Path dependence and meta-routines in organizations: the Toyota Production System re-examined

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Abstract

We understand path dependence as resulting from a combination of sensitivity to initial conditions and lock-in. Applying this concept to the analysis of organizational change raises major theoretical issues. We illustrate this with an extensive re-analysis and reflection on the development of the Toyota Production System (TPS). Firstly, this analysis shows that assessing the initial conditions, both their contents and their timing, is a major research task. Toyota's response to external challenges significantly depended on its specific *meta*-routine of "self-testing, trial and error" rather than simply reflected general circumstances. The meta-routine was not only to be part of the initial conditions, but also locked in Toyota to her production system in a dynamic sense. Our analysis thus, secondly, shows that the empirical distinction between sensitivity to initial conditions and lock-in is not as clear-cut as is often summarily assumed. In addition, special events during the crucial years of 1949 and 1950 were vital for locking-in Toyota to its still infant production system. All in all, a focus on (meta-) routines relating initial conditions and lock-in in combination with attention to specific events during a critical juncture, enable us to steer a middle road between overly deterministic and overly voluntaristic interpretations of organizational change.

1. Introduction

The notion of path-dependence, that was first explicitly applied to explain prevailing technical standards (David, 1985, Arthur, 1991), has been discussed in recent decades as a useful way of analyzing the development of a range of other subjects, including national innovation systems (Iammarino, 2005), industrial districts (Kenney and von Burg, 1999), and politics (Pierson, 2004). At the micro-level of individual organizations for a long time much less elaborate use of the concept has been made, with the notable exception of David (1994), and only recently the interest in this field of application has increased (e.g. Sydow et al., 2005). We submit that using path dependence for the historical analysis of organizational change can be very fruitful too. The key elements of path dependence – sensitivity to initial conditions and lock-in mechanisms - need to be conceptualized more precisely.

We do so empirically by re-examining the Toyota Production System. It is a subject that is studied before (Cusumano, 1985, Fujimoto, 1999, Coriat, 2000). We draw on a wide range of relevant empirical literature, including recent accounts that have not been used much until now (Wada and Yui, 2002 and Hino, 2006) and analyze the case from a more elaborate path dependence perspective than in earlier publications (compare Coriat, 2000). This, we submit, sheds new light on both this important empirical case as well as the conception of path dependence. Our empirical analysis includes comparisons with Toyota's main Japanese rival, Nissan.

2. Path dependence and meta-routines

Where in fields that have a more extensive history in using path dependence the precise understanding of this concept is certainly not uncontested (e.g., see Schwartz, 200x and Beyer, 2005), a study of organizational change in these terms implies specific problems due to the complex, multiple nature of organizations compared to technical artefacts. In the common interpretation, sensitivity to initial conditions is defined as separate from lock-in mechanisms. The latter are usually defined in the path dependence literature; Beyer (2005) for instance distinguishes several mechanisms creating continuity, that is,

increasing returns, sequences of events, functionality, complementarity, power, legitimacy and conformity.[1] In vain, however, one searches for a theoretical elaboration on the nature of initial conditions. In the strategy field, studies using the term initial conditions provide us something to hold on by alternatively understanding them as (mainly) internal to the firm (Porter, 1991; Doz, 1996 and Dahlquist et al, 2000) or as external (Swaminathan, 1996). Furthermore, specific (sequences of) events are often regarded as playing a vital role during the initial selection, but there is no clear consensus in the literature whether there are part of initial conditions or not. Goldstone (1998, p. 834) explicitly poses that: "…a system that exhibits path dependency is one in which …. the particular outcome … depends on the choices or outcomes of *intermediate events* between the initial conditions and the outcome" (italics added). In our view, this understanding of "initial conditions" is akin to Stinchcombe's (1965) general societal structure that "imprints" organizations during their time of founding.[2] This perspective seems at odds with the typical path dependence interpretation that "initial conditions are chance-like" (Howlett and Rayner, 2006, p. 5). In line with this, some authors explicitly seem to equate initial conditions with a "critical juncture" (see for instance, Mahoney, 2000) and consider the initial conditions themselves as very sensitive to ("small") events (e.g. Dopfer, 1991); even Goldstone in an earlier publication (1991, p. 60) defines events as constituting initial conditions.

