KNOWLEDGE CREATION IN ORGANIZATIONS: AN AGENT-BASED DEMOGRAPHIC PERSPECTIVE

Steffen Blaschke

Department of Information Systems,
School of Business Administration and Economics,
Philipps-University Marburg, Germany
steffen@blaschke.biz

Session G-2

Abstract

This paper considers the relation between organizational demography and organizational learning. It focuses on communication and consciousness as the knowledge creating process of organizations and individuals, respectively. Demography relates to communication structures in that these become inert with increasing tenure of participants; likewise, individuals adopt a specific communication style at the time of entry into the organization. The paper uses computer-based simulations to examine the effects of different tenure distributions on organizational learning. The results implicate a need to reconsider managerial practice concerning the development of organizational knowledge creation. Personnel turnover is recommended as the primary feature in the management of organizational demography to the benefits of organizational learning.

Keywords: Organizational Learning, Organizational Knowledge, Organizational Demography, Autopoiesis, Simulation.

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Steffen Blaschke

Department of Information Systems,
School of Business Administration and Economics,
Philipps-University Marburg, Germany
steffen@blaschke.biz

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This paper considers the relation between organizational demography and organizational learning. It focuses on communication and consciousness as the knowledge creating process of organizations and individuals, respectively. Demography relates to communication structures in that these become inert with increasing tenure of participants; likewise, individuals adopt a specific communication style at the time of entry into the organization. The paper uses computer-based simulations to examine the effects of different tenure distributions on organizational learning. The results implicate a need to reconsider managerial practice concerning the development of organizational knowledge creation. Personnel turnover is recommended as the primary feature in the management of organizational demography to the benefits of organizational learning.

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Suggested Track: (G) Organizational Learning

Introduction

Organizational learning, knowledge, and competences have been the subjects of many scientific inquiries. It almost seems as every academic discipline had something to contribute in the past. Every discipline? Not quite: Demography, and in particular *organizational demography*, had little to say about knowledge so far. In his widely influential article, Pfeffer (1983:303) defined *internal* organizational demography as "the composition, in terms of basic attributes such as age, sex, educational level, length of service or residence, race, and so forth of the social unit under study." In the past years it has attracted numerous researchers focusing on various organizational outcomes of demographic behavior (e.g., innovation, adaptation, or personnel turnover). However,

to the best of my belief, there are no studies linking demographic dynamics and knowledge creation in organizations. The foremost reason seems to be the general matter of available empirical data. Most demographic work on the organizational level relies on information about top management teams (Harrison et al., 1988; Smith et al., 1994; Wagner et al., 1984; Wiersema, 1992) or results from surveys in small companies (O'Reilly et al., 1989; Zenger and Lawrence, 1989). This paper avoids empirical tests and instead adopts a strictly theoretical approach. In a first step, a general demographic model of knowledge creation is developed based on previous works in organizational demography (Pfeffer, 1983; Lawrence, 1997) as well as complex systems theory (Holland, 1975, 1995; Kauffman, 1993; Maturana and Varela, 1980; Luhmann, 1984). Second, with the aid of multi-agent based simulation (Axelrod, 1997; Gilbert and Troitzsch, 1999; Billari and Prskawetz, 2003), inferences are drawn from different model scenarios. Lastly, theoretical as well as practical implications are discussed.

Organizational Demography, Complexity, and Communication

Most research in organizational demography treats organizations as a "black box" (Lawrence, 1997). Organizational age and/or tenure distributions are investigated to explain organizational outcomes such as turnover, structural and strategic change, or communication frequency. Nonetheless, there are some exceptions which explicitly address organizational demographic behavior, most notably, the simulation study by Harrison and Carroll (1991) that develops a formal model of cultural transmission. Concerning organizational learning, knowledge creation, or the development of competitive advantages,[1] research in organizational demography has neither attempted a black-box approach, nor has it made an effort to develop a formal model. Reasons certainly include the lack of empirical data, but so far even theoretical research fails to address these issues. This paper attempts to remedy some of the shortcomings. More specifically, I propose the science of complexity as a promising candidate to fill the void between organizational demography and organizational learning, knowledge, and competences.

Complexity theory subsumes a number of different ideas (Waldrop, 1992), e.g., chaos theory, complex adaptive systems, or cellular automata. Yet another basic concept in

[1] Organizational learning (Senge, 1993) is the process of evolutionary change in momentary knowledge creation. Competitive advantages (Prahalad and Hamel, 1990) describe effective knowledge creation with regard to organizational action.

the complexity sciences, *autopoiesis* (Maturana and Varela, 1980), in particular applies to the domain of organizational demography. Autopoiesis is the process whereby a system's essential components interact with each other in such a way as to continuously produce and maintain that set of components and the relationship between them. Autopoietic operations are autonomous and self-organizing; i.e., the organization, constraint, or redundancy of a system spontaneously increases without external interferences (Holland 1975, 1995; Kauffman, 1993). Moreover, second-order self-observations of system/environment distinctions permit structural coupling between systems and their environments. The notion of autopoiesis first and foremost relates to living systems such as cells, organisms, and brains. Nonetheless, Niklas Luhmann (1984) presents an all encompassing theory of social systems based on the autopoietic process of communication. Organizations, specifically, reproduce themselves by means of communicated decisions (Luhmann, 2000). In other words, "the communication activity is the organization" (Weick, 1995:75).

