.1 as low and a value of 0.9 as high. Figure 7 exhibit the results for different values of inf .

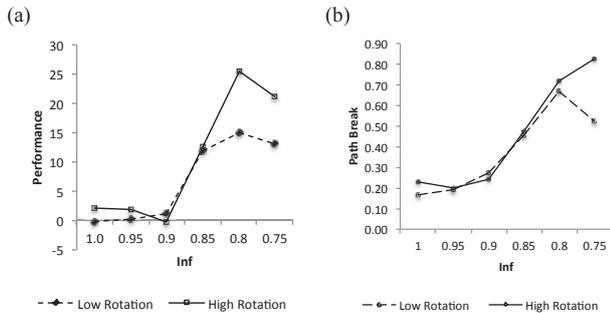


FIGURE 6: (a) Performance of the organization after restructuring and (b) probability of breaking paths for low and high rotation rates.

In general high rotation leads to higher performance values than low rotation. Particularly for $inf < 0.85$ the difference in performance becomes apparent. While the average performance is higher for a rotation rate of 0.9 the result for $inf=0.8$ mirrors that it is not necessarily more appropriate to break paths. Performance values are more dispersed implying riskiness for high rotation rates. This may suggest that high efforts made in restructuring do not pay out. Nevertheless it does affect the probability of un-locking paths positively therefore confirming RQ2.

RQ3: Turnover

Turnover describes the process of replacing individuals in the organization with individuals from outside of the organization. We distinguish between labour turnover and turnover on the management level. In the case of labour turnover we randomly replace individuals with a probability of 0.01 (low) or 0.1 (high). For management turnover we choose 0.2 (low) and 1 (high) reflecting partial turnover and full turnover of management.

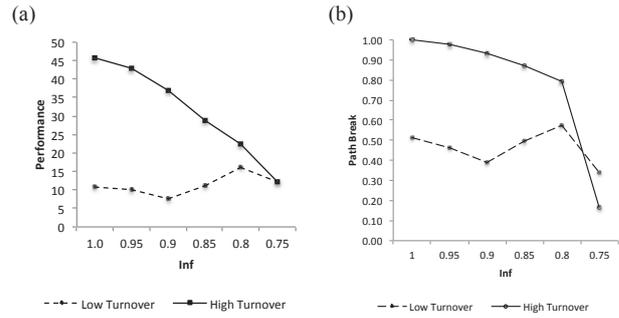


FIGURE 7: (a) Performance for high & low turnover values (b) Probability of breaking a path

High turnover of labour increases performance and the probability of path break for all $inf > 0.75$. Performance is then decreasing with an increase in weight on *similarity*. This was expected as *similarity* ensures heterogeneous beliefs among different groups and impedes proper integration of new beliefs. For low turnover the picture is different. The local maximum for $inf=1$ reflects the positive effects of turnover in an organization due to the possibility that superior beliefs can more easily propagate through the organization. This effect is decreasing until the local minima at $inf=0.9$ as it gets more difficult for beliefs to propagate through the organization. From $0.8 < inf < 0.9$ low turnover supports the integration of subunits while the performance drop for $inf=0.75$ stems from the property that individuals are not able to integrate new beliefs because of high weight on similarity. We therefore confirm RQ3.1.

To test the effects of turnover on management level, we integrate a hierarchical management according to the dominant coalition in Miller's (2006) model by assigning at the beginning the best performing 5% of the organization the status of a management member. The members of the management bargain a strategy according to a simple majority rule. Each individual in the organization updates beliefs on every dimension according to this strategy with a probability of 0.01 for low influence and 0.1 for high influence of the management. Aligning individuals to a strategy coordinates actors in the organization and improves performance as shown in Figure 8. Coming at the cost of lower belief variety in the organization this can hamper the possibility of endogenously breaking paths.

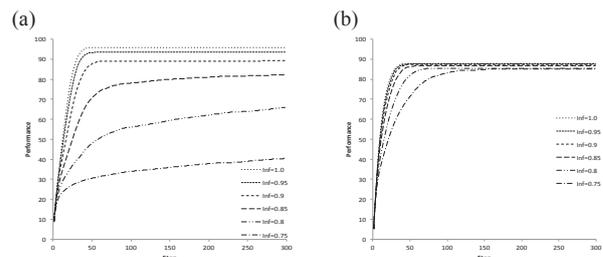


FIGURE 8: (a) Performance for low influence of management and (b) performance for high influence of management

We test if management turnover can break paths by conducting simulation runs for high turnover (all management members are replaced) and low turnover (20% are replaced) for each high and low influence of management. Actors in the organization start learning from the management after the shock occurred. Figure 9 shows that high turnover is beneficial for performance and breaking paths irrespective the degree of influence.