Prevailing (external) circumstances, small events, the phenomenon to be explained itself and the way it is selected are all often (implicitly) amalgamated in one diffuse category of "initial conditions". This is a serious shortcoming of the literature, since identifying initial conditions should be an important part of the research to be carried out under the banner of path dependence (Goldstone, 1998, p. 841). In fact, as we argue here and show below for Toyota, what conditions are salient is not obvious both for the actors themselves and the scholars studying their behaviour. In particular the selection mechanisms as part of the initial conditions need to be more clearly conceptualized, since initial selection is less undetermined than customarily assumed in the path dependence

[1] Beyer avoids the term "lock-in", since he – unlike us – equates this term with a complete absence of change of the phenomenon as it initially emerged.

[2] Personal communication with Jack Goldstone. Please note that Stinchcombe himself did not use the term "imprinting forces".

literature. We agree with Sydow et al. (2005, p. 28) who point out that the stage before a path starts "is not dominated by undirected search and random selection" and, unlike the authors quoted, consider "imprinting" (Stinchcombe, 1965; Marquis, 2003) during initial conditions as part and parcel of a path dependent process. The concept of meta-routine in particular fulfils a need to be more specific about what does the initial selecting. As organizations may fruitfully be seen as collections of routines held in common (Becker, 2004), where a routine is defined as the inclination of an agent to choose a particular solution for a type of problems confronted, the mechanisms that give direction to the path an organization takes may best be called meta-routines.[3] Meta-routines select among the routines that may be developed for a specific kind of problem, or suggest a relatively small set of salient routines that may each provide solutions.

These meta-routines are thus a part of the initial conditions. Like other initial conditions, meta-routines can be both external and internal to the firm. Some of these routines prevail in the industry as a whole or even in the economy at large, some emerge within the organization itself and thus are firm specific. Industry or economy wide routines can be held responsible for the time-sensitive social "imprinting" (Stinchcombe, 1965; Marquis, 2003). The term imprinting should not be taken too literally, as there are always interpretation and conscious action by agents involved (Johnson, 2007). In this line, Porter (1991) argues that (internal) initial conditions partly result from earlier managerial choices in their turn reflecting then current environment. Boeker (1988, p.35), inspired by Stinchcombe (1965), connects internal and external elements of initial conditions by the figure of the founder of firms, who acts as "…a primary conduit by which larger social conditions become incorporated into organizational strategy and structure."

Meta-routines as an analytical instrument bridges initial conditions and lock-in mechanisms There are two general reasons to qualify the strict separation of initial conditions and lock-in mechanisms. First, initial conditions are a combination of elements and gradual changes in one or more of these elements can create a context that differs from the initial conditions, but that is still related to it. Second, organizational

[3] Kogut & Zander (1996) talk about "higher-order principles". Their analysis is largely along similar lines, but stresses identity, symbolic communication, and dialogue more than we do in our more mundane account.

features such as a company's production system are manifold phenomena that are not created or selected in their entirety at a certain distinct point of time; the phenomenon under study itself is dynamic (path dependence of routines as collorary to routines creating path dependence).

Regarding the first consideration, as Schwartz (200x) argues, initial conditions partly act as "constant causes" (see Stinchcombe, 1968). This undermines the whole concept of path dependence as the mechanisms of "production" and "reproduction" are no longer distinct (Schwartz, 200x). The second consideration implies that more than one path should be investigated, which is not incompatible with at least some interpretations of path dependence (e.g. Mahoney, 2000 and Djelic and Quack, 2007), but nevertheless casts doubts on a straightforward application of the concept. Still, we think using the concept of meta-routines can bridge the current gap between sensitivity to initial conditions and lock-in mechanisms, without loosing the analytical advantages of to some extent separating the two elements in a path dependent analysis.

Meta-routines develop over time, exerting a lasting influence on later developments. They thus conceptually provide the dynamic link between initial conditions and lock-in. Not only the selection mechanism, but *what* is selected should be conceptualized as routines. As Becker (2004) has noted: routines ensure path dependence in organizations. Our focus on meta-routines does not imply that the twofold nature of path dependence is denied and we do not claim that initial conditions and lock-in mechanisms should be discussed in terms of meta-routines only. Rather, we argue that initial conditions are underspecified in the path dependence literature. The distinction between external and internal conditions and the role of selection mechanisms in the shape of meta-routines are not sufficiently acknowledged. There is also no consensus on the exact conceptual status of (sequences of) events, which is disturbing since they figure also as lock-in mechanisms. This lack of clarity makes a straightforward use of the concept of path dependence in a context of organizations questionable, the more organizational phenomena are – unlike technical artefacts - multi-faceted, which makes distinguishing the effects of initial conditions and lock-in mechanisms very problematic. Therefore, constitutive elements of path dependence, in particular initial conditions, must be unpacked, and the interrelations between them further analyzed and conceptualized. We

have submitted that in particular the concept of meta-routines will allow one to do this. These theoretical considerations lead to pressing questions for empirical research. Which initial conditions can be specified? Can sensitivity to initial conditions and lock-in mechanisms be related to each other, in particular through the concept of meta-routines? How do meta-routines interact with specific circumstances and (sequences of) events in selecting and locking-in certain choices?