Communication is a complex emergent process; that is to say, it necessitates both endogenous selection and exogenous relations. "It arises through a synthesis of three different selections, namely, selection of *information*, selection of *utterance* of this information, and a selective *understanding* or *misunderstanding* of this utterance and its information" (Luhmann, 1992:252). Organizational decisions come about only at the congruence of this threefold selection. But as much as communication is operationally closed, it is impossible in its existence without structural coupling to the environment; just like there is no organization without individuals. Information, utterance, and (mis)understanding maintain and modify the overall communication structure as a matter of distinction to individuals. This of course includes demographic characteristics such as age, tenure, and educational level as well as individual contributions to the decision enabling process. In fact, individuals are also autopoietic systems in that their consciousness continuously creates expectations as a consequence of past conscious experiences and communication. Individual interaction thus is loosely coupled (Weick, 1976) by means of communication. Ultimately, this theory develops a stand in that "*only communication can communicate*" (Luhmann, 1992:251).

Structural coupling between autopoietic systems yields mutual adaptation in both organizational communication and individual consciousness. The communication structure on the one hand changes so to reflect past decisions and distinct individual beliefs, while individuals on the other hand modify their expectations as a consequence of historical experiences and distinctions to communication. Apparently, complexity

theory – with reference to autopoiesis and self-organization in and between systems – is able to describe the connection between organizational demography and organizational learning at the basic level of communication and consciousness. The next section develops an agent-based simulation model including organizational communication to further investigate demographic effects on organizational learning and knowledge creation in detail.

An Agent-Based Demographic Model of Knowledge Creation

Organizational demography refers to the distribution of individual attributes such as tenure, age, sex, etc. in an organization. Although the theory clearly operates at a sociological level, demographic models incorporate psychological aspects of single individuals (e.g., motivation, emotion, or learning capability). The following agent-based demographic model likewise includes both theoretical levels, i.e., organizations as emergent social systems, and individuals as psychic agents. Moreover, the model addresses demography in terms of educational level (skills) and tenure in the organization.

Basic Model Properties

Consider a simple model of knowledge creation in organizations. There are four key features to the model:

(1) There is an *enacted* organizational environment (Daft and Weick, 1984) described by *m* dimensions, each of which can take on values of either 0 or 1 and may change over time. Values of 1 represent market demands, for example, in software technologies, in engineering solutions, or in financial consulting services. In other words, the environment is an exogenous set of opportunities as perceived by an organization.

(2) At each time period, an *m*-dimensional set of expectations is held by every one of *n* individuals in an organization. Values on any particular dimension are 0 or 1 and may change over time. Positive expectations represent individual capabilities such as programming languages, engineering skills, or financial expertise. Expectations in positive congruence with the environment are considered individual knowledge[2] or

[2] First, since 0 is not a positive value only matching values of 1 on corresponding dimensions account for knowledge. Second, individual knowledge here refers to knowledge held by individuals as perceived by the organization. The reason for this is the focus on organizational knowledge creation with the organizational environment as reference for all knowledge.

justified true belief (Nonaka, 1994). In addition, individuals are attributed with a single value for organizational tenure.

(3) Similar to individual expectations, organizational communication consists of *m* themes with values of 0 or 1 which, again, may change over time. Values of 1 on any particular dimension display suggested decisions on any subject of interest. Themes accrue in synergy of information, utterance, and understanding structures. Specifically, there are *n* information and understanding structures, both of which are *m*-dimensional with values of either 0 (no selection) or 1 (selection).[3] Thus, themes of 1 mark a sum of at least one selected decision, and in case of positive congruence with the environment, they are considered organizational knowledge. Moreover, communication possesses a particular level of organizational inertia which is represented by the median of the organizational tenure distribution.

(4) Both, individuals and the organization are operationally closed: individual consciousness systems continuously reproduce present from past expectations, while the same autopoietic reproduction holds true for the organizational communication regarding themes. Nonetheless, they are structurally coupled to each other. Individuals form new expectations as a matter of distinction between themselves and organizational themes, and the organization develops its communication structure to fit individual knowledge. The organization is furthermore structurally coupled to its environment which is implicitly expressed by its adaptation to individual knowledge – *not* individual expectations. The latter instance would describe a mutually exclusive relationship between individuals and the organization, whereas structural coupling between individual knowledge and organizational themes takes environmental opportunities into account. Conversely, the fact that individuals adapt to themes and not organizational knowledge is just to say that individual environments are neglected here, because the focus remains on *organizational* knowledge creation.

Model Dynamics

Organizational knowledge creation is a complex emergent process based on individual(s)/organization and organization/environment distinctions. More precisely,

[3] Hereupon utterance is regarded to be all selective of selected information. The reason to exclude it from methodological analysis is simple: Although the communication structure arises from a synthesis of information, utterance, and (mis)understanding, utterance is most suited to simulate organizational structures such as departments, project teams, or communities. The remainder of this paper, however, is not concerned with communication structure per se and therefore neglects the function of utterance (i.e., all dimensions are fixed at values of 1). Note that information and (mis)understanding here uphold the two alternating communication roles, namely, Alter and Ego (Luhmann, 1984).

individuals modify their expectations with probability, p_{tenure}, on those dimensions where positively deviating organizational themes enable them to make an understanding effort. Let me give an example to clarify this: An engineer has no experience with a particular software product (his expectation is 0) but is asked to give an opinion whether it should be employed in an upcoming project. Luckily, there are several software developers in the same organization who have been working with the product before (their expectations are 1). As the engineer and the developers engage in communication, the unity of information and understanding makes it possible to produce a suggested decision whether it would be beneficial to use the software or not (the theme is 1). Simultaneously, the engineer is given the possibility to form an expectation of his own (his expectation *may* change to 1).