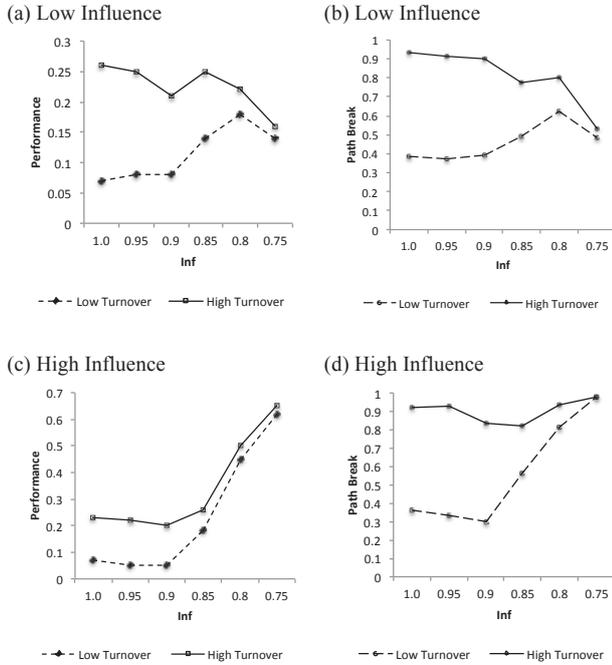


FIGURE 9: (a) performance for different degrees of turnover and low influence of management and (b) probability of a path break (c) performance for different degrees of turnover and high influence of management and (d) probability of a path break

The gap between high and low turnover becomes smaller for decreasing values of *inf*. As beliefs of management captured by the strategy are normative for actors in the organization the likelihood of overlapping beliefs is increasing with the influence of management. Moreover this overlap in beliefs increases the similarity between actors hence making it more likely for actors to learn from each other when the weight on *sim* > 0. This can be comprehended as the coordination effect of strategy because the alignment allows actors to integrate superior beliefs from other subunits. Especially for low values of *inf* coordination is important to obtain high performance. Furthermore, as for high turnover the whole management is replaced with new members holding random beliefs the resulting strategy may not reflect the reality accurately. Hence the mere presence of shared beliefs, even if wrong, may achieve high performance because increasing similarity facilitates learning. High turnover and high influence of management make it more likely to break a path for low *inf* values compared to low turnover and low influence. When there is only little management succession and the influence of the management is low it is more likely that the path will persist. The findings indicate that

turnover on management level affects the probability of breaking a path hence confirming RQ 3.2.

CONCLUSION

On the basis of a simulation model we demonstrated that each of the three approaches could potentially break organizational paths depending on the weights of similarity (*sim*) and information (*inf*). Probability of path breaking for integration and restructuring are on average lower as for turnover. The main reason we discovered is that while turnover induces new beliefs hence increasing the variety in the organization, integration and restructuring draw on existing beliefs. Nevertheless we could show that paths can be broken endogenously through integration and restructuring. This confirms the argument of Pentland et al. (2012) that the same micro rules that caused path dependence may under certain conditions break paths. The results also emphasize the difficulties inherent in breaking paths by exhibiting constellations where the probability of breaking a path approaches zero. Table 1 summarizes the approaches according to their effectiveness of breaking path dependencies.

Approach	Integration	Restructure	Labour Turnover	Management Turnover
Probability	low	moderate	high	very high

TABLE 1: Probability of path break for different approaches

FURTHER RESEARCH

As computer simulations can only contribute but not substitute empirical research we propose to examine our findings empirically to overcome some of the limitations of the method applied. For example, one could explore the approaches in ongoing change processes qualitatively or conduct experiments with managers. Also one can think of more approaches to break path dependence as for example induced errors in communication (Walsh & Unger, 1981; March, 2006). We considered that a path is broken when the performance value exceeds 10%. Altering the level will yield different results about the impact of different interventions. Taking a higher value will decrease the chance of path break. Furthermore we used a very simple selection rule in the model. A complex rule could capture the behaviour of individuals in organizations more accurate. One can also think of different rule guided micro behavior besides the balance-information rule as for example conformity, opportunism or creativity and examine how these rules alter the outcome of the simulation. For the time being we work at further extensions of the simulation to test such approaches.