The origin and development of the often-studied Toyota Production System (TPS) seems an appropriate case for such an empirical application. We show that one of the elements hinted at by Coriat (2000), a firm specific meta-routine, rooted in the prehistory of the Toyota Motor Company, rather than general circumstances, was predominant in shaping TPS. The meta-routine adopted by Toyota was not only part of the initial conditions, but has shaped the development of the company ever since. Meta-routines created a dynamic lock-in guiding the development of TPS, in interaction with certain events, in particular during the crucial 1949-1950 period (Coriat, 2000). We are thus steering a middle road between overly deterministic and overly voluntaristic interpretations of organizational change (Beyer, 2005).

3. Toyota and the development of the Japanese Car Industry

Several Japanese firms started to produce cars on a small scale from around 1900, but – with the exception of one of the forerunners of Nissan from 1911 – without much enduring success (Odaka et al., 1988, 21-27). After the Kanto earth quack from 1923, demand for buses and trucks boomed, and the leading U.S. car makers Ford (1925) and GM (Chevrolet in 1927) opened so-called knock-down plants on Japanese soil, driving the domestic producers from the market (Odaka et al., 1988, 27). In May 1936, however, five years after Japan had occupied Manchuria and under war economy circumstances, a new law designed by the military increased import duties to make production by foreign companies virtually impossible (for a time table of crucial changes external and internal to Toyota between 1931 and 1955, see table 1). Ford and GM finally ended their activities in Japan completely in 1939 and left the market to domestic producers recognized by the Japanese government: Nissan, Toyota, and three firms merging into

Table 1. Important events external and internal to Toyota (1931-1955)			
Date	**Environment**	**Date**	**Toyota**
1931	Japan invades Manchuria		
May 1936	Japan virtually prohibits imports of cars		
		1937	Founding Toyota Motor Company
		1938	JIT-production at Koromo Plant
1939	Ford and GM discontinue car production in Japan		
July 1941	Full U.S.-British-Dutch embargo on Japanese imports		
Aug. 1945	Japan surrenders to allied powers		
		1947	start multi-machine handling in machine shop
		c. 1948	Start JIT in machine shop
April 1949	anti-inflation measures (Dodge Line)		
Oct. 1949	ban on producing luxury cars lifted	Nov. 1949	Toyota faces bankruptcy
		May 1950	split Toyota Motor and Sales
June 1950	Start Korea War; US place mass orders for trucks	June 1950	lay-offs of 1,700 workers; Kiichiro Toyoda resigns
		1955	Toyota issues first mass-produced car

United Motors (later called Isuzu) in 1939. Nissan pioneered domestic large scale production of cars in Japan from 1935. Kiichiro Toyoda was preparing this under the roof of textile machinery factory Toyoda Automatic Loom Works from 1930 - the Toyota Motor Company was founded in 1937. The government forced automakers to focus on military trucks by then and in 1939 even more or less forbade further luxury car production. This ban was finally removed in October 1949, more than five years after Japan's defeat in World War II. After Toyota had almost gone bankrupt due to capital shortage, the Korea War saved the Japanese auto industry from extinction: the U.S. forces placed massive orders for military trucks from June 1950. Like Nissan, Toyota developed into a mass producer of automobiles – from 1965 it produced more passenger cars than trucks.

Toyota became famous for the Toyota Production System. Its two closely related main elements are (1) "lean production", of which the just-in-time-system - which implies that parts are only made or delivered when needed at the next stage in the production process, thus minimizing intermediate stocks - is the most well-known element, and (2) the use of a both flexible and integrated multi-layered network of suppliers. Given limitations of space, we focus on the first element of lean production. The gradual extension of lean production, that was pioneered by Toyota from 1938, reflects as we will argue, Toyota's meta-routine of "self-testing, trial and error." After seeing the successes of the system (Womack et al., 1990) other car makers, both in- and outside Japan, have tried to emulate Toyota's approach, but have certainly not completely succeeded in this. Toyota is considered the best organized and most productive carmaker in the world for decades and currently is at the point of taking over the number one global position from ailing General Motors.