At every time period, the probability to learn from communication, p_{tenure}, is unique to each individual, *i*. The model employs the following function:

$$p_{tenure,i} = basic\ learning\ rate\left(1 - \left|\frac{tenure_i - inertia_{median}}{inertia_{median}}\right|\right).$$

The *basic learning rate* is a given simulation parameter between 0 (no learning) and 1 (definite learning). The right hand side of the equation determines the strength of the individual/communication relationship in that tenure scores closer to the organizational median receive higher probabilities.[4] Theoretically speaking, individuals include organizational themes *and* organizational demography as perceived distinctions in the conscious process of recreating expectations. This simple concept introduces a known effect of organizational tenure distributions (Zenger and Lawrence, 1989; Pfeffer, 1983) where individuals who enter the organization at the same time develop a particular communication style specific to their cohort. To continue the example from above, suppose the engineer is new to the organization, whereas the software developers are long-tenured experts. Although the communication produces a theme, the technical terminology in the contributions by the developers will likely decrease the engineer's probability to adopt an expectation himself. Note that even in stable scenarios – i.e., without turnover, reorganization, etc. to affect organizational demography – an increase in tenure *per se* also increases an individual's probability to learn. The absolute length of service thus accounts for basic enculturation into the organization (Harrison and

[4] In rare instances, an individual's length of service may exceed twice the mean tenure in the organization; here the probability falls to – and remains at – a value of 0. Negative probabilities, however, could be interpreted as individual forgetting (from an organizational perspective). A further discussion, however, needs to be left to future research.

Carroll, 1991), whereas the relative tenure position marks cohort barriers (Tajfel and Turner, 1986).

Individuals modify their expectations based on distinctions between themselves and communication. Likewise, communication alters its themes to match up with individual knowledge. These adjustments in information and understanding structures come about with probability, $p_{inertia}$, on those dimensions with either a perceived distinction between individual knowledge and information or a similarity in case of individual knowledge and understanding. Table 1 indicates the possibilities of organizational learning and organizational forgetting.

Table 1. Organizational Learning and Organizational Forgetting in Information and Understanding Structures

Individual Knowledge	Information,*t*	Information,*t*+1*	Individual Knowledge	Under-standing,*t*	Under-standing,*t*+1*
1	1	1	1	1	{0}
1	0	[1]	1	0	0
0	1	{0}	0	1	1
0	0	0	0	0	[1]

* [Organizational Learning]; {Organizational Forgetting}

Both learning and forgetting are structural changes which enable communication to (re)produce themes closer to environmental demands and thus not only (re)create but also increase organizational knowledge. To pursue the example, suppose the organization has an opportunity to sell a particular service (the environment is 1). Unfortunately, it cannot decide on matters because there is no knowledge about the service (the theme is 0). The engineer, however, has the knowledge to suggest a decision (his expectation is 1). Communication therefore shifts with probability, $p_{inertia}$, to the engineer for information, while simultaneously the other organizational participants are asked to make an understanding effort to conclude the decision on whether or not to sell the service (the theme *may* change to 1). In like manner, organizational forgetting relocates information without the presence of knowledge and understanding where knowledge is already attained. Forgetting thus is just as important as learning: it sets free communicational capacities to cope with environmental complexity (Blaschke and Schoeneborn, 2004).

Structural flexibility directly affects organizational learning and forgetting. In general, older organizations exhibit more stable structures than their younger rivals (Stinchcombe, 1965); that is to say, the ability to make changes to the communication

structures suffers with age. Here the probability, $p_{inertia}$, to learn and to forget is determined from the tenure distribution of the organization as follows:

$$p_{inertia} = basic\ learning\ \&\ forgetting\ rate\left(\frac{1}{inertia_{median}}\right).$$

The *basic learning & forgetting rate* is a given simulation parameter between 0 and 1. The right hand side of the equation establishes organizational inertia as an absolute influence on structural flexibility. An increase in the median tenure in the organization thus decreases the adaptability of communication. Think about recently founded start-up businesses: median tenure scores are low because employees have only been working together for a short time. Most likely, communication is still in flux. On the other hand, long-established companies exhibit significantly higher median tenure scores since – in spite of turnover – most organizational members have been working together for quite some time. Here communication structures are usually more stable.

Multi-Agent Based Simulations of Organizational Knowledge Creation

Computational simulations have become an accepted method in conducting scientific research (Axelrod, 1997). In the following, simulations are used to analyze the effects of different demographic distributions on organizational knowledge creation. In all of the simulation scenarios here, the number of dimensions (*m*) of the environment, individual expectations, and organizational themes is set at 50, the number of individuals (*n*) is set at 50, and the length of simulation runs is 60 periods. Each simulation is repeated 50 times from the same initial conditions and parameters (e.g., given probabilities for communication structure, individual expectations, and exogenous opportunities) to estimate the distribution of outcomes. The below reported quantitative results depend on these specifications, but the qualitative results are insensitive to simulation parameters. In addition to the basic agent-based demographic model, simulations also include personnel turnover and environmental turbulence.

