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Stability of organizational routines and the role of authority

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Abstract

The present paper uses empirical data to examine the extent to which endogenous and exogenous factors shape routine dynamics. We find that action patterns for carrying out the task we study are typically not stable over time and that most endogenous and exogenous factors can both increase and decrease the sequential variety of these action patterns, depending on the degree of formal authority applied to a routine. Our findings point to an important aspect of routine dynamics, namely, their strategic root cause: By defining the degree of discretion of those who carry out the routine, organization designers can actively manipulate when routine dynamics occur, what sources they have, and whether or not they are useful for the organization. We discuss implications for theory and practice.

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Abstract

The present paper uses empirical data to examine the extent to which endogenous and exogenous factors shape routine dynamics. We find that action patterns for carrying out the task we study are typically not stable over time and that most endogenous and exogenous factors can both increase and decrease the sequential variety of these action patterns, depending on the degree of formal authority applied to a routine. Our findings point to an important aspect of routine dynamics, namely, their strategic root cause: By defining the degree of discretion of those who carry out the routine, organization designers can actively manipulate when routine dynamics occur, what sources they have, and whether or not they are useful for the organization. We discuss implications for theory and practice.

Keywords: organizational routines, routine dynamics, stability and change, change in organizational routines, formal and real authority

1) Introduction

Organizational routines have long been considered central to understanding organizations, how they accomplish their tasks, and their performance outcomes (March and Simon, 1958; Cyert and March, 1963; Nelson & Winter, 1982). Organizational routines refer to actors jointly accomplishing interdependent tasks in ways that are stable over time.[1] This stability, which is a hallmark of the traditional conception of routines (Nelson & Winter, 1982; Cohen et al., 1996), is challenged by recent research that identifies variation between one iteration and the next (Pentland & Rueter, 1994; Pentland, 2003a, 2003b). Interestingly, routines can change, not just due to exogenous pressures for change (Gersick & Hackman, 1990) but even without such pressures, as the participants in routines can and do also change them endogenously (Feldman, 2000, 2003; Feldman & Pentland, 2003; Pentland et al., 2009, 2010, 2011, 2012; Rerup & Feldman, 2011).

Even despite this active stream of research on organizational routines and their change, the number of empirical studies that examine stability and change in routines is still surprisingly small (Parmigiani & Howard-Grenville, 2011: 447). Recent research has pointed out that the organizational context within which routines are embedded is paramount for understanding the performance and change of routines (Parmigiani & Howard-Grenville, 2011: 442), because some essential features of organizational context have not adequately been considered in depth yet. Even 'studies in the practice perspective [which] are so concerned with situated action ..

[1] While several authors consider organizational routines to refer to recurrent interaction patterns and sequences of actions (Pentland et al., 2011), the general term organizational routines refera more broadly to what generates these sequences of actions, for instance, the 'organizational dispositions to energize conditional patterns of behavior within organizations, involving sequential responses to cues that are partly dependent on social positions in the organization' (Hodgson and Knudsen, 2010: 140). In this article, sequences of actions are in the focus. When we use the term 'routines' to point to these sequences of actions, it is only for convenience and as a short-hand.

sometimes ignore fundamental organizational attributes that exist above the level of the routine but nonetheless affect its performance' (Parmigiani & Howard-Grenville, 2011: 443). In our study we shed light on the influence of one fundamental but neglected organizational attribute, namely hierarchical authority and its role in organizational routines. While such an influence has long been stipulated, extant research has not yet explored this link, leaving a significant gap in extant research. In their seminal work on organizational routines, Nelson & Winter (1982: 109) pointed out that 'ordinarily, .. control systems … leave individual members with substantial areas of behavioral discretion' in how to carry out tasks. Other streams of research have also noted that a typical feature of many organizations is to leave the execution of tasks in the hand of those who the tasks are allocated to; this happens especially for recurring, routine tasks. Aghion & Tirole (1997) propose that while the superior holds the *formal authority* concerning the task, the actual decision rights concerning how to carry out a task are often de facto delegated to lower level agents who execute the task and therefore hold what Aghion & Tirole (1997) call *real authority*. Superiors intervene to decide in exceptional cases (Bittel, 1964), but mostly simply engage in rubberstamping (Rivkin & Siggelkow 2003). This common feature of organizations raises some major questions for routine research: In the absence of the exercise of formal authority by superiors, the agents who carry out a task have discretion, or real authority, and can adapt the routine due to a myriad of possible motivations (cf. Feldman, 2000; 2003; Feldman & Pentland, 2003). When superiors employ their formal authority to enforce rules and to shape organizational routines (Knott, 2001), the discretion of the agents carrying out the routine is limited and change in routines is predominantly explained by the exercise of formal authority.

The connection between types of authority and routines has, surprisingly, not been made so far. In what follows, we provide empirical evidence that sheds light on the role of formal and

real authority for explaining changes in organizational routines. Our findings confirm prior research by showing that discretion is paramount for understanding organizational routines and their stability. We thereby add to emerging theory on the role of decision rights for organizational routines and their stability and change. We find that how managers specifically define formal and real authority is more important for understanding routine dynamics than many exogenous and endogenous factors. On this basis, we propose a research agenda that puts an emphasis on micro level structures within routines.

The paper structures as follows: the subsequent section reports prior research and develops hypotheses, section three presents data and measures, section four results and section five discussion and conclusion.

2) Change of organizational routines: Prior research and hypothesis development

Prior research has identified two different types of sources of change in routines: exogenous and endogenous sources (Gersick & Hackman, 1990; Feldman, 2000). While there are several environmental influences on the change of routines, such as external shocks (Gersick & Hackman, 1990), in the context of business firms, top-down management intervention is an important form of exogenous influence on routines and change of routines (Becker et al., 2005, Pentland & Feldman, 2008). Managers can therefore be conceived as a source of exogenous change in organizational routines. Prior research points to three ways in which managers can influence routines: (a) by exercising their formal authority to enforce that tasks are carried out in a particular way, e.g. by establishing priorities, deadlines, etc. (Knott, 2001); (b) by directly engaging in restructuring processes on a micro-level, such as in business process reengineering

(Davenport and Short, 1990; Hammer, 1990; Hammer and Champy, 1993; Davenport, 1993; Grover & Malhotra, 1997; Hung, 2006; Peng et al., 2008); or (c) by exercising their authority to change the structure of the underlying technology, e.g. more standardized products (Baldwin & Clark, 2000).

Recent research has also argued that routines are capable of *endogenous* change because they are generative systems with an internal structure (Feldman and Pentland 2003; Pentland et al., 2011; Turner & Rindova, 2012). The key to endogenous change in routines is to include routine participants in the analysis of routines, i.e., the actual people who perform the routines and who should be the most salient driver of endogenous change (Feldman, 2000: 611; Feldman, 2003; Feldman and Pentland, 2003: 99).

In what follows, we develop hypotheses on the variables identified as important exogenous and endogenous drivers of change.

2.1) Exogenous influences on routine dynamics

2.1.1) Hierarchical authority

Arguably, one of the most important exogenous interventions for changing routines is management intervention. Of particular interest is usually the minimization of variation in reoccurring organizational action patterns. Due to their hierarchical authority, managers can enforce particular ways of accomplishing work in firms, and put in place mechanisms such as incentives and sanctions to enforce the envisioned ways of accomplishing work (Mintzberg, 1979). Prior research has thus argued that in order to understand routines, hierarchy and authority

should be considered (Gavetti, 2005) by investigating the relation between authority and routines (Parmigiani & Howard-Grenville, 2011: 437). Lazaric & Raybaut (2005), e.g., consider how hierarchical pressure influences the efforts exercised by different groups that participate in a routine. Zbaracki & Bergen (2010) noted that an individual's hierarchical position may influence how a routine is enacted.