4. Assessing the Initial Conditions for Lean Production

Opening the black box of initial conditions implies precisely separating individual causes of the emergence of the phenomenon under study. We have structured the discussion on the emergence of TPS presented below accordingly. This strategy illuminates the problematic nature of a straightforward path dependence approach of organizational change, by specifying the manifold nature of initial conditions both in contents and timing and the fuzzy border between sensitivity to initial conditions and lock-in mechanisms.

Dating the Initial Conditions. A first major analytical problem is dating the start of a phenomenon, and thus the initial conditions. Toyota Motor Company's founder, Kiichiro Toyoda, introduced the concept of JIT a few months before of the official opening of the Koromo factory (at Nogoya) in September 1938 (Wada and Yui, 2002, pp. 278-279). According to Toyota's only official history published in English, Kiichiro actually installed a JIT-system in this Toyota factory, the first new one built for automobile production (Toyota, 1988, pp. 70-73). In May 1939, Kiichiro ordered coordination of the work in all shops and, interestingly, gave workers freedom to leave for home when they had achieved their target production for the day before end of working hours (Wada and Yui, 2002, pp. 288-289). He was thus be able to detect bottlenecks at other parts of the company; a central advantage of JIT-production. However, in September 1939, with Toyota's inventory of parts and materials more than half of its yearly amount of vehicles could be produced (Wada and Yui, 2002, p. 290). In other words, Toyota was far removed from the ideal of minimizing intermediate stocks, even before the war circumstances made it increasingly impossible to keep applying this philosophy (Toyota, 1988, p. 142). The person often considered to be the founding father of TPS, engineer Taiichi Ohno, reintroduced JIT-practices at Toyota around 1948. This leaves us with an ambiguity in exactly dating the initial conditions and thus in temporally separating sensitivity to initial conditions from lock-in mechanisms.

Nature of demand. Dating the initial conditions is highly relevant, since a peculiar combination of scarce resources and low demand (Odaka et al. 1988, p.39) should have invited for a specific Japanese organization of car production. Leading studies on the Japanese auto industry indeed more of less suggests this was the case (Cusumano, 1985; Fujimoto, 1999). But Toyota was not simply conforming to (perceived) market conditions. The initial Japanese market for cars was characterized by "small land space, bad road conditions, and low income levels", asking for small cars in stead of large ones (Shimokawa, 1994, 226). Nevertheless, Kiichiro Toyoda, driven by his ambition to become a mass producer of cars, unlike Nissan, opted for a 3000 cc "people car" in stead of "small car" in the 1930s (Wada and Yui, 2002, pp. 239-241). His first prototype automobile was based on American models, in particular a Chevrolet (Odaka et al, 1988, p. 125; Wada and Yui, 2002, p. 247). Ohno has empathically mentioned that the *postwar* fragmented demand for many product varieties required JIT production (Ohno, 1988, p. xiii). Japanese car makers mainly produced trucks for civilian purposes during the first years after Japan's defeat, trucks that were less standardized than the military ones. They faced a very low demand for private cars. The Japanese government was subservient to the US Supreme Commander of Allied Powers (SCAP) or General Head Quarters (GHC) between 1945 and 1952. In continuing Japanese war policy, scarce resources were to be directed to necessary goods, in particular the heavy industry. GHC lifted the ban on domestic production of private cars only slightly in June 1947 (to a maximum of 300 cars per year) and completely as late as October 1949. Moreover, Japanese car makers were not protected for imports of U.S. cars that were far superior in quality (Cusumano 1985, p.7). Postwar demand was thus initially indeed both low and fragmented, but - given the facts that the Toyota introduced the concept of JIT to produce a type of car not accustomed to typical Japanese circumstances several years before and that other Japanese car makers only followed suit after considerable delay - acted as a constraining rather than as an imprinting initial condition.

Availability of material resources. The same qualification applies to an imprint on the Toyota Production System by an initial scarcity of material resources that is often suggested in the literature. For instance, a group of Toyota officials has labeled the lack

of natural resources as "the most distinctive feature of Japan" (Sugimori et al. 1977, p.553) and claimed that this focused Japanese industries on producing high quality goods while minimizing costs compared to other countries. More specifically, Coriat (2000, p. 218) identifies the lack of law materials as a circumstances peculiar to the first postwar years, stimulating Japanese companies to search for material-saving working methods. Scarcity of raw materials actually plagued the Japanese economy, including Toyota (Toyota, 1988, pp. 75-76 and 99-100), in particular from 1941, when the allied forces blocked shipments to Japan, and in the first postwar years when the victors put the Japanese economy on short rations (Cohen, 1949). Still, there are no hard data indicating that scarcity of raw materials actually stimulated the (re)introduction of JIT production at Toyota in the first postwar years; regarding resources, more relevant seems to have been the limited financial means available to the Japanese car makers, in particular Toyota, during the first postwar years (Fujimoto, 1999; Cusumano, 1985).