REFERENCES

- Antonelli, C. (1999): "The economics of path dependence in industrial organization", *International Journal of Industrial Organization*, 15. 643-675.
- Arthur, WB. (1994): "Increasing Returns and Path Dependence in the Economy", Ann Arbor: University of Michigan Press.
- Arthur, WB. (2009): "The Nature of Technology: What it is and how it evolves". The Free Press (Simon & Schuster).
- Augsdorfer, P. (2005): "Bootlegging and path dependency". *Research Policy*, 34(1). 1-11.
- Axelrod, R. (1997): "The Complexity of Cooperation" Princeton University Press, Princeton, NJ.
- Becker, K. (2005): "Individual and organisational unlearning: directions for future research". *International Journal of Organisational Behaviour*, 9 (7). 659-670.
- Beckman, CM; Burton, MD. (2008): "Founding the future: Path dependence in the evolution of top management teams from founding to IPO", *Organization Science*, 19. 3-24.
- Block, Z.; MacMillan, IC. (1995): "Corporate venturing: creating new businesses within the firm". Harvard Business School Press, Cambridge/MA.
- Bowman, EH.; Singh, H. (2007): "Corporate restructuring: Reconfiguring the firm". *Strategic Management Journal*, 14 (1). 5-14.
- Burgelman, RA. (1991): "Intraorganizational ecology of strategy making and organizational adaptation: Theory and field research". *Organization Science*, 2 (3). 239-262.
- Burns, T.; & Stalker, GM. (1961): "The management of innovation". London: Tavistock.
- Byrne, D. (1971): "The Attraction Paradigm". Academic Press, New York.
- Carley, KM.; Svoboda, DM. (1996): "Modelling organizational adaptation as a simulated annealing process". *Sociological Methods & Research*, 25 (1). 138-168.
- Carroll, GR.; Harrison, RJ. (1994): "On the Historical Efficiency of Competition between Organizational Populations." *American Journal of Sociology*, 100: 720-749.
- Castaldi, C., Dosi, G. (2006): "The Grip of History and the Scope for Novelty. Some Results and Open Questions on Path Dependence" in A. Wimmer and R. Koessler, eds., *Understanding Change*, Palgrave.
- Cohen, MD.; Bacdayan, P. (1994): "Organizational routines are stored as procedural memory: Evidence from a laboratory study" *Organization Science* 5(4). 554-568.
- Cohen, WD.; Levinthal, DA. (1990): "Absorptive capacity: A new perspective on learning and innovation", *Administrative Science Quarterly*, 35 (1). 128-152.
- Coleman, J. (1990): "Foundations of Social Theory". Cambridge, MA, and London: The Belknap Press of Harvard University Press.
- Collins, D. (1998): "Organizational Change: Sociological Perspectives". London, UK: Routledge.
- Cowan, R. (1990): "Nuclear Power Reactors: A Study in Technological Lock-in". *The Journal of Economic History*, 50 (3). 541-567.
- Cusumano, MA; Mylonadis, Y.; Rosenbloom, RS. (1992): "Strategic Maneuvering and Mass Market Dynamics The Triumph of VHS over Beta". *Business History Review*, 66. 51-94.
- Cyert, RM., March, JG. (1963): "A Behavioral Theory of the Firm". Prentice Hall, Englewood Cliffs, NJ.
- David, PA. (1985): "Clio and the Economics of QWERTY". *American Economic Review*, 75. 332-337.
- Dosi, G.; Marengo, L.; Fagiolo, G. (2003): "Learning in Evolutionary Environments," LEM Papers Series2003/20, Laboratory of Economics and Management (LEM), Sant'Anna School of Advanced Studies, Pisa, Italy.
- Dosi, G.; Marengo, L.; Paraskevopoulou, E.; Valente, M. (2011): "The value and dangers of remembrance in changing worlds: a model of cognitive and operational memory of organizations". LEM Working Paper, in progress.
- Egidi, M.; Narduzzi, A. (1997): "The emergence of path dependent behaviors in cooperative contexts". *International Journal of Industrial Organization*, 15. 677-709.
- Fang, C.; Lee, J.; Schilling, MA. (2010): "Balancing exploration and exploitation through structural design: The isolation of subgroups and organizational learning. *Organization Science*, 21 (3). 625-642.
- Festinger, L. (1950): "Informal social communication". *Psych. Rev.* 57, 271-282.
- Festinger, L. (1957): "A Theory of Cognitive Dissonance". Stanford, CA: Stanford University Press.