An important finding of prior literature is that agents who participate in a routine and who make decisions regarding how and when to execute tasks typically also have some control over the task, simply by the real authority that exists in any delegation that involves discretion (Aghion & Tirole 1997). For most typical routine tasks this means that the average participant in a routine has effective control (real decision authority), while the formal authority is held by a manager (Aghion & Tirole 1997). Managers only intervene when there are exceptions (Bittel, 1964), but even then, most of the time stick to rubberstamping the decisions taken by their subordinates (Rivkin & Siggelkow, 2003). On the other hand, if the formal authority holder decides to intervene, her managerial intervention can have a powerful influence on the stability of a routine. We therefore hypothesize:

> *H1: The more formal authority, rather than real authority, determines the degree of discretion within a routine, the more stable the routine is over time.*

2.1.2 Quality management

Quality management, as a "philosophy or an approach to management" (Sousa & Voss, 2002: 92) focuses on a set of management practices including process management and improvement. To achieve process improvement, quality management and related frameworks have developed a

range of tools and approaches to systematically tackle different sources of (unwanted) variation in processes or routines. Two important sources of such variation are unwanted errors, and doing something that is wasteful or that the customer does not want. Approaches such as six sigma, kaizen and continuous improvement provide tools and mechanisms for error detection, root-cause-analysis, and eradicating the error causes. Techniques such as the prioritization of processes to assure that the most value-creating processes are privileged, and for eliminating double-work and waste such as 'muda' in the Toyota Production System, provide concrete examples for reducing the variation in processes (Grover & Malhotra, 1997). We hypothesize:

> *H2: The less (more) developed quality management, the more (less) prevalent routine dynamics are to be expected.*

2.1.3 Standardization of products

One of the main goals of business process reengineering (and related literatures) is to minimize variation by standardizing or homogenizing inputs (Hammer & Champy, 1993). This can be done e.g. by capturing customer complaints using pre-established categories or in the case of physical products, establishing standardized interfaces between the different modules of the product (Baldwin & Clark, 2000). Standardizing inputs allows minimizing variance in the subsequent processes that deal with these inputs, for instance responding to customer inquiries (Pentland & Rueter, 1994) or paying invoices (Pentland et al., 2011). To the extent that many customer inquiries can be bundled in product categories, standardizing the product and its components should lead to less routine dynamics in the processes for each product type.

H3: The less (more) developed product modularity, the more (less) prevalent routine dynamics are to be expected

2.2 Endogenous influences on routine dynamics

2.2.1 Individuals as endogenous source of routine dynamics

In her influential paper, Feldman (2000: 614) argues that 'routines are performed by people who think and feel and care. … Their actions are motivated by will and intention. They create, resist, engage in conflict, aquiesce to domination. All of these forces influence the enactment of organizational routines and create in them a tremendous potential for change'. Building on this insight, research has identified mechanisms by which routine participants can generate endogenous change. Feldman (2000: 611, 620) argues that when outcomes of action fall short of ideals (e.g., do not produce the intended outcomes), agents reflect on and react to those outcomes, e.g. by making efforts to change or "repair" routines to attain these ideals or by expanding them to take advantage of new possibilities. Feldman and Pentland (2003: 113) identify mechanisms of guiding, referring, and accounting by which participants in routines can create variations that other participants recognize as legitimate. Routines thus change endogenously as people react to outcomes of prior iterations of a routine or retain changes introduced by other participants in a routine (Feldman, 2000; 2003; Feldman & Pentland, 2003; Pentland et al., 2011a, 2011b, 2012). Through mechanisms such as these, one and the same routine can generate many different patterns (Pentland et al., 2010: 29). Therefore, a 'tendency toward endogenous change is a natural part of routines' (Pentland et al., 2011: 1381), and the

individuals who carry out routines are considered important drivers of such variability of routines (Feldman & Pentland, 2003). We thus hypothesize:

H4a: Individuals have an impact on routine dynamics.

2.2.2 Individuals do not have an impact on routine dynamics

A strong and long-standing counter-position to H4a exists in the literature, i.e. the notion that individuals do not have an impact on routine dynamics. This counter-position is built on the notion that organizational routines are built from individual-level habits (Cohen & Bacdayan, 1994; Cohen, 2007; Hodgson & Knudsen, 2010; cf. Nelson and Winter, 1982, ch. 4 and 5) that are, similarily to routines, characterized by stability (Ouellette & Wood, 1998; Marteau et al., 2012; Neal et al., 2012).

From this perspective, it would appear unlikely that individuals – the carriers of stable habits – would lead to routine dynamics, at least as long as little is known about the process by which individual habits aggregate to organizational routines. As a recent review points out, 'the link between individual skills and organizational routines has not been examined systematically and is referred to mainly via the analogy that routines are "habit-like" or "skill-like" organizational-level entities' (Salvato & Rerup, 2011: 474). Scholars thus point to a gap with regard to knowledge about the relationship of individual habits and organizational routines (Salvato & Rerup, 2011; Parmigiani & Howard-Grenville, 2011).

The idea that individuals do not have an impact on routine dynamics is consistent with the empirical observation that routines can resist turnover of individuals involved in the routine

(Winter, 1991). As Winter (1991: 187) writes, 'organizations seem to have a remarkable tendency to keep interaction patterns stable, even in the face of continuing turnover in the population of individuals displaying the pattern'. We thus hypothesize:

H4b: Individuals do not have an impact on routine dynamics

3) Data and measures

Data

We gathered 5 years of data capturing the specific action sequences of a routine that was employed for dealing with customer claims in a manufacturing firm that produces ventilation systems mostly for commercial purposes.[2] Claims include any type of customer inquiry in the context of after-sales, mostly concerning malfunctioning or broken products. The reason for selecting this routine for our research was that it is an operational business process that is frequently occurring with about 45 claims per week. While this routine is repetitive, it is not fully automated, not optimized using advanced production control and thus still leaves some discretion for individuals to influence how they execute their task. In addition, this routine is constant in the sense that the firm did neither introduce completely new products nor change the technology (IT systems) used for executing the routine during the observation period; it also did not make major changes to the employees that were working on the claims. The documentation of the routine's action sequences was made possible because the firm had an IT system which documented the routine in detail and allowed us to examine its dynamics. What makes the dataset particularly

[2] The firm is a mid-size company with approximately 500 employees. It is vertically integrated and manufactures its products in-house. While the distribution is global, most of the firm's customers are located in Europe.

interesting is the fact that the time of observation can easily be divided in time periods in which the degree of formal authority exercised in the claim process varied significantly: the claim process was first carried out with a low and then with a high degree of formal authority. The roles that management played in monitoring, supervising and changing the routine were distinctively different in different time periods and allow for the examination of a naturally occurring intervention that includes features of a natural experiment (Kogut & Zander, 2000; Gittell et al., 2008), i.e. most of the underlying parameters remained unchanged while displaying variation in our areas of interest. This provides the occasion to identify the impact of changes in the degree of hierarchical authority employed on the routine dynamics.

One of the authors was employed as part-time employee in the firm's quality management department for a period of six months in 2009. During that time we gathered internal documents such as workflow charts and organizational diagrams, and we carried out a series of semi-structured interviews with the employees of the quality department who were in charge of the claim process. In addition, we carried out participant observation to understand the claim process in detail, including the organization's decision structures and related routines, as well as the individual behaviours and habits of all participating employees. This data provided us with a rich understanding of the organization's overall setting and the specificities within the routine.

The main dataset entails a total of 11,560 claims which all consist of action sequences that entail the initial acceptance of the customer inquiry, the assignment and execution of various claim handling procedures and the final closing of the customer claim. A claim starts when customers that have an after-sales inquiry contact their sales representative. Reasons for inquiries that may result in claims include malfunctioning products, incomplete deliveries, or technical problems in the daily operation. Given that many of the firm's products are installed at the customers'

facilities, sales representatives or service engineers often have to visit the customer site in order to assess the problem or directly repair the product. After an inquiry is accepted as a claim, the sales representative needs to fill out a service report by officially opening a claim in the firm's IT system.[3] This report includes information concerning time spent during a customer visit, the distance driven to the customer, failure reasons, the sales representative involved, etc., which employees have to fill out in the software in order to complete a claim's service report. After a claim is opened, the claim is documented within the organization and further actions are taken as the claim progresses. Once all necessary actions are completed the claim is closed. A list of all possible actions can be found in Table 1 and a screenshot from the software system can be found in Figure 1.

Insert Figure 1 and Table 1 here

Changes in the degree of hierarchical authority employed to the routine divide the dataset in four distinct time periods, three of which we use for the analysis:[4]

Period 1: Before 2003, the claim process was quite primitive. The claim procurement between stages was based on paper notes that were internally shipped between the different departments. It often happened that some of them were delayed or simply lost. It was also very difficult to locate a claim after it entered the firm, e.g. when a customer approached the firm a second time. Because of that an analysis of the claim process was nearly impossible for management and only

[3] Various scholars consider event logs systems as valuable tools for systematic analyses. For instance, van der Aalst and Weijters (2004) state that extraction of information from event logs can reveal real execution of business processes.

[4] We use this approach with different time periods following the line of work of March et al. (2000), who also distinguished several historical periods that were characterized by important organizational differences (in the case of March et al., 2000, different patterns of environmental and university change).

very limited formal authority was dedicated to the claim routine. Due to the lack of any possibility to monitor the claims process, period one was therefore characterized by a nearly complete lack of the application of formal authority. In period one, the claim process was effectively in the hands of those who executed it, and in doing so they exercised real authority (Aghion & Tirole, 1997).