Labor relations. Moreover, and characteristically, Ohno himself stressed the importance of JIT for the avoidance and identification of "waste" in the shape of idle *labour* - rather than of materials (Ohno 1988, p. 13; Shingo, 1989). This despite the abundance of labour in the first postwar years, when production for the military had stopped and many skilled laborers were available on the labor market. It should be noted that, on the other hand, the auto workers' position was strengthened considerably by the democratization policy of GHQ in the first postwar years. Japanese union membership exploded from virtually zero to more than 6.5 million in June 1948 (Okayama, 1987, p.171) and an industry wide car workers union was formed. In 1947, Ohno introduced the practice of workers handling more than one machine each in a so-called L-layout at Toyota's machine-shop (Ohno, 1988, p. 11). Multi-machine handling, a prime example of what later denoted as "autonomation" ("automation with a human face") became a central element in Toyota's lean production system. To save labour, Toyota increasingly used multi-functional workers, restructuring jobs so that the workers' operations became more versatile, but also demanded less skill than before. The craft-like way of producing that prevailed in Japanese car production until then was abandoned (Daito, 2000, pp.147-149; Okayama, 1987, pp.178-179; Fujimoto, 1999, p.64). Seen in this light, Toyota's first application of

lean production owed more to a strategic consideration to depend less on skilled labor than to an "imprinting" by the external condition of scarcity in material resources.

Meta-routines as selection mechanism. The common focus on specific external economic initial conditions, in particular scarcity of material resources, as the main imprinting factor of the emergence of lean production at Toyota does thus not pass the empirical test. JIT, that after Kichiiro's first application at Toyota in 1938 was reintroduced by Ohno in the machine shop around 1948 (Ohno, 1988),[4] has also been related however to a routine that was specific to the Japanese society and economy at large: "the wartime passion for avoiding the waste of resources [which] laid the foundations of one of postwar Japan's most successful managerial techniques: the famous 'just-in-time' system" (Morris-Suzuki, 1994, p. 155). In addition to such an explanation being rather unspecific, it does not explain the differences between Japanese car manufacturers. The fact that Toyota and Nissan reacted differently to largely identical initial circumstances, Nissan not early developing a JIT system and related elements where Toyota did, indicates that at Toyota different mechanisms were at work than at Nissan.

The different approach of Toyota and Nissan from the start of car production has been widely noticed in the literature (Cusumano, 1985, Daito, 2000, Fujimoto, 1999). Nissan was the abbreviation that came into use to denote the Nippon Sangyo holding firms created by Yoshisuke Aikawa, an engineer who had been active as an entrepreneur in Japan since 1911, in 1928 (on Nissan, see Cusumano, 1985 and Odaka et al., 1988). Nissan comprised a range of firms in metal parts, machinery and chemical production, including the well known Hitachi firm. Through a complicated story of mergers and restructurings, Nissan became involved in production of cars, named Datsun, in 1933. Aikawa admired U.S. big business and had worked in the U.S.A. between 1905 and 1907 and spent several months there also to buy machines in 1908 and 1909 (Cusumano, 1985). Although he deliberately started his working life at the shopfloor (Odaka et al, 1988, p. 93), he is described as someone "…who was more interested in building empires

[4] Ohno (1988, p. 31) writes that he made the first step towards JIT in 1949-1950; the timeline on the inside of the cover of this book mentions the start of "withdrawal by subsequent processes" in 1948.

than cars…" (Cusumano, 1985, p. 52). Nissan produced Datsun cars and parts for the U.S. car plants in Japan under the guidance of American engineers from 1935, which was in fact a continuation of the cooperation between Aikawa with William R. Gorham and other U.S. engineers that went back to 1920 (Odaka et al, 1988, p. 95-96). When after a few years, Nissan shifted its focus to truck production in reply to demand from the military, Aikawa "… hired American engineers and imported designs and an entire truck factory from the United States – creating a bias in Nissan toward American automated equipment and mass-production techniques that continued through the 1980s." (Cusumano, 1985, p. 27).