- Festinger, L. (1964). "Conflict, Decision, and Dissonance". Stanford, CA: Stanford University Press.
- Freedman, J. (1965): "Preference for dissonant information" *J. Personality and Soc. Psych.*, 2. 195–202.
- Friedkin, NE.; Marsden, P. (1994): "Network studies of social influence". S. Wasserman, J. Galaskiewicz, eds. *Advances in Social Network Analysis* Thousand Oaks, CA. Sage, 1–25.
- Fosfuri, A.; Ronde, T. (2009): "Leveraging resistance to change and the skunk works innovation". *Jornal of economic behavior & organization*, 72(1). 274-289.
- Giddens, A. (1984): "The constitution of society: Outline of the theory of structuration". Cambridge: Polity Press.
- Gilbert, N. (1995): "Emergence in social simulation" in *Artificial Societies: the computer simulation of social life*, edited by N. Gilbert and R. Conte. London: UCL Press. 144-156.
- Greve, HR. (2003): "Organizational learning from performance feedback: A behavioral perspective on innovation and change". Cambridge University Press.
- Harrison, GA. (1988): "Human Biology: An Introduction to Human Evolution, Variation, Growth, and Adaptability". Oxford University Press: Oxford, U.K
- Holtmann, JP. (2008): "Pfadabhängigkeit strategischer Entscheidungen. Eine Fallstudie am Beispiel des Bertelsmann Buchclubs Deutschland.". Gabler Verlag, Wiesbaden.
- Kane, AA; Argote, L; Levine, LM (2005): "Knowledge transfer between groups via personnel rotation: Effects of social identity and knowledge quality". *Organizational Behavior and Human Decision Processes*, 96. 56–71.
- Kauffman, SA. (1993): "Origins of order: Self-organization and selection in evolution". Oxford: Oxford University Press.
- Katz, D.; Kahn, R. (1978): "The Social Psychology of Organizations". Wiley, New York.
- Kenneth, KF.; Fahrbach, K. (1999): "Organization culture as a complex system: Balance and information in models of influence and selection". *Organization Science*, 10(3). 253-277.
- Kogut, B.; Zander, U. (1992): "Knowledge of the Firm, Combinative Capabilities, and the Replication of Technology," *Organization Science* 3(3): 383-397.
- Lazer, D.; Friedman, A. (2007): "The network structure of exploration and exploitation". *Administrative Science Quarterly*, 52 (4): 667-694.
- Levinthal, DA. (1997): "Adaptation on rugged landscapes". *Management Science*, 43 (7). 934-950.
- Liebowitz, SJ.; Margolis, SE. (1995): "Path Dependence, Lock-in, and History". *Journal of Law, Economics and Organization*, Oxford University Press, 11(1). 205-226.
- Mahoney, J. (2000): "Path dependence in historical sociology". *Theory and Society*, 29 (4). 507-548.
- March, J.; Simon, HA. (1958): "Organizations". Wiley, New York.
- March, JG. (1991): "Exploration and exploitation in organizational learning" *Organization Science*, 2 (1). 71-87.
- March, JG. (2006): "Rationality, foolishness, and adaptive intelligence". *Strategic Management Journal*, 27: 201-214.
- Miller, KD.; Zhao, M.; Calantone, RJ. (2006): "Adding interpersonal learning and tacit knowledge to March's exploration-exploitation model". *The Academy of Management Journal*, 49(4). 709-722.
- Miller, KD.; Lin, S. (2010): "Different truths in different worlds". *Organization Science*, 21(1). 97-114.
- Monteiro, FL.; Arvidsson, L.; Birkinshwa, J. (2007): "Knowledge Flows Within Multinational Corporations: Explaining Subsidiary Isolation and Its Performance Implications". *Organization Science*, 19 (1). 90-107.
- Nelson, RR.; Winter, SG. (1982): "An Evolutionary Theory of Economic Change". Belknap Press/Harvard University Press: Cambridge.
- Nooteboom, B. (2007): "Cognitive distance in and between communities and firms: Where do exploitation and exploration take place, and how are they Connected?". Discussion Paper 2007 (4), Tilburg University, Center for Economic Research.
- Ocasio, W. (1997): "Towards an attention-based view of the firm". *Strategic Management Journal*, 18. 187-206.
- Pentland, BT.; Feldman, MS.; Becker, MC.; Liu, P. (2012): "Dynamics of organizational routines: A generative model". *Journal of Management Studies*, 49(8). 1484-1508.
- Petermann, A. (2010): "Pfadabhängigkeit und Hierarchie: Zur Durchsetzungskraft von selbstverstärkenden Effekten in hierarchischen Organisationen". Berlin.
- Petermann, A.; Klaußner, S.; Senf, N. (2012):