Period 2. To deal with the problems and better monitor in the claims process mentioned above, the firm implemented a new IT system at the end of 2003. After its introduction the IT system remained unchanged during our observation period which makes data easy to compare. Between 2003 and 2007, the underlying logic of the routine remained unchanged since management was mostly monitoring and intervening only in extreme cases. One reason for this was that the claim process was officially taking place in the sales and the quality management department, and both managers, while jointly having formal authority over the routine, dedicated their authority to other more pressing topics. Hence, the claim routine received limited formal authority and mostly operated based on the routine participants' real authority, who completed the task based on the historic account and their personal preferences.

Period 3. At the beginning of 2007, the quality manager left the company. At the same time, the company's management concluded that the claim process should simply continue operating without direct management monitoring, i.e. the claim process was considered to be routinized and self-sustaining. A first consequence of this decision was that claim duration increased since none of the employees involved viewed themselves as process owner, especially when unclear situations emerged and exception handling was necessary. This became even more significant when the firm, at the same time, implemented minor changes to some of the product categories. An interviewee explained, 'unfortunately, from the end of 2006 [the firm] was suffering from the

absence of a quality manager, who had been the founder of this process and its coordinator. Our sales were increasing and the claim process needed more attention.' This situation was reinforced by the manager of the sales department, who believed that the original division of responsibility between him and the quality manager would remain. As a result, all routine participants who were not working under his supervision were effectively operating without direct formal authority.[5] Overall, the claim routine was now completely in the hands of those who executed it, and formal authority was never intervening.

In February 2008, a new quality and process manager was hired. During the first months, one of her focus areas was to assess the situation on the various business processes, including the claim process. She used this time to systematically document the situation and discovered major problems in the claim process. Many claims had not been properly processed and were waiting in different stages of the claim process, because they were forgotten, employees had de-prioritized them, and management decisions were needed. The new manager concluded that several immediate actions would be required.

Period 4. As a first step, the new manager applied formal authority to implement and enforced simple rules that reduced complexity and introduced time limits for the execution of each of the claim tasks. In addition, for some product categories it was decided that all products older than 9 months should not be repaired but rather replaced with new ones. Another example is that components with a value below 70 Euros were not repaired but simply replaced. Moreover, priority codes were re-defined to better serve different customer segments. In addition, a maximum duration of seven days was defined for many claim types. In this period, a high degree

[5] The next responsible manager was an extra level up in the hierarchy, and did effectively not want to be bothered with claims.

of formal authority was dedicated to the claims process and the discretion for routine participants was significantly reduced. While taking these steps, senior management also realized that the claim process could be further streamlined if the entire claim process would directly be overseen by only one manager.

This was implemented in July 2009, when the quality function merged with after sales service which was overseen by the sales manager who was already responsible for the sales representatives who initiated and coordinated claim processes. With this change, a high degree of formal authority was focused on the entire claim process, and many of the previously occurring problems disappeared, because the manager could more easily identify cause-effect relationships in routine dynamics, and better address exception handling and employee training. Period four was, therefore, characterized by the new manager pulling back the control of the claims process to her own realm of influence, and consciously applying her formal authority while reducing the real authority of the routines participants.

Measuring routine dynamics

To measure variation over time in the action sequences that were used to deal with complaints, we employ the method pioneered by Pentland (Pentland, 2003a, 2003b; for applications see Pentland et al., 2009, 2010, 2011; Salvato, 2009a, 2009b). This method identifies the actions involved in carrying out a task (the lexicon of actions), and the sequences in which these actions are realized. To measure such variation, Pentland (2003a, b) developed the measure of *sequential variety* which derives from string matching approaches used in biology to compare DNA strings (Abbott, 1995). Sequential variety provides a measure that captures the extent to which a process or routine is performed in different ways (Pentland, 2003a, 2003b). For instance, in a restaurant,

these steps might involve the waiter bringing the menu, taking the order, serving drinks, serving the food, and presenting the bill. They might occur in different sequences, such as serving the food before drinks, etc. The sequential variety variable measures the variety in the sequences of steps that are used to accomplish the same task in a given time period. Pentland's sequential variety measure compares the concrete sequences of actions across several instantiations in which the same task was accomplished. As Pentland et al. (2010) argue, this method can also be used to analyze whether patterns generated by a single routine are changing over time. The sequential variety measure is calculated by comparing the different sequences in which the same task was accomplished in a given time period and indicates how similar the sequences for carrying out the same task in the sample are and thus, variation in sequences for accomplishing the same task. To do so, optimal matching techniques (Abbott 1990, 1995) are applied, which directly measure sequence resemblance (Pentland 2003a, 2003b, Salvato, 2009b). For our dataset we compiled three types of sequential variety using three different time periods: *Quarterly sequential variety* (QSV) on the quarters used in accounting, *monthly sequential variety* (MSV) grounded on monthly time periods, and *weekly sequential variety* (WSV) constructed on weekly occurrences.

Other variables

Apart from sequential variety, the firm's internal documentation allows for a straightforward identification of additional relevant variables (see also Table 2). *Claim duration* measures the time needed between the initiation of the claim process and the completion of it. *SalesRep* identifies the sales representative who initiates and oversees the claim process. *ProductFamily* refers to the firm's three major product lines. *MainItemGoup* further distinguishes the products based on modularized components that are used across product lines. *WarrantyCode* separates

different warranty agreements that the firm offers. *Priority Code* allows the firm to fast-track claims from important customer firms. *ErrorCode* clusters the typical errors that the firm's products have revealed during the last years. *Quarter* allocates each claim to the quarter in which it was initiated.

Insert Table 2 here

4) Results

We start by looking at differences between the four periods in terms of the stability and change of the claim routine. The simplest way to examine its stability and change is shown in Figure 2 which shows that all three sequential variety (SV) measures are not stable but change across time periods. Remarkable is that the overall WSV is lower than the MSV, which is lower than the QSV (see Table 3). For all time periods this difference is also statistically significant with $p<0.001$ (Mann Whitney U test).

Insert Figure 2 and Table 3 here

An explanation for the difference is that daily work during a week is relatively steadier and changes more slowly because the incoming claims are comparatively similar, i.e. there are no seasonal cycles and no individual product groups are more failure prone than others. Also notable are the changes over time as can be seen in Figure 2. While period two[6] displays only limited variation, period three reveals a significant development: Sequential variety initially dropped slightly while then displaying a sharp increase. This reflects the changes concerning

[6] Note that we do not consider period 1 for advanced analysis since the documentation is inconsistent and partially incomplete. This is due to employees being unfamiliar with the new software system and the firm being partially unclear about what needed to be reported.

management authority in this period described above. The routine, having low degrees of management authority and being "left alone" self-develops variation in quarter 21 and 22 that exceeds any previous levels. In period 4 the sharp reduction in SV reflects the high degree of formal authority which was a reaction to the increased variation in the previous period. Senior management decided to oversee the routine "under one roof" and define authority clearly.

In this context an important robustness check is whether the drastic changes in claim duration, i.e. the time between opening and closing a customer after-sales inquiry, may have an influence on SV. Figure 3 shows the changes in claim duration for the firm's ten most used task sequences (covering ~75% of all cases). Again, period 2 remains fairly stable while period 3 shows clear variation towards the end. In period 4 the claim duration is significantly reduced, as expected.

Insert Figure 3 here

A more systematic analysis of routine dynamics is the comparison of SV within the three main time periods. Table 4a-c lists the mean SV on the weekly and monthly basis for all quarters. It also compares these means across quarters using a Mann Whitney U test. The most eminent insight is that in all time periods statistically significant differences can be found across the various quarters. Hence, routine dynamics are pre-eminent, rather than infrequent occurrences and routines are not stable over time when compared using SV as the measure.

Insert Table 4a-c here

We now turn to examining H1, which states that organizational routines to which a high degree of formal authority is applied are more stable over time than those to which a low degree of formal authority is applied. First, the regression analysis shows that time periods with different degrees of formal authority systematically display varying sequential variety on the monthly as

well as the weekly basis. This is no surprise given the above analysis. What is remarkable is that for both regressions (Table 5 and 6) the overall variance of sequential variety explained by the models, with the adjusted R-squared, substantially increases from period 2 to 3 and again from period 3 to 4. We also see that fewer and fewer variables are significant as management either addressed the issues discussed in the hypotheses section, or actively used some of the variables to instill organizationally desired variation in SV. Also, in the regressions for period 4 only very few variables remain significant. These results show that across time periods, managers have recognized which areas have caused routine dynamics and exercised their authority to either lower unwanted SV, or accept it as part of the firm's business practice in a particular time period. Overall, the results clearly point to SV being a useful measure for managers to systematically think about routines.

The further hypotheses are best examined using a regression analysis with WSV and MSV as dependent variables (Table 5 and 6). Several variables of interest are introduced as dummy variables which allows for a focused analysis of the role of each instance of all these variables. For convenience and to facilitate an easy presentation of the results, the hypotheses are discussed using the analysis in both regression tables simultaneously.