Tenure Distribution Scenarios

The last of the above examples associated start-up businesses with low median tenure scores and long-established companies with relatively higher median tenure scores. Organizations in general display a variety of tenure distributions. These are a result of unique histories of organizational entry and exit. For instance, a company may experience a period of rapid growth (in terms of membership) but reduce hiring after it has reached a particular size. A histogram of individual tenures most likely resembles a normal distribution. In like manner, uniform, right-skewed, left-skewed, and bi- or

multimodal distributions are found in organizations. Uniform distributions are a consequence of balanced entry and exit which are usually observed in public services; right-skewed is a typical snapshot of a start-up at a first boost in employee numbers; on the contrary, left-skewed marks a successful spin-off or outsourcing attempt in that the organization started with a particular large number of members and continued business without further growth; and bimodal or multimodal distributions are hybrid cases of the above mentioned scenarios.

Demographic distributions supposedly affect organizational communication and subsequently organizational knowledge creation. But since different distributions reflect unique histories of events, they hardly compare to each other at a particular point in time. Take two organizations, one with a “young” (right-skewed) and another with an “old” (left-skewed) tenure distribution. While communication in the first one is just as flexible as the organization is young, its older opposite is presumably most inert. However, the latter organization also accounts for a longer “life” in which the communication structure adjusted to individual beliefs and thus improved knowledge creation. It is obvious that the further development of organizational knowledge creation not only depends on the present demographic distribution but also on the state of the communication structure. Unfortunately, social scientists rarely “pre-breed” artificial organizations just so to be able to compare them to younger rivals later on. All simulations start at a specified time, t_0. Accordingly, organizations begin their artificial lives without a “real” history. This is not to say that there is no history at all; rather, their initial – i.e., at the beginning of the simulation – demographic distributions, communication structures, and organizational themes are simulated too.

In the following, five different tenure distributions are discussed in short concerning their effects on organizational knowledge creation. Each demographic distribution is randomly drawn from a specified mathematical distribution; this represents organizational histories of entering and exiting individuals. Self-organization in and between systems thus is neglected prior to the simulation start. The somewhat fanciful assumption of a (demographic) past without a trace (of learning) nevertheless offers a plausible picture. Organizations enact their environment (Daft and Weick, 1984); any major strategic change then is a compelling reason to face different opportunities. Earlier structural improvements are rendered obsolete and new gains to organizational knowledge only occur in time. This is just the case for the following five organizational scenarios. They differ in their demographic tenure distribution, but at the start of the simulation each encounters a new set of environmental opportunities.

Perceived changes in the organizational environment demand novel themes to stay competitive. It is assumed that organizational knowledge creation most positively benefits from *right-skewed* tenure distributions. The majority of employees just recently entered the organization and in this the flexible communication structure quickly allocates valuable distinctions to produce new decisions. For contrary reasons, *left-skewed* tenure distributions are most detrimental to organizational learning. Communication eventually comes to a deadlock where the greater part of organizational members is working with each other for years (if not decades). New environmental opportunities of course irritate the communication structure, but the development of new themes is by far slower than compared to right-skewed rivals. These two instances mark the extreme tenure scenarios. On the one hand, there is a young and flexible start-up company which jumps at the latest challenge; and on the other hand, there is a long-established company at the turn of the (strategic) tide, ready to revive its business in a new market.

Between the presumably best and worst development of organizational knowledge in right-skewed and left-skewed tenure distributions, respectively, remain another three demographic scenarios to be simulated and analyzed; these are organizations with *normal*, *bimodal*, and *uniform* tenure distributions. Note that all organizations are likely to experience similar improvements in their communication structures because the distributions favorably compare to each other in terms of organizational inertia. (Technically speaking, the median tenure scores are almost identical.) Nonetheless, normal distributions shape a demographic enclave wherein communication styles are alike. Expectations on part of the individuals thus build up more rapidly, which again provides an improved basis for organizational learning. A similar line of argumentation applies to bimodal tenure distributions. But since communication is foremost divided between two demographic cohorts, organizational knowledge creation is believed to be less efficient than in either right-skewed or normal tenure distributions. Lastly, organizational learning in organizations with uniform tenure distributions supposedly performs worse compared to the other distributions except for the left-skewed instance. Even though communication tends not center on a specific cohort, it is more capable of change than its older rival. In summary, the development of organizational knowledge creation will be best in organizations with right-skewed tenure distributions. Following in line are normal, bi-modal, and uniform distributions. Organizational learning in left-skewed scenarios will perform worst.

Turnover and Turbulence

Organizational learning in theory and simulation eventually leads to an equilibrium in that all individuals share the same beliefs. The path-dependent development of expectations restricts selection in both information and understanding to but a few distinctions. Ultimately, the organization encounters a communicational *lock-in* (Arthur, 1989; Liebowitz and Margolis, 1995) in which the autopoietic reproduction of themes is no longer possible. The organization as such ceases to exist. In practice, however, system/environment distinctions are plentiful in presence; that is to say, "there is always communication about something" (Luhmann, 2000:60). Just consider the risk (or in some cases, the chance!) of *mis*understanding. Communication here not only serves as a basis for mutual expectation building but also enables the development of genuine new knowledge. Another solution to escape a communication deadlock is to introduce personnel turnover and environmental turbulence into the simulation model. Both processes provide irritations to the organization and in this affect organizational learning.