Toyota's general routine can be described differently: "Kiichiro Toyoda made every effort to develop an indigenous product and a production system compatible with local conditions" (Daito, 2000, p.141). This typical Toyota approach can be traced back to the activities of the Sakichi Toyoda (1867-1930), the father of Toyota's founder (Mass and Robertson, 1986; Wada, 2006). Sakichi was a famous Japanese inventor, active in the textile machinery business. Sakichi learned the carpenter's craft from his father. However, he became obsessed with improving the hand looms he saw his mother and other women use in the textile cottage industry. Sakichi specialized in developing and improving looms, he gained his first patent in 1891, culminating in his famous type-G loom of 1924 – the first automated loom with a non-stop automated shuttle change. Sakichi's concerns through his career were securing enough funds to finance his inventions and improvements of textile machines, and creating possibilities to test them in practice. He founded, owned, restructured, and/or managed a range of firms in textile and textile machinery business between 1895 and 1933. The poor performance of his first power loom in comparison with British Platt Bross looms in a one-year lasting mill experiment by the Kanegafuchi Cotton Spinning Co around 1907 (Wada and Yui, 2002, p.26-27) taught Sakichi to develop and test his innovations under (his own) mill conditions (Mass and Robertson, 1986, p.6; Toyota, 1988, p.30).

This was the germ of the "self-testing, trial and error" meta-routine of Toyota. While Sakichi was self-educated, his son Kiichiro (1894-1952) went to Tokyo University, instigated by his uncle Heikichi who persuaded Sakichi to let Kiichiro graduate as a mechanical engineer in 1920 (Eiji Toyoda, 1987, p. 22). Similarly, Heikichi's son, Eiji

Toyoda, eighteen years younger than Kiichiro, also went to the university and graduated as an engineer in 1936. From 1921, Kiichiro was mainly responsible for inventions (Mass and Robertson, 1986, p.25). Toyoda Automatic Loom acted as seedbed of Toyota automotive production (Mass and Robertson, 1986, p.33). With the income from these textile activities, Toyoda Automatic Loom Works financed Kiichiro's experimenting on car production from 1930 onwards. In 1933 an Automobile Department was set up (Wada and Yui, 2002, p.235). When Toyota Motor Co. was founded in 1937, Sakichi's son-in-law Risaburo became president, but Kiichiro as vice-president in fact ran the company. Unlike Nissan, that relied heavily on U.S. engineers, Kiichiro and his collaborators – supported by university people - tried to master the production of parts themselves by various and lengthy experiments during the first years of existence (Odaka et al, 1988, 125-130). Between September 1933 and May 1935 not a single vehicle was actually produced – which indicates both the care Kiichiro took to master production processes himself and the large problems involved with it.

The adoption of Toyota's lean production system from 1947 in fact can thus be seen as application of the meta-routine of "self-testing, trial and error". This meta-routine emerged well before the adoption of the JIT system. For (meta-)routines to exert an influence over long periods of time, "transmission mechanisms" are needed. Toyota's policy of transferring knowledge through the circulation of personnel within plants and the extensive recording of experience were vital for the enduring effect of the meta-routine. Kiichiro became famous for his habit of writing down very detailed reports of his experiments and manuals for production and organization (Wada and Yui, 2002). Such a formalization by the president himself was highly unusual among Japanese companies (Hino, 2006, 10) and was vital for the transfer of experience on all kinds of practices to other (later) Toyota managers and workers (Hino, 2006; Eiji Toyoda, 1987). In the case of Toyota, the transmission by personal interaction was probably at least equally important (Hino, 2006, pp. 28-29). Both Kiichiro and Eiji were stimulated to keep in touch with work floor practices and insights during and after their study – in line with Sakichi's philosophy. Sakichi's "attitude of 'actually trying comes first'…must have had a lasting influence" on Kiichiro (Wada and Yui, 2002, p.130; see also Toyota, 1988, p.38). Toyota management also structurally supported mechanical engineer Taiichi Ohno

(1912-1990) in his innovations. This architect of Toyota's production system, started to work at Toyota Spinning and Weaving in 1933. His experiences there were crucial for his shaping of the Toyota-system after he moved to Toyota in 1943. Characteristically, after an extensive study of textbooks and articles on the latest American management methods in 1937-1938, "he then decided that the best way to improve the Toyoda factory was to put the textbooks aside, go to the shop floor, and study the plant and workers in operation" (Cusumano, 1985, p.272). The empiricist meta-routine adopted by Toyota's key managers implied that they were receptive for American management methods too. Like Sakichi, Kiichiro visited the United States and Great Britain, in 1921 and 1929/1930, studying operations in textile firms. He urged his collaborators to read Henry Ford's *My life and work* (Toyota, 1988, p. 42). For his part, Ohno was a great admirer of both Ford and Taylor; in his obsession to reduce "waste", he extensively used of time-and-motion studies (Ohno, 1988).[5]

Besides this general effect of the meta-routine, Toyota offers very intriguing examples of direct replication of specific routines that can be considered as earlier, idiosyncratic outcomes of the application of the meta-routine of "self-testing, trial and error". Multi-machine operating (see above) had been common already at Toyoda Weaving and Spinning before 1947. It required that machines automatically stop in case of trouble or at the end of the production process and "Ohno got part of the idea for this system from the device Sakichi Toyoda had invented many years earlier, where a loom would stop automatically when a thread broke" (Toyota, 1988, p. 142).