Insert Table 5 and 6 here

We start out by two observations. First, we already mentioned the role of claim duration as being a possibly relevant empirical factor that could shape routine dynamics. In fact we find that claim duration is not significant, as expected, in any of the models. Hence, the claims' waiting time does not correlate with SV. Second, the frequency with which a routine is executed offers

interesting findings. While the variable is significant in most models, the signs of the coefficients change from WSV being negative to MSV being positive. The frequent practice of a routine lowers SV on the weekly basis but increases the SV on the monthly basis. This result may at first hand seem puzzling, but it reveals an important insight. A possible explanation is that frequent daily practice of some action sequences may have positive effects for weekly SV through learning but at the same time detrimental effects for SV on the monthly basis. Those effects can include boredom or repetitive fatigue among the employees that are participating in the routine. What is most interesting is that the significance level is reduced for WSV and we find insignificance for MSV for period 4. In this case, the sequence frequency does not explain MSV since management has eliminated those action sequences that were creating variation on this level. It suggests not only that the degree of formal authority in a specific time period is a significant determinant for the detection of routine dynamics, but also that timescales (monthly vs. weekly) are critical for how formal authority is practically applied in routines. In other words, managers can identify SV, in our case MSV, that is "below" the radar and which they do not (want to) detect, or they acknowledge as acceptable.

Insert Figure 4 here

Moving on to the next main area of interest, we now analyze the role of individual participants in an organizational routine. H4a states that individuals have an impact on routine dynamics, and H4b suggests that they do not have an impact. A first way to approach this question is comparing all 35 sales representatives and the mean SVs when they were executing a claim. If a few individuals would drastically disobey what the organization demands, it should show graphically. In fact, we do not find such a result, as Figure 4 shows. Except for very few cases, the overall differences seem moderate. However, the existence of differences already indicates

that there is more to the story. As the regression analysis for WSV shows for time periods 2 and 3, some sales representatives are insignificant and others are not; particularly in period 3 many are significant. In period 4, all sales representatives are insignificant. The pattern of who is significant and who is not in period 2 and 3 is not obvious. Note that the prevalence of experienced sales representatives is not shaping these results, since those who often engage in the routines are not necessarily those with high significance levels (see Figure 5 to identify experienced sales representatives). For MSV we find insignificance in period 2 and some significance in period 3 and 4 (except for two individuals in the latter case). Overall we find support for hypotheses H4a and H4b, since there are time periods in which individual participants significantly change SV on all levels, and we also find instances in which their influence is very restricted (period 4). One main insight is that a general statement cannot be made, since the individuals' role in determining SV depends on other factors, including individual-level as well as surrounding factors. Another main insight is that the degree of formal authority dedicated to the claims process in period 2 was sufficient to reduce routine dynamics on the monthly but not weekly basis. Limited formal authority in period 3 did not control routines dynamics at all, while dedicated formal authority was quite effective to reduce overall SV on the weekly and monthly basis. Hence, the degree of formal authority can significantly shape how routine dynamics occur within defined time periods. It also becomes clear that well defined managerial rules or other initiatives such as targeted training (to those who still create SV), can be effective for reducing routine dynamics.

Insert Figure 5 here

Hypothesis 2 and 3 again reveal interesting details across the time periods. For modularity (H3), which is measured with the variables *ProductFamily* and *MainItemGoup,* we find significance

across all time periods for WSV. Remarkable in this case is that the coefficients for significant results change from being positive in period 2 to being negative in period 3 and 4. A better and more consistent allocation of modularity types helped reduce SV. For MSV, the results are insignificant for period 2 and 4, but significant for period 3. Overall we find that modularity can significantly influence SV, and the degree of formal authority to the firm's modularity can shape routine dynamics. Again we have instances that confirm and disconfirm the hypothesis H4a and 4b.

For quality management (H2) we find similar results. The variables *WarrantyCode*, *PriorityCode*, and *ErrorCode* capture this aspect. For WSV we find highly significant results in period 2 and insignificance in period 3 and 4. The very fact that all of the significant variables have a positive sign suggests that these variables were heavily used to create "unusual" processing, which management may have even supported, e.g. for exception handling. MSV has a few significant instances in period 2 and 3, and several significant results in period 4. Given the degree of formal authority dedicated to the routine in this time period (and her approach to "weeding out" SV as documented by the qualitative evidence) the error codes were creating instability in routine. Interestingly, the quality manager, at the end of her assignment to this routine, pointed out that error codes are the next important step to focus on (she said that before we conducted our regression analysis).

5) Discussion and conclusion

This paper sets out to study the role of hierarchical authority for routine dynamics by examining the sequential variety of a stereotypical routine over a 5 year period. The results allow for a

discussion of how managers can use formal and real authority to strategically go about the sources of routine dynamics. We find that routines are not stable, because of endogenous and exogenous sources of instability. In our dataset endogenous sources are the individual participants of routine, exogenous sources include the organization's approaches to quality management and product modularity, as well as the degree of formal authority dedicated to the routine. In particular the latter provides important insights that are novel to the debate. While recent studies have already empirically shown the existence of routine dynamics (Pentland et al., 2009, 2010, 2011), the present paper contributes by laying out distinct managerial measures that an organization can take to strategically influence routine dynamics. Several contributions and implications follow.

First, the distinctive feature of our study is the explicit inclusion of two different types of authority, formal and real authority (Aghion & Tirole, 1997). The results on the impact of formal authority on routine dynamics extend prior knowledge on routine dynamics by identifying boundary conditions for exogenous and endogenous change of routines, and by shedding light on how exogenous and endogenous influences can managerially be manipulated to shape routine dynamics (Becker et al., 2005; Pentland & Feldman, 2008). We find that routines can change endogenously as long as they are 'left alone', and managers do not apply their formal authority to them. This situation is very common when frequently recurring tasks are standardized, delegated to subordinates (Cyert & March, 1963) and significant hierarchical authority is only deployed when handling exceptions. This represents a fundamental organizational principle which is rooted in the scarcity of managerial attention (Simon, 1947; Ocasio 2011). Note that even in a situation with considerable high-level managerial control, there generally is a range of flexibility within which the routine can change without management being involved (Becker et

al., 2005: 779). In such a situation, while managers hold the formal decision authority, the agents carrying out the routine have discretion and maintain real decision authority (Aghion & Tirole, 1997) which can be the root causes of routine dynamics. Our results show that the degree of formal authority deployed to a routine shapes the extent to which change in routines can emerge, providing proof of concept of an idea that was present in the original contributions on organizational routines (Nelson & Winter, 1982: 109) but that has not yet been demonstrated or developed. This relationship seems crucial since it suggests a neglected lever that organization designers can use to shape the evolution of routines by deciding upon the allocation and distribution of formal and real authority in the organization.

This insight contributes to the debate in various ways. Precisely in a situation where formal authority is employed only in a limited way, we find that routines do not stay stable but develop variation, thereby exhibiting pronounced routine dynamics. This is surprising because this is the paradigmatic case, for which the traditional idea of routines as being stable should hold. Hence, our study presents another empirical counter-example where the traditional standard case does not hold (Feldman, 2000; Pentland et al., 2011) and supports the view that routines can change, also endogenously (Feldman, 2000; Feldman & Pentland, 2003). Further we identify formal authority as an important influence on the change of routines and a means for stabilizing routines. While this basic notion has already been mentioned (a) in the literature on business process reengineering (Hammer & Champy 1990) and (b) in a few theoretical contributions (e.g. Nelson & Winter, 1982; Becker et al., 2005), we show that formal authority may be the key variable for explaining why changes in routines emerge and how decision makers may be able to go about them.

Second, we extend prior research on designing routines and shaping routine dynamics (Pentland & Feldman, 2008) by addressing the problems identified by Becker et al. (2005). On one hand, we lend support to the idea that sequential variety is an empirical measure that is useful for describing routine dynamics and identifying situations of high or low routine dynamics (Pentland, 2003a, 2003b). On the other hand, we identify and illustrate how the sequential variety measure can be used as a managerial tool that allows for reconfiguring routines. Thereby, we address the lack of inefficacies of instruments to influence actual processes and routines which earlier work pointed out (Becker at al 2005). By identifying sequential variety as an appropriate 'target measure' for how well formal authority is used within a routine, we provide an additional lever for managers to extend their influence on routine dynamics. This adds to levers identified in prior literature such as artifacts or IT (Pentland & Feldman, 2008), but also suggests that earlier work that points to the limitations of managerial influence (Becker et al 2005) may have underrated possibilities that emerge when analyzing micro level routine structures. Formal authority does, therefore, provide an alternative that can particularly take into account behavioral and structural aspects of routine. Our analysis not only introduces concrete ways to measure and analyze sequential variety, but also shows how managers can use the resulting insight for shaping routines and their dynamics. Specifically, our regression analysis allows for an unambiguous identification of concrete sources of routine dynamics, such as quality management or product standardization, which has been discussed as hard to measure in prior literature (e.g. Becker et al., 2005).