In the first instance, variability is produced by means of personnel changes. Despite the fact that staffing choices may be deliberate, suppose that at any time period, t, each individual has a probability, $p_{turnover}$, of leaving the organization and being replaced by an individual with a set of naïve (i.e., unaffected by adaptation processes) beliefs. Newcomers bring improvements to knowledge in that they deviate from organizational themes in a favorable way. This is the college graduate who holds the latest theoretical ideas on a particular subject or the experienced engineer who developed specialized knowledge in his earlier career. Moreover, turnover influences an organization's demography. While personnel entries and exits rejuvenate communication structures, too high a fluctuation rate is as detrimental to organizational learning as one to low. The simulation neglects this trade-off by far.[5] Instead, I follow the general argument and hypothesize that (moderate) turnover positively affects organizational learning. The strength of the effect on the five different tenure distribution scenarios follows the sequence in which they were discussed above. Organizations with a left-skewed tenure distribution experience the least disruption in terms of their demographic structure. Therefore, they are able to quickly incorporate new beliefs into communication. The opposite holds true for right-skewed tenure distributions. Although turnover increases

[5] Of course the simulations are run with numerous parameters sets. For example, turnover ranges from very low (0.01) to very high (0.9). The reported results, however, refer to a moderate turnover rate of 0.05.

structural flexibility, organizations most likely experience communicational barriers between newcomers and long-tenured experts.

In addition to irritation by turnover, organizations perceive environmental turbulence as shifts in system/environment distinctions. In the model, perceptive changes of opportunities (from 0 to 1 or 1 to 0) occur with probability, $p_{turbulence}$, on any particular dimension. This captures in an elementary way the notion that organizations selectively construct their environment (Daft and Weick, 1984). Opportunities are merely exogenous references against which organizations establish themes; and changing them does not alter demographic distributions. Nonetheless, communication structures are affected indirectly in that organizations need to remain competitive by producing superior knowledge. Turbulence therefore gives rise to organizational learning. As with turnover, a trade-off exists between low turbulence, which eventually causes a communicational deadlock, and high turbulence, which reduces the change of building and sustaining organizational themes in congruence with opportunities. At any rate, environmental turbulence is believed to positively affect the development of organizational knowledge creation. The effect on different tenure distributions follows the already discussed sequence. Organizations with right-skewed tenure distributions learn more effectively than their normal, bimodal, uniform, and left-skewed rivals.

Simulation Results

In one way or the other, organizations need to be competitive to survive (Carroll and Hannan, 2000; Prahalad and Hamel, 1990). The development of organizational knowledge, capabilities, and competences – in short, organizational learning – is not only existential to mere survival but also sustains superior market performance. The discussion so far established a theoretical connection between organizational demography and autopoietic knowledge creation. Figure 1 shows the results from simulations of the five different tenure distributions with the development of (mean, i.e., across 50 iterations) organizational knowledge plotted against time.