5. Identifying Lock-in mechanisms

The Toyota case illustrates that making a distinction between first selection under initial conditions and subsequent lock-in in practice is inherently arbitrary. Toyota's meta-routine had an enduring effect long after the emergence of the first JIT applications at the firm, by acting as a "constant cause", rather than only having a "one shot" impact during

[5] Ironically Ohno's concept of small-lot production was inspired by General Motors' (Cusumano 1985, p.271). Ohno also stressed the model of the (American) supermarket, where supplies were replenished according to actual purchases by customers, as a source of inspiration for the JIT-approach.

a critical juncture, as we will show in the last part of this section. As "lock-in" was expressed at Toyota in a steadily wider application and perfecting of lean production, we should consider it a dynamic phenomenon, which makes "lock-in" an even fuzzier phenomenon to conceive in organizations. Still it is possibly to identify vital specific circumstances arising after the initial adaptation of a form of lean production, in a comparative short period of the years 1949-1950, which locked-in Toyota to lean production. These circumstances were not wholly unrelated to the initial conditions identified above, but were heavily coloured by a sequence of specific events. This latter typical path dependent element makes a strict analytical separation of individual causes even more difficult than in regard to initial conditions – for convenience, we have combined two couple of factors under one subheading.

Stocking crisis and shortage of capital. Shortly after Toyota's first experiments with lean production, a sequence of events committed the company firmer to the path of small-lot production. The occurrence of an acute shortage of capital for Toyota at the end of 1949 was crucial. After the presentations of a governmental five year plan in August and October 1948, that set a national production target of 120,000 vehicles per year in 1953 (Toyota, 1988, pp. 92 and 104-105), auto makers sharply increased their output. Toyota aimed at producing 15,840 units in 1949, compared to 3,900 ones in 1947. However, the anti-inflation measures implemented by GHQ in April 1949 depressed business conditions and, mounting the number of unsold cars, brought Toyota to the verge of bankruptcy in November 1949 (Toyota, 1988, p. 105). This episode proved to be a turning point in Toyota's history. The banks were only prepared to save Toyota if it split off sales and marketing into separate companies. Toyota Motor Sales (TMS) Company was founded, headed by a separate management, in March 1950. TMS would act as a customer of Toyota Motor Company. By this separation, that was discontinued only in 1982, the banks sought to prevent overproduction. This dramatic episode made Toyota's leaders' acutely aware of the importance of balancing production and sales (Fujimoto, 1999, pp. 60-61), to which a JIT-system was particularly suited.

Labor conditions and demand. After Toyota had almost gone bankrupt due to capital shortage, monthly production strongly decreased from more than 1,000 at the beginning of 1950 to slightly more than 300 units in May 1950 (Toyota, 1988, p. 109). At that time, still coping with the stocking crisis, Toyota and other car producers were laying off workers in large numbers, despite a promise to the unions not to do this. After long disputes with the union and a long strike, in the summer of 1950, Toyota-founder Kiichiro resigned from his post and around 1,700 workers lost their job (Cusumano, 1985, p. 147; Okayama, 1987, p. 175 and Toyota, 1988, p. 106-110). Precisely at the time, an exogenous event in the shape of the Korea War saved the Japanese car industry from extinction: the U.S. forces started placing large orders for military trucks from June 1950. Toyota now had to expand production with a reduced workforce, which invited an intensive search for rationalization, for instance by increasing the number of machines per operator (Toyota, 1988, pp. 110-111) along the lines already pioneered by Ohno.

The enduring relevance of the meta-routine. Ironically in the light of dominant interpretations in the literature, thus, if one looks for major tangible time-specific influences creating path dependence, it was a sequence of events between 1949 and 1950 put in motion by a stocking crisis rather than enduring postwar scarcity in materials that locked-in Toyota to the JIT-system. Pioneered by Ohno in the machine-shop, it was implemented at an ever wider scale within Toyota and eventually also at its suppliers. As argued above, a path dependence analysis should include an account of agency. The diffusion of JIT through Toyota closely followed Ohno's career from management positions at, among other appointments, the machine shop (1948), the manufacturing department for engines, transmissions, and vehicle assembly (1953), and the Motomachi factory (1960). Only in 1962 JIT was put into operation in all Toyota plants (Kanban, 1986, pp.119-124).