We also identify the time scales in which managers employ their formal authority as a variable that is important for understanding routine dynamics. The results show that depending on what time scale (e.g., week, months, or quarters) is used, the values of the corresponding sequential

variety measure on the same data will be different. Thus, it is possible that managers can draw different conclusions from analyzing varying sequential variety measures. The choice of an appropriate time scale (Zaheer et al., 1999) for calculating sequential variety is therefore indispensable for any informed discussion of routine dynamics. Furthermore, we contribute to knowledge about how to shape routine dynamics through deploying formal authority by identifying a criterion for *when* to employ formal authority to routines. As Becker et al. (2005: 779) point out, encouraging and putting in place criteria for stopping certain practices are important means for managerial intervention in routines. Our analysis suggests a specific criterion, i.e., threshold values for sequential variety that trigger a change in the deployment of formal authority, e.g. by pulling real decision authority back to the formal authority holder (Agion & Tirole, 1997). This is important because it allows informed managers to systematically define wanted and unwanted routine dynamics on various levels. For instance, a management team may deliberately decide to ignore weekly SV and only focus on monthly SV because these are the routine dynamics relevant in a particular business case. It may also decide to allow SV to emerge for some reasons but not for others, and administer corresponding training for the participants of a routine. Such strategic choices concerning routine dynamics are novel to the debate and important for formulating managerially useful advice concerning routines.

We also acknowledge that our study has a series of limitations. Our data stems from one organization and as such has limited generalizability, e.g. we cannot assess what are in relative terms high or low levels of sequential variety. We also analyzed only one of the firm's routines and not several. Our setting also does not allow for an assessment of the firm's concrete business or performance impact of routine dynamics. All of these are important questions and we leave them to future research. Our research has also identified promising research questions that

include, for instance, which other managerial interventions beyond the ones we measured can lead to diminishing routine dynamics?

To conclude, this paper discusses routine dynamics by illustrating an apparent routine instability. Routine instability can be attributed to many sources and it is the task of an organization designer to identify those and consider appropriate action. This may include the acceptance of instability on some level but may also require severe actions to drastically limit routine dynamics. These actions can include well understood mechanisms of organization design, including modularity, process improvement or quality management, but also requires the consideration of the individual actors and their awareness of the consequences of their own behavior. Formal authority is core to understand routine dynamics and to administer actions suited for a purposeful organizational development. Limited formal authority may create high levels of variation in routine dynamics which may be useful to stimulate exploration in a R&D context. At the same time, applying formal authority to an organizational routine may be useful to create semi-stable SOPs useful in a production context. What is important is that routine dynamics are treated adequately in their particular context. While many studies have discussed routines conceptually, largely based on qualitative accounts, it seems that the field is ripe for complementary quantitative empirical approaches that consider both technical and behavioral aspects of routine dynamics. We hope our paper can be useful for following this path.

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Tables and Figures

Figure 1: Screenshot with examples from the firm's internal IT system

Event history per claim

Claim number	Event ID	Stage	Action name	Time elapsed
61836	2	Goods receival in DK	Send to SPV	1,22
61836	3	SPV	Edit Attachments	0,00
61836	4	SPV	Add Note	0,00
61836	5	SPV	Send to sales	13,70
61836	6	Sales	Send to SPV	2,38
61836	7	SPV	Send to sales	42,76
61836	8	Sales	Credit	0,01
61836	9	Crediting	Credit Complete	18,18
61836	12	Factory completion	Complete	8,01
61836	14	Purchase	Complete	19,70

Figure 2: Sequential Variety (SV) is changing across time periods

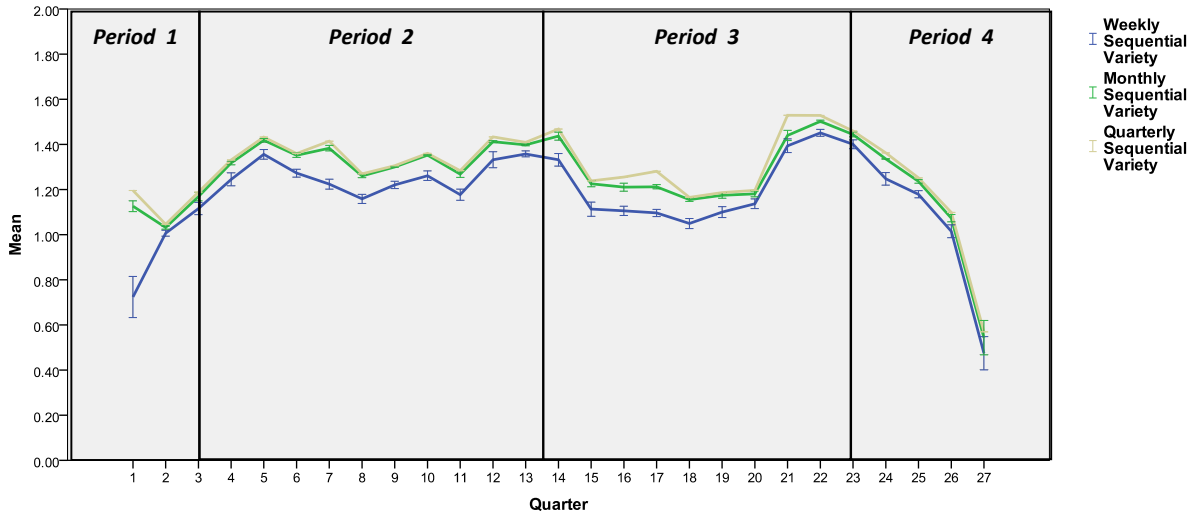

Figure 3: The ten most frequently used routines, i.e. task sequences (covering ~75% of all cases), display significant changes in duration.

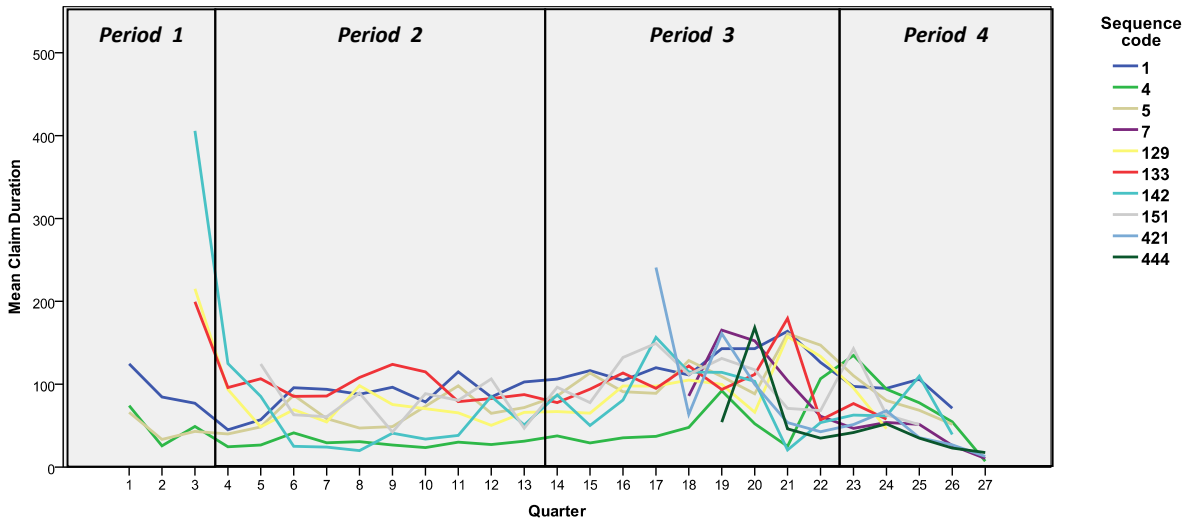

Figure 4: Overall mean sequential variety for all the firm's sales representatives (measures SVs of all claims in which the person was participating)