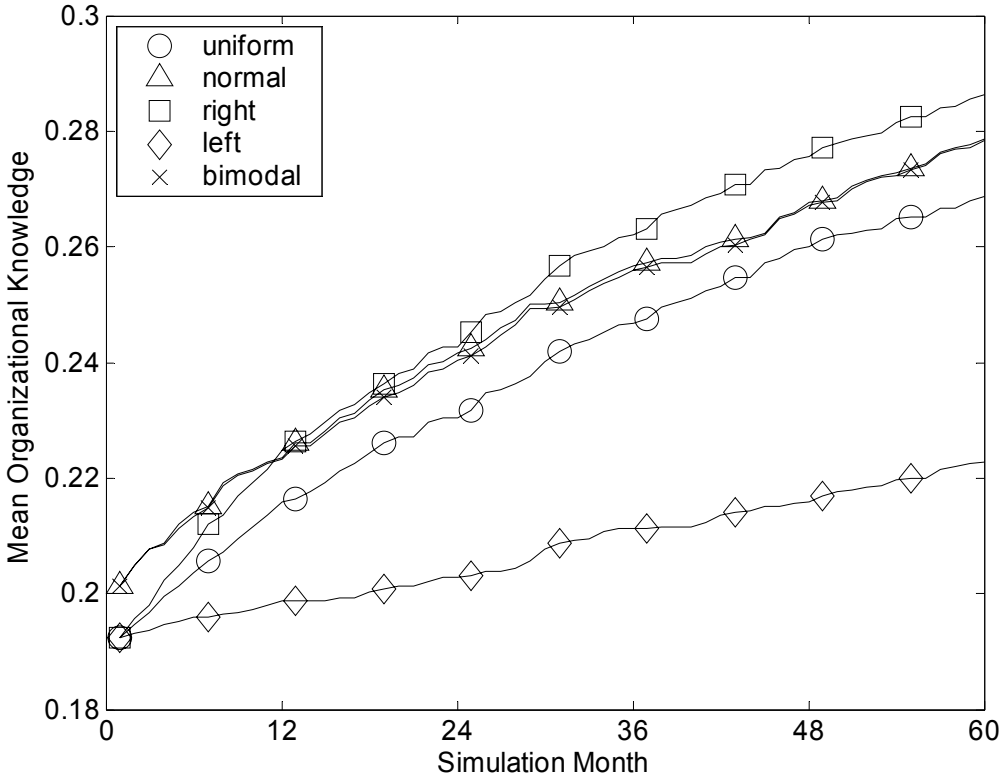

Fig. 1. Demographic Effects on Organizational Knowledge Creation

All organizations (roughly) start with equal knowledge creation capacities.[6] Over time, organizations with a right-skewed tenure distribution are able to develop outstanding knowledge in contrast to all other rivals. It is obvious that younger organizations are more flexible in their structures and therefore quickly attune to new opportunities. As hypothesized, normal and bimodal tenure distributions follow next in line. While both compare favorably with uniform tenure distributions in terms of organizational inertia, they nevertheless perform significantly better than the latter (normal/uniform two-tailed $t(118) = 2.226$, $p = 0.0252$; bimodal/uniform two-tailed $t(118) = 2.1018$, $p = 0.0377$). This underlines the effects of demographic cohorts. Recall that normal and bimodal distributions shape one or more communicational enclaves, whereas in uniform tenure distributions individuals are "spread out" across the entire organization. Lastly, organizational learning in left-skewed scenarios performs worse than any other

[6] Knowledge creation capacities are slightly different from organization to organization because communication structures, individual expectations, and environmental opportunities are initiated at random. Although the parameters are equal for each simulation run, chance attributes some organizations with more knowledge creation potential than others.

organization. The explanation here is first and foremost found in a disability to shift the necessary communicational production of themes towards environmental opportunities.

Organizational learning is of course closely intertwined with individual learning. Although the simulations focus mainly on the first, Figure 2 outlines the development of mean individual knowledge creation (i.e., across 50 iterations concerning 50 individuals) for each of the five tenure distributions over time.

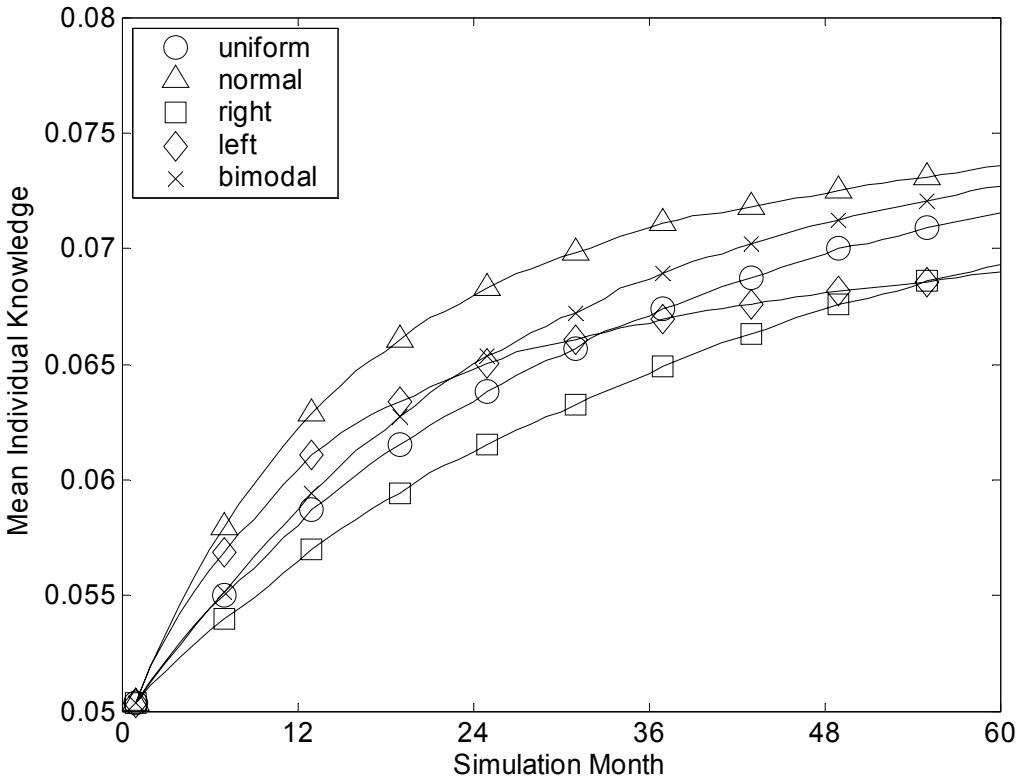

Fig. 2. Demographic Effects on Individual Knowledge Creation

Interestingly, individual learning is most efficient in organizations with normal tenure distributions. Right-skewed distributions, on the contrary, perform significantly worse – although they displayed the best results with respect to organizational learning. The findings emphasize cohort effects on individual knowledge creation. Normal and bimodal tenure distributions put the majority of employees in favorable communication which neither uniform, nor left- or right-skewed tenure scenarios are able to achieve. Moreover, right-skewed distributions rapidly shift communication structures to produce new themes. This leaves less variability for individuals to learn from but clearly benefits organizational knowledge creation. Perhaps an example may elucidate this rather counter-intuitive finding: Consider a recently founded company that requires each employee to decide on virtually any subject just to get the business started. Although

the organization here is most flexible, individuals soon contribute to but a few themes. In other words, the daily communicational routine gives rise to experts in the organization; and where individual knowledge creation focuses on specialized subjects, organizational knowledge creation spans the whole expert range. Conversely, older companies have difficulties to shift communication to produce new themes. While at first individuals still develop capabilities in congruence with environmental demands, organizational inertia eventually slows down individual *and* organizational learning (compare the development of left-skewed tenure distributions in Figure 1 and Figure 2).