Organizational Path Dependence: The Prevalence of Positive Feedback Economics in Hierarchical Organizations. In: Troitzsch KG, Möhring M and Lotzmann U (eds.): In Proceedings 26th European Conference on Modelling and Simulation, Koblenz, p.721-730.

Pfeffer, J.; Salancik, J. (1978): "The external control of organizations" New York: Harper and Row.

Phelps, CC. (2010): "A longitudinal study of the influence of alliance network structure and composition on firm exploratory innovation". *Academy of management journal*, 53 (4). 890-913.

Radner, R. (1986): Preface based on "Radner on Marschak" (1984). C. McGuire, R. Radner, eds. *Decision and Organization; A Volume in Honor of Jacob Marschak* University of Minnesota Press, Minneapolis. xxi.

Rosenberg, N. (1994): "Exploring the Black Box: Technology, Economics and History". Cambridge: Cambridge University Press.

Siggelkow, N. (2001): "Change in the presence of fit: The rise, the fall, and the renaissance of Liz Claiborne". *Acad. Management Journal*, (44). 838–857.

Siggelkow, N. (2002): "Evolution toward fit." *Administrative Science Quarterly*, 47. 125–159.

Siggelkow, N.; Levinthal, D. (2003): "Temporarily divide to conquer: Centralized, decentralized, and reintegrated organizational approaches to exploration and adaptation". *Organization Science*, 14. 650–669.

Suarez, FF.; Oliva, R. (2005): "Environmental change and organizational transformation". *Industrial and Corporate Change*, 14 (6). 1017-1041.

Sydow, J.; Schreyögg, G.; Koch, J. (2009): "Organizational path dependence: Opening the black box". *Academy of Management Review*, 34(4). 689-709.

Sydow, J.; Schreyögg, G.; Koch, J. (2005): "Organizational Paths: Path dependency and beyond". 21st EGOS Colloquium, June 30 – July 2, 2005, Berlin, Germany.

Tolbert, PS. (1988): "Institutional sources of organizational culture in major law firms". In L. G. Zucker (Ed.), *Institutional patterns and organizations*: 101–113. Cambridge, MA: Ballinger.

Tripsas, M.; Gavetti, G. (2000): "Capabilities, cognition, and inertia: evidence from digital imaging". *Strategic Management Journal*, 21 (10). 1147-1161.

Vanhaverbeke, W.; Peeters, N. (2005): "Embracing Innovation as Strategy: Corporate Venturing, Competence Building and Corporate Strategy Making". *Creativity and Innovation Management*, 14 (3).

Vergne, JP.; Durand, R. (2010): "The Missing Link Between the Theory and Empirics of Path Dependence: Conceptual Clarification, Testability Issue, and Methodological Implications". *Journal of Management Studies*, 47(4). 736-759.

Weick, KE. (1979): *The Social Psychology of Organizing*, 2nd ed. Random House, New York.

Zajac, EJ.; Kraatz, MS. (2007): "A diametric forces model of strategic change: Assessing the antecedents and consequences of restructuring in the higher education industry". *Strategic Management Journal*, 14 (1). 83-102.

AUTHOR BIOGRAPHIES



Felix Obschonka was born in Filderstadt, Germany and went to the Technical University of Berlin, where he studied Electrical Engineering & Business. He obtained his Diploma in Engineering in 2010. Before starting his doctoral studies he was working in multi-national companies, as a consultant and founded a leading VoIP-company. His research focuses on path dependencies in organizations and approaches to break or dissolve organizational paths. His e-mail address is felix.obschonka@fu-berlin.de.



Arne Petermann is Professor of Management at the Berlin University for Professional Studies. In his research he focuses on organization, leadership, entrepreneurship and social simulation. His research results have been presented at the leading conferences in his field, have been recognized with a best paper award and are published in peer-reviewed Journals and books. He is also founder and CEO of Linara GmbH, an international HR agency for the European home care sector.