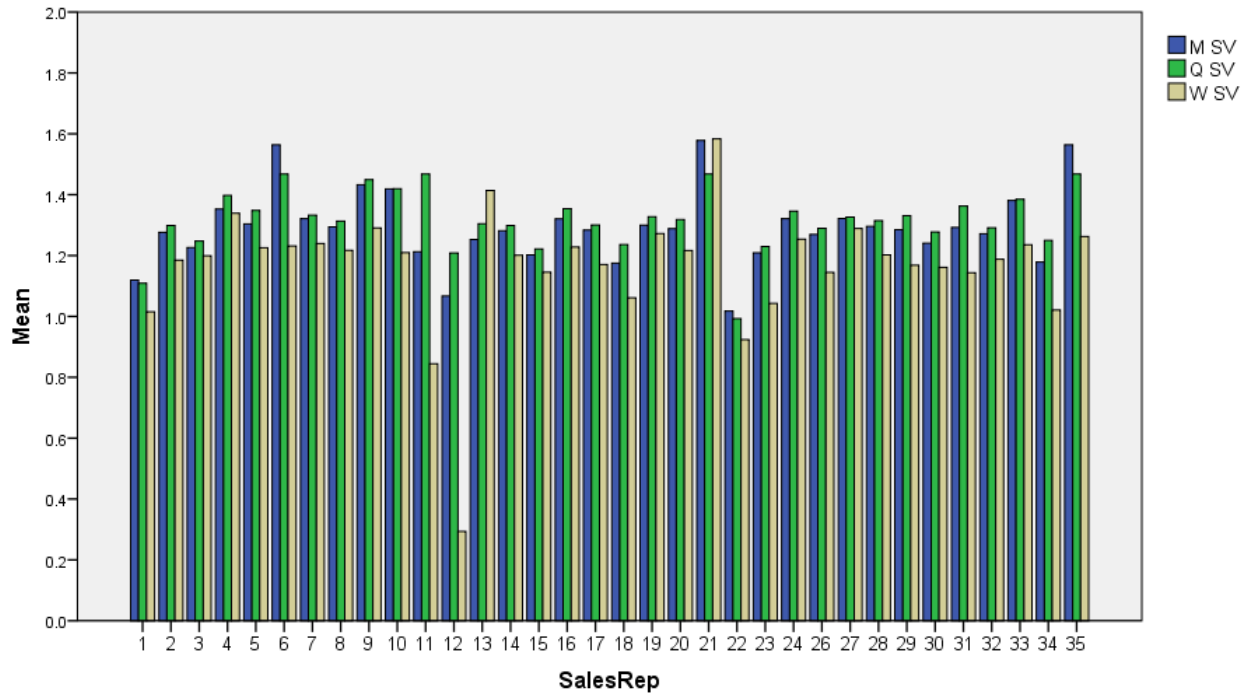

Figure 5: Frequency with which individual participants engaged in specific instances of the routine (covering ~83% of all cases, with the 20 most frequent sequences)

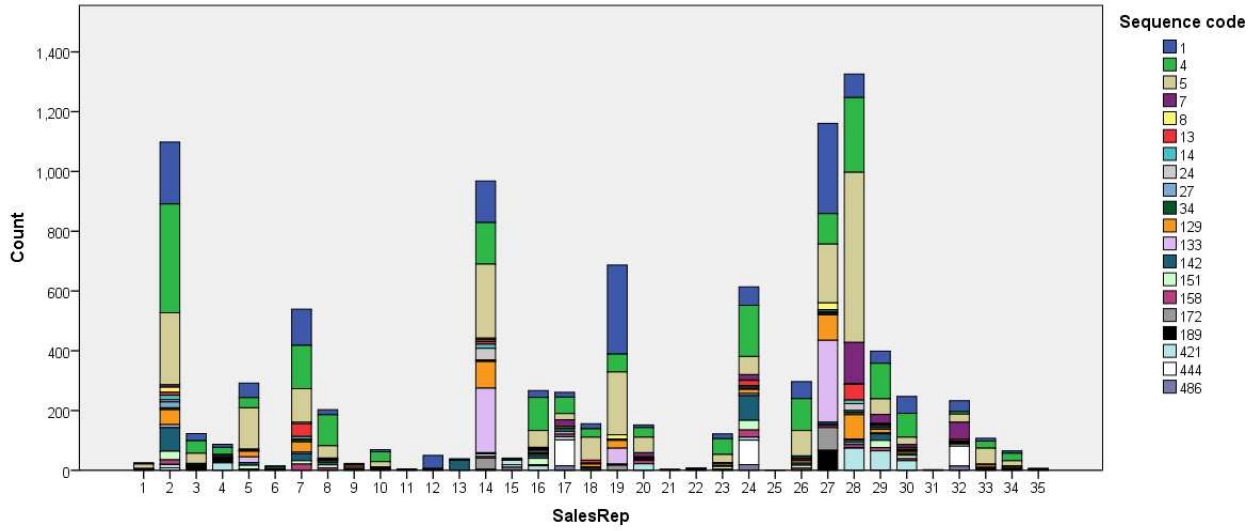

Table 1: Actions within routines

Process routine name	**Stage code**	**Explanation**
Sales	1	Creation of reclamation order in the firm's IT system
Goods receive in warehouse	2	Returned goods are registered in the firm's IT system. Stock levels are updated
SPV test	3	Experienced employee tests returned goods to assess failures. Test reports are administered in the IT system
Crediting	4	Financial transfer to customer or between departments is initiated
Goods received completed	5	Goods receive claim numbers and lacking information is gathered
Factory completion	6	Repair is completed. Information is sent to logistics and purchase departments. Customer is informed
Claim code check	7	Employee checks claim description, change of fail code assignment if necessary
Purchase	8	Purchase of spare parts if necessary
Logistics	9	Shipment is prepared
Closed	10	Employee confirms info within administration and closes the claim

Table 2: Variables and descriptive statistics

Variable name	**Type**	**Min**	**Max**	**Mean**	**Standard Deviation**	**Explanation**
Claim duration	scale	0	713.18	77.67	76.90	Number of days between the opening and closing of a claim
Error text code	discrete	0	93	42.71	27.37	Classification of technical errors
M SV	scale	0.00	1.64	1.30	0.17	Monthly sequential variety
Main item group	discrete	1	2	4.99	3.64	Product categories
Period	discrete	1	4	2.52	0.76	Time period with constant managerial attention
Priority code	discrete	1	5	4.48	1.28	Importance of claim
Product family	discrete	1	3	2.92	0.391	Product types
Q SV	scale	0.57	1.53	1.32	0.13	Quarterly sequential variety
Quarter	discrete	1.00	27.00	13.08	7.00	3-month period
SalesRep	discrete	1	35	18.60	9.87	Sales representative
Sequence Frequency	discrete	1	2394	1225.63	977.09	Frequency with which an action sequence occurred
W SV	scale	0.00	2.09	1.22	0.26	Weekly sequential variety
Warranty code	discrete	1	4	3.03	0.78	Classification of warranty types

Table 3: Mean sequential variety across time

		Weekly Sequential Variety	Monthly Sequential Variety	Quarterly Sequential Variety
Time Period	1	0.9633	1.0570	1.0798
	2	1.2656	1.3363	1.3474
	3	1.2121	1.2925	1.3193
	4	1.2331	1.2844	1.3034

Table 4: Comparisons of Column Means

Comparisons of Column Means for Period 2

	Quarter									
	4	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*
Key	*(A)*	*(B)*	*(C)*	*(D)*	*(E)*	*(F)*	*(G)*	*(H)*	*(I)*	*(J)*
Monthly Sequential Variety	1.3216 *E F H*	1.4219 *A C D E F G H I J*	1.3522 *A E F H*	1.3896 *A C E F G H*	1.2597	1.3002 *E H*	1.3521 *A E F H*	1.2740	1.4134 *A C D E F G H J*	1.3982 *A C E F G H*
Weekly Sequential Variety	1.2641 *E F H*	1.3757 *A C D E F G H*	1.2826 *D E F H*	1.2370 *E H*	1.1641	1.2298 *E H*	1.2737 *D E F H*	1.2012 *E*	1.3515 *A C D E F G H*	1.3596 *A C D E F G H*

Comparisons of Column Means for Period 3

	Quarter								
	14	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*
Key	*(A)*	*(B)*	*(C)*	*(D)*	*(E)*	*(F)*	*(G)*	*(H)*	*(I)*
Monthly Sequential Variety	1.4542 *B C D E F G*	1.2275 *D E F G*	1.2184 *E F G*	1.2141 *E F G*	1.1569	1.1760 *E*	1.1890 *E*	1.4701 *B C D E F G*	1.5082 *A B C D E F G H*
Weekly Sequential Variety	1.3677 *B C D E F G*	1.1418 *D E*	1.1239 *D E*	1.0834	1.0631	1.1113 *D E*	1.1544 *C D E F*	1.3892 *B C D E F G*	1.4672 *A B C D E F G H*

Comparisons of Column Means for Period 4

	Quarter				
	23	*24*	*25*	*26*	*27*
Key	*(A)*	*(B)*	*(C)*	*(D)*	*(E)*
Monthly Sequential Variety	1.4452 *B C D E*	1.3362 *C D E*	1.2388 *D E*	1.0726 *E*	.5500
Weekly Sequential Variety	1.4071 *B C D E*	1.2696 *C D E*	1.1825 *D E*	1.0301 *E*	.4927

All results are based on two-sided tests assuming equal variances with significance level .05. For each significant pair, the key of the smaller category appears under the category with larger mean.