To this point, the simulation results underline the hypothesized demographic effects on organizational knowledge creation. The theoretical discussion above continued with similar assumptions about organizational learning in scenarios including turnover and environmental turbulence. The actual findings, however, yield no significant differences between the five tenure distributions whether simulations include just turnover or turnover and turbulence (Figure 3).

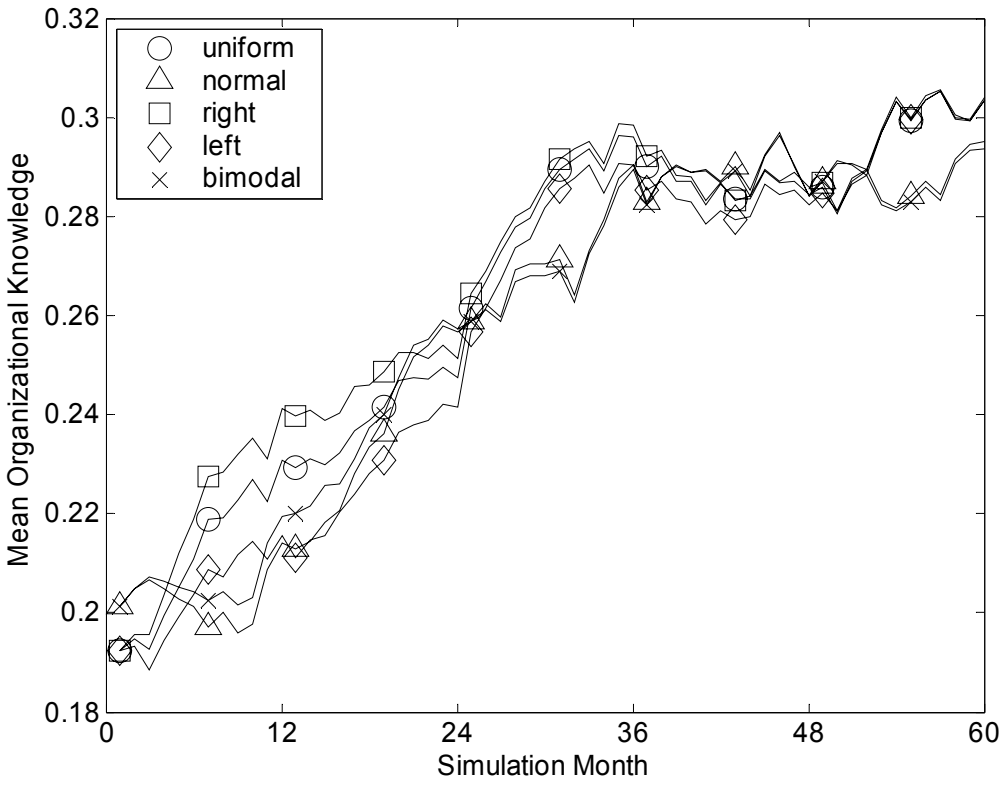

Fig. 3. Demographic Effects on Organizational Knowledge Creation including Personnel Turnover and Environmental Turbulence

All organizations experience irritations from newcomers or changes in their environment alike. Yet turnover additionally alters demographic structures and in that

benefits older organization the most. This finding contradicts the above assumption, but it emphasizes the rejuvenating function of turnover. Although the different tenure distributions are statistically indistinguishable concerning demographic effects on organizational learning, turnover and environmental turbulence nevertheless support the general development of knowledge creation. Figure 4 illustrates these effects for organizations with a uniform tenure distribution.