Table 5: OLS with weekly sequential variety as DV

VARIABLES	All Periods (4-27 Quarters)		Period 2 (4-13 Quarters)		Period 3 (14-22 Quarters)		Period 4 (23-27 Quarters)	
ClaimDuration	$3.17x10^{-6}$	(0.000)	$2.62x10^{-5}$	(0.000)	$-05.56x10^{-5}$	(0.000)	$4.82x10^{-5}$	(0.000)
SequenceFrequency	$-1.7x10^{-5}$***	(0.000)	$2.38x10^{-6}$***	(0.000)	$-2.16x10^{-5}$***	(0.000)	$-1.23x10^{-5}$*	(0.000)
1.SalesRep	-0.029	(0.045)			0.093**	(0.029)	0.030	(0.058)
2.SalesRep	-0.147*	(0.062)	-0.008	(0.071)	-0.120	(0.146)		
3.SalesRep	-0.168***	(0.048)	-0.109***	(0.029)	0.033	(0.085)		
4.SalesRep	-0.498***	(0.121)			-0.425*	(0.177)		
5.SalesRep	-0.753***	(0.049)	-0.082	(0.125)	0.304	(0.219)		
6.SalesRep	-0.082*	(0.041)	0.020	(0.014)	-0.022	(0.035)	0.013	(0.063)
7.SalesRep	-0.065	(0.042)	0.014	(0.022)	0.050*	(0.025)		
8.SalesRep	-0.067	(0.043)			0.074**	(0.025)	-0.024	(0.035)
9.SalesRep	-0.058	(0.044)			0.056*	(0.026)		
10.SalesRep	-0.029	(0.042)			0.082***	(0.024)	0.046	(0.037)
11.SalesRep	-0.034	(0.044)			0.079**	(0.028)	0.069	(0.069)
12.SalesRep	-0.100*	(0.045)			0.027	(0.027)		
13.SalesRep	-0.048	(0.042)	0.029	(0.018)	0.053*	(0.025)	0.029	(0.034)
14.SalesRep	-0.097*	(0.042)	-0.041*	(0.017)				
15.SalesRep	-0.005	(0.041)	0.037*	(0.015)	0.129***	(0.023)	-0.125	(0.176)
16.SalesRep	-0.055	(0.040)	0.006	(0.013)	0.062**	(0.022)	0.029	(0.035)
17.SalesRep	-0.102*	(0.042)	-0.066*	(0.027)	0.031	(0.022)	-0.014	(0.037)
18.SalesRep	-0.047	(0.043)			0.070**	(0.024)	0.052	(0.054)
19.SalesRep	-0.098*	(0.045)	-0.042	(0.024)	0.078	(0.100)		
20.SalesRep	-0.100*	(0.048)			0.027	(0.033)		
14 SalesRep insign. results								
1.Mainitemgroup	0.017*	(0.008)	0.020	(0.012)	0.019	(0.013)	0.027	(0.021)
2.Mainitemgroup	0.011	(0.009)	0.030*	(0.014)	-0.014	(0.016)	-0.038	(0.024)
3. Mainitemgroup	-0.001	(0.008)	0.028*	(0.012)	-0.023	(0.013)	0.000	(0.022)
4.Mainitemgroup	-0.004	(0.036)	0.045	(0.049)	0.031	(0.083)	-0.248**	(0.089)
5.Mainitemgroup	0.035	(0.020)	0.069**	(0.025)	-0.165	(0.112)	0.049	(0.103)
6.Mainitemgroup	-0.555**	(0.214)			-0.544*	(0.218)		
13 Mainitemgroup insign. results								
3 Productfamily insign. results								
1.Warrantycode	0.012	(0.014)	0.024*	(0.012)	-0.005	(0.023)	-0.004	(0.027)
2 Warrantycode insign. results								
1.Prioritycode	0.346***	(0.065)	0.346***	(0.071)	0.072	(0.219)		
3 Prioritycode insign. results								
1.Errortextcode	0.079**	(0.027)	0.143**	(0.047)	0.081	(0.055)	0.017	(0.045)
2.Errortextcode	0.070	(0.036)	0.157**	(0.056)	0.050	(0.078)	-0.102	(0.097)
3.Errortextcode	0.044	(0.026)	0.134**	(0.046)	0.049	(0.055)	-0.019	(0.051)
4.Errortextcode	0.056*	(0.027)	0.094	(0.054)	0.058	(0.054)	-0.012	(0.042)
5.Errortextcode	0.067	(0.037)	0.181**	(0.057)	0.064	(0.076)	-0.059	(0.098)
6.Errortextcode	0.055	(0.031)	0.138**	(0.052)	0.029	(0.062)	0.035	(0.088)
7.Errortextcode	0.047	(0.029)	0.137*	(0.061)	0.047	(0.056)	-0.014	(0.048)
8.Errortextcode	0.041	(0.027)	0.129**	(0.047)	0.080	(0.058)	-0.010	(0.055)

9.Errortextcode	0.047	(0.028)	0.118*	(0.049)	0.070	(0.058)	0.007	(0.056)
10.Errortextcode	0.095**	(0.033)	0.176***	(0.052)	0.088	(0.073)	-0.007	(0.129)
11.Errortextcode	0.071*	(0.030)			0.057	(0.057)	0.018	(0.052)
12.Errortextcode	0.094	(0.063)	0.162*	(0.083)	-0.147	(0.225)	0.014	(0.130)
13.Errortextcode	0.047	(0.026)	0.137**	(0.046)	0.031	(0.055)	-0.018	(0.046)
14.Errortextcode	0.032	(0.049)	0.151*	(0.071)	-0.016	(0.085)		
15.Errortextcode	0.062*	(0.028)	0.157***	(0.048)	0.055	(0.060)	-0.130	(0.078)
16.Errortextcode	0.035	(0.037)	0.162*	(0.064)	0.010	(0.068)	-0.044	(0.060)
17.Errortextcode	0.052	(0.027)	0.147**	(0.047)	0.036	(0.056)	-0.022	(0.061)
18.Errortextcode	0.008	(0.040)	0.158*	(0.061)	-0.078	(0.073)		
19.Errortextcode	0.047	(0.035)	0.138*	(0.055)	0.035	(0.069)	0.204	(0.130)
20.Errortextcode	0.047	(0.030)	0.150**	(0.049)	-0.020	(0.062)	0.097	(0.067)
21.Errortextcode	0.031	(0.029)	0.124*	(0.051)	0.017	(0.058)	0.029	(0.056)
22.Errortextcode	0.079**	(0.029)	0.188***	(0.049)	0.026	(0.069)	0.068	(0.083)
23.Errortextcode	0.012	(0.029)	0.112*	(0.050)	-0.028	(0.059)	-0.032	(0.056)
24.Errortextcode	0.090	(0.073)	0.192*	(0.094)	0.070	(0.138)		
32 Errortextcode insign. results								
1.Quarter	0.164***	(0.023)						
2.Quarter	0.268***	(0.023)						
3.Quarter	0.381***	(0.022)	0.109***	(0.014)				
4.Quarter	0.286***	(0.022)	0.015	(0.014)				
5.Quarter	0.237***	(0.023)	-0.035*	(0.015)				
6.Quarter	0.153***	(0.023)	-0.104***	(0.016)				
7.Quarter	0.212***	(0.023)	-0.040**	(0.015)				
8.Quarter	0.242***	(0.022)	-0.008	(0.015)				
9.Quarter	0.173***	(0.023)	-0.081***	(0.016)				
10.Quarter	0.346***	(0.023)	0.100***	(0.017)				
11.Quarter	0.359***	(0.023)	0.111***	(0.017)				
12.Quarter	0.356***	(0.023)						
13.Quarter	0.129***	(0.024)			-0.217***	(0.016)		
14.Quarter	0.112***	(0.024)			-0.226***	(0.016)		
15.Quarter	0.061**	(0.023)			-0.285***	(0.016)		
16.Quarter	0.051*	(0.023)			-0.291***	(0.016)		
17.Quarter	0.105***	(0.024)			-0.234***	(0.017)		
18.Quarter	0.149***	(0.024)			-0.189***	(0.017)		
19.Quarter	0.362***	(0.024)			0.022	(0.017)		
20.Quarter	0.435***	(0.024)			0.092***	(0.017)		
21.Quarter	0.375***	(0.025)						
22.Quarter	0.240***	(0.025)					-0.136***	(0.014)
23.Quarter	0.158***	(0.025)					-0.221***	(0.014)
24.Quarter	0.000	(0.027)					-0.372***	(0.017)
25.Quarter	-0.545***	(0.050)					-0.907***	(0.041)
26. Quarter	0.000	(0.027)					-0.372***	(0.017)
27. Quarter	-0.545***	(0.050)					-0.907***	(0.041)
Constant	1.101***	(0.065)	1.052***	(0.104)	1.423***	(0.150)	1.414***	(0.059)
Observations	11,581		4,925		4,287		1,219	
R-squared	0.338		0.146		0.359		0.522	

Standard errors in parentheses; *** p<0.001, ** p<0.01, * p<0.05

Explanation: Apart from the variable ClaimDuration and SequenceFrequency, all variables are introduced as dummies. To shorten the length of the table, all instances without significance are summarized in one row which is displayed in italics.

Table 6: OLS with monthly sequential variety as DV

VARIABLES	All Periods (4-27 Quarters)		Period 2 (4-13 Quarters)		Period 3 (14-22 Quarters)		Period 4 (23-27 Quarters)	
Claimduration	$3.39x10^{-5}$	(0.000)	$5.97x10^{-5}$	(0.000)	$8.34x10^{-5}$	(0.000)	$1.5111x10^{-4}$	(0.000)
SequenceFrequency	$1.29x10^{7}$***	(0.000)	4.9310^{6}***	(0.000)	$9.53x10^{-6}$***	(0.000)	$9.79x10^{-6}$	(0.000)
1.SalesRep	-0.053**	(0.020)						
2.SalesRep	-0.050*	(0.022)	0.006	(0.010)				
3.SalesRep	-0.061**	(0.022)			0.026	(0.017)	0.062*	(0.026)
4.SalesRep	-0.066*	(0.029)			0.068	(0.080)	0.001	(0.021)
5.SalesRep	0.055	(0.035)			0.201*	(0.084)		
6.SalesRep	-0.050*	(0.020)	0.007	(0.005)	0.115	(0.081)		
7.SalesRep	-0.055**	(0.021)	-0.007	(0.007)	0.126***	(0.037)		
8.SalesRep	-0.025	(0.023)	0.005	(0.011)	0.178***	(0.049)		
9.SalesRep	-0.302***	(0.060)			-0.151	(0.102)		
10.SalesRep	-0.129***	(0.024)	-0.013	(0.046)	0.177	(0.126)		
11.SalesRep	-0.061	(0.033)	-0.011	(0.022)				
12.SalesRep	-0.050*	(0.020)	0.008	(0.005)	0.022	(0.020)	-0.035	(0.028)
13.SalesRep	-0.058*	(0.025)					-0.010	(0.018)
14.SalesRep	-0.053*	(0.021)	0.003	(0.008)	0.045**	(0.014)		
15.SalesRep	-0.043*	(0.021)			0.062***	(0.014)	-0.010	(0.016)
16.SalesRep	-0.063**	(0.022)			0.042**	(0.015)		
17.SalesRep	-0.041*	(0.020)			0.054***	(0.014)	-0.015	(0.016)
18.SalesRep	-0.040	(0.022)			0.061***	(0.016)	0.026	(0.031)
19.SalesRep	0.049	(0.059)			0.199*	(0.101)		
20.SalesRep	-0.044*	(0.022)			0.058***	(0.015)		
21.SalesRep	-0.054**	(0.020)	-0.012	(0.007)	0.049***	(0.014)	-0.005	(0.015)
22.SalesRep	-0.051*	(0.020)	-0.001	(0.006)				
23.SalesRep	-0.029	(0.020)	0.003	(0.006)	0.084***	(0.013)	0.050	(0.078)
24.SalesRep	-0.042*	(0.020)	0.004	(0.005)	0.060***	(0.013)	0.003	(0.016)
25.SalesRep	-0.066**	(0.020)	-0.010	(0.010)	0.041**	(0.013)	-0.035*	(0.017)
26.SalesRep	-0.050*	(0.021)			0.051***	(0.014)	0.021	(0.024)
27.SalesRep	-0.220*	(0.086)			-0.146	(0.135)		
28.SalesRep	-0.051*	(0.021)			0.049**	(0.016)	-0.013	(0.016)
29.SalesRep	-0.026	(0.022)	0.011	(0.009)	0.168**	(0.057)		
30.SalesRep	-0.064**	(0.024)			0.041*	(0.019)		
31.SalesRep	0.055	(0.042)			0.198**	(0.075)		
3 SalesRep insign. results								
1.Mainitemgroup	0.010*	(0.005)	-0.001	(0.005)	0.021	(0.012)	0.022	(0.012)
2.Mainitemgroup	0.009*	(0.004)	0.007	(0.004)	0.014	(0.007)	0.018	(0.009)
3.Mainitemgroup	-0.006	(0.005)	0.001	(0.005)	-0.018*	(0.009)	0.000	(0.011)
4.Mainitemgroup	-0.007	(0.004)	0.001	(0.005)	-0.021**	(0.007)	0.005	(0.010)
5.Mainitemgroup	-0.149**	(0.053)			-0.182*	(0.073)	-0.090	(0.078)
14 Mainitemgroup insign. results								
3 Productfamily insign. results								
4.Prioritycode	-0.040	(0.032)	-0.057*	(0.026)	0.068	(0.126)		
5.Prioritycode	-0.007	(0.004)	-0.004	(0.005)	-0.019*	(0.009)	-0.006	(0.010)
2 Priority code insing. Results								
1.Errortextcode	0.035*	(0.018)	-0.007	(0.021)	0.084	(0.045)	0.076	(0.043)
2. errortextcode	-0.007	(0.004)	-0.004	(0.005)	0.084	(0.045)	0.076	(0.043)

3.Errortextcode	0.026	(0.014)	-0.009	(0.023)	0.043	(0.032)	0.043*	(0.021)
4.Errortextcode	-0.053*	(0.022)			-0.047	(0.039)	0.021	(0.037)
5.Errortextcode	0.001	(0.013)	-0.015	(0.017)	0.052	(0.034)	0.050*	(0.025)
6.Errortextcode	0.033*	(0.015)			0.047	(0.033)	0.025	(0.023)
7.Errortextcode	0.038	(0.025)			0.044	(0.057)	0.056*	(0.026)
8.Errortextcode	0.077	(0.039)			0.072	(0.057)	0.157*	(0.079)
9.Errortextcode	0.036	(0.023)			0.049	(0.040)	0.091*	(0.040)
10.Errortextcode	0.025	(0.034)	-0.128**	(0.049)	0.101	(0.060)	0.082	(0.058)
11.Errortextcode	-0.002	(0.031)	-0.076*	(0.035)	0.079	(0.058)		
12.Errortextcode	0.017	(0.015)	0.005	(0.018)	0.008	(0.035)	0.060*	(0.030)
45 Errortextcode insign. results								
1.Quarter	-0.109***	(0.011)						
2.Quarter	0.038***	(0.011)						
3.Quarter	0.173***	(0.011)						
4.Quarter	0.274***	(0.011)	0.100***	(0.005)				
5.Quarter	0.204***	(0.011)	0.030***	(0.005)				
6.Quarter	0.243***	(0.011)	0.066***	(0.006)				
7.Quarter	0.111***	(0.011)	-0.060***	(0.006)				
8.Quarter	0.148***	(0.011)	-0.021***	(0.006)				
9.Quarter	0.197***	(0.011)	0.032***	(0.006)				
10.Quarter	0.124***	(0.011)	-0.045***	(0.006)				
11.Quarter	0.259***	(0.011)	0.092***	(0.006)				
12.Quarter	0.247***	(0.011)	0.079***	(0.006)				
13.Quarter	0.296***	(0.011)						
14.Quarter	0.080***	(0.012)			-0.206***	(0.009)		
15.Quarter	0.069***	(0.012)			-0.212***	(0.009)		
16.Quarter	0.063***	(0.011)			-0.225***	(0.009)		
17.Quarter	0.010	(0.012)			-0.273***	(0.009)		
18.Quarter	0.030*	(0.012)			-0.249***	(0.010)		
19.Quarter	0.044***	(0.012)			-0.235***	(0.010)		
20.Quarter	0.317***	(0.012)			0.033**	(0.010)		
21.Quarter	0.353***	(0.012)			0.067***	(0.010)		
22.Quarter	0.289***	(0.012)						
23.Quarter	0.179***	(0.012)					-0.107***	(0.006)
24.Quarter	0.083***	(0.012)					-0.202***	(0.006)
25.Quarter	-0.086***	(0.013)					-0.367***	(0.008)
26.Quarter	-0.618***	(0.024)					-0.888***	(0.018)
Constant	1.213***	(0.032)	1.326***	(0.039)	1.352***	(0.086)	1.412***	(0.026)
Observations	11,581		4,925		4,287		1,219	
R-squared	0.606		0.324		0.571		0.836	

Standard errors in parentheses; *** p<0.001, ** p<0.01, * p<0.05

Explanation: Apart from the variable ClaimDuration and SequenceFrequency, all variables are introduced as dummies. To shorten the length of the table, all instances without significance are summarized in one row which is displayed in italics.