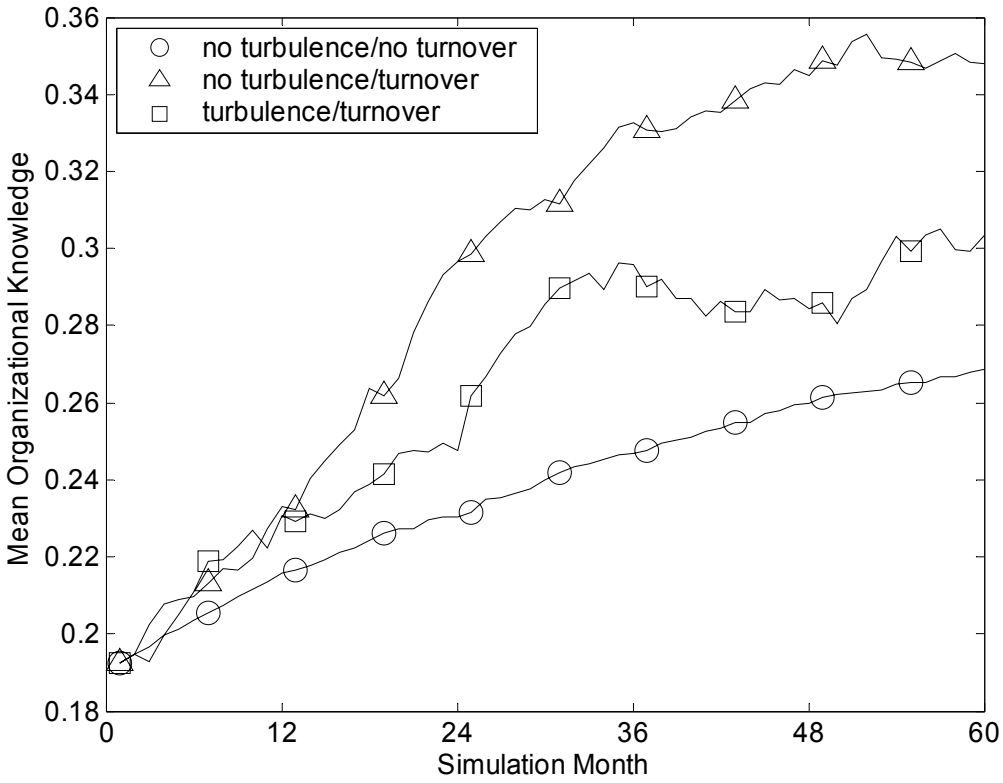

Fig. 4. Demographic Effects (Uniform Distribution)
on Organizational Knowledge Creation

Turnover clearly enables organizations to develop outstanding knowledge creation capabilities in that it introduces new system/environment distinctions and affects an organization's demography. Environmental turbulence reduces this overall positive effect. If the perception of the environment constantly changes, individual contributions to organizational themes shift from mere personal expectations to actionable knowledge – and vice versa. Organizations with turnover then benefit from the occasional newcomer who matches exogenous opportunities, but communication is nevertheless bound to restructure as strategy demands.

Conclusions

Research in organizational demography all too often treats organizations a black box. The here presented agent-based demographic model attempts to fill this shortcoming concerning the autopoietic process of organizational knowledge creation. Moreover, I suggested that organizational demography plays a leading role in organizational learning. The simulation results support the hypothesized demographic effects – at least in scenarios without turnover and/or turbulence. In face of new environmental opportunities, younger companies then learn significantly better than any of their rivals; older organizations, on the contrary, are unable to quickly create new knowledge and therefore suffer competitive disadvantages. Turnover and environmental turbulence increase organizational knowledge creation but also blur the unique effects of different tenure distributions. The findings, nonetheless, implicate the importance of organizational demography.

In conclusion, I propose that managerial practice regarding the development of organizational knowledge needs reconsideration. The theoretical advancements and the supporting simulation results in this paper advert to a deliberate management of an organization's demography as a suitable means to achieve competitive advantage. Unfortunately, the most attention managers pay to demographic matters is found in official company reports which occasionally mention organizational age distributions or gender ratios. A genuine attempt to develop organizational capabilities requires forgoing the notion that knowledge creation can be controlled. Instead, organizations are regarded as self-organizing social systems that work on irritations. Changes in an organization's demography produce such irritations. A more general management approach then includes decisions on hiring selectivity, retirement incentives, etc. – in other words, the management of personnel turnover. All of these decisions assist in shaping the organizational demography with reference to specific environmental demands. As the simulation results show, new opportunities are more easily met in younger organizations. On the contrary, older organizations hold specialized knowledge. The rather obvious implication is to increase turnover alongside strategic change and decrease turnover in relatively stable environments, respectively.

It is a non-trivial task to find the right fluctuation rate for each demographic distribution, if there is one at all. At any rate, turnover is a healthy organizational process in that it rejuvenates communication structures and introduces diverse individual knowledge. It furthermore allows organizations to forget, which is most crucial to the development of new knowledge (Blaschke and Schoeneborn, 2004). For example, organizations

constantly produce structures, procedures, routines, etc. to cope with reoccurring environmental demands. But if corporate strategies drastically change the environment, most organizational institutions quickly become obsolete. Hedberg (1981) recommends organizational unlearning to regain competitiveness. Managing an organization's demography additionally supports this perspective. To put it bluntly, turnover breaks up inert structures by replacing specialized experts with naïve employees – all but to learn anew on top of unlearning and relearning.

A close supervision of personnel entry and exits is just a one approach to foster organizational learning. Demography concerns the entire organization. Functional departments, project teams, or communities of practice all exhibit specific demographic distributions. Therefore, management decisions on reorganization, staffing, facility layouts, information systems, etc. need to take organizational demography into account. Just consider a recently established project team: Despite the fact that the team has just been founded, most of its members may have been working with each other for quite some time. Institutionalized communication structures here limit knowledge creation for the most part to the familiar themes. On the contrary, the team's demography may resemble more of a right-skewed distribution in that the majority of team members are new to the organization as a whole. At the start of the project, knowledge creation certainly includes less actionable knowledge, but over time innovation capacities most likely benefit from communicational flexibility and individual diversity. Hence, managers with a strong belief in the self-organizing capabilities of systems and a constructivist approach to strategic goals inevitably must pay attention to organizational demography.

Appendix

Table 2. Simulation Parameter Settings

Number of Individuals (*n*)	50
Number of Dimensions (*m*)	50
Number of Simulation Periods (Month)	60
Number of Iterations	50
Basic Learning Rate for Individuals	0.1
Basic Learning & Forgetting Rate for Organizations	0.1
Initial Probability of Environmental Opportunities	0.5
Initial Probability of Individual Expectations	0.1
Initial Probability of Information & Understanding Selections	0.1
Personnel Turnover ($p_{turnover}$)	0.05
Environmental Turbulence ($p_{turbulence}$)	0.05
Tenure Distribution Interval (Month)	1-120
Tenure Distribution Mean and Standard Deviation	$\mu = 60$, $\sigma = 60$

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