The prevailing meta-routine made Toyota much more receptive for such an approach than Nissan, that still largely faced the same circumstances as Toyota. After years of high turnover in top management, Genshichi Asahara, an academically trained chemist, resumed Nissan's presidency in 1951. Like Aikawa, he considered technology as something you bought (Cusumano, 1985, p. 90). Toyota adopted American-made

specialized tools from the 1950s onwards too (Okayama, 1997, p.178; Daito, 2000), but much more selectively than Nissan and while maintaining its older, multi-purpose equipment alongside of them (Cusumano, 1985, p. 275). Here again application of the meta-routine was expressed through using the specific Sakichi-loom routine as a source of inspiration: "Ohno found that is was possible to make older machinery, with different functions and capacities, perform repetitive operations almost automatically by adding feeding devices, limit switches, timers and other attachments, on the principle of the Toyoda automatic loom" (Cusumano, 1985, p.275).

In the 1960s, Japanese car production, under the protective shield of the government, boomed. Toyota's production of luxury cars surpassed those of trucks by around 1965 and its total vehicle production exploded from 150,000 to 1.6 million between 1960 and 1970. Despite its development into a mass producer of cars, Toyota abstained from the U.S. practice of long production runs of one and the same model although this might seem the most efficient in the circumstances. In stead, by means of technical adjustments of existing machinery, Ohno et al. succeeded in reducing set-up times for stamping dies, from two to three hours before 1955, to not more than a three minutes by 1971 (Cusumano, 1985, pp. 284-285). This enabled "mixed production" of short production runs of different models, that kept inventories low and made Toyota very flexible in responding to changes in demand. That Toyota stuck to this approach can be considered as a case of path dependence set on track in the past and despite new circumstances that pointed into a different direction (see also Grønning, 1997, p. 428; quotation of a publication in Japanese). Above we have cast doubt on the relevance on a lack of material resources as an initial condition imprinting a lean production approach. Keeping faith to this doctrine was certainly not for lack of financial resources: the company accumulated enough means to finance expensive specialized machinery and large buffer stocks and – stopping long-term lending in 1977 altogether (Cusumano, 1985, p.76) - even became known as the "Bank of Toyota".

Nissan too began trying to reduce its inventory levels and to synchronize operations with suppliers from the mid 1950s, with considerable success, but its reliance on computers in stead of kanban - the "low tech", self-developed technique typically preferred by Toyota - tended to give its production system more a push than a pull

character (Cusumano, 1985, ppp. 307-19). Nissan proved to be less competitive than Toyota: the latter was more productive and profitable from as early as 1951 (Cusumano, 1985, pp.396-7; Odaka et al., 1988, pp.91, 108-109). In 1955 Toyota took over Nissan's no. 1 position in Japanese vehicle production (Cusumano, 1985, p.392); in 1963 in passenger car production (Shimokawa, 1987, p.229). The 1973 oil crisis and the subsequent worldwide depression put Toyota's production system (including its multi-tiered supplier network) in the international spotlights, making it the model to be emulated by both domestic and foreign car makers (Womack et al., 1990).

To repeat, lock-in by (meta-) routines does not mean that a rigid or static organizational system ensues. For instance, Fujimoto (1999) considers Toyota's export success, based on a production model aimed at the domestic market, as an example of its superior evolutionary capability to learn from unforeseen opportunities. This author further emphasizes consensus building at Toyota with and on the shop-floor that has ensued. He argues that this has been an important element, as the "core group of shop floor leaders function as an informal intra-organizational mechanism for pre-screening the routines…" (Fujimoto, 1999, p.275) and an effective convergence system could "quickly convert a variety of organizational elements into a coherent system" (Fujimoto, 1999, p.264). These learning mechanisms observed by Fujimoto show high affinity with Toyota's meta-routine of self-testing, trial and error. Similarly, the rule that workers could stop the lines when JIT production became in danger or when other problems occurred, that was introduced in the engine shop in 1950 (Cusumano, 1985, p. 280), can be considered to have helped to sustain the application of Toyota's meta-routine.

The general routine of Toyota still seems to be visible in recent times. As late as the mid 1980s, Toyota's efforts in continuously improving operations were still more oriented at the organization of processes compared to Nissan's stronger focus at machines and equipment (Totsuka, 1995; Nohara, 1999, p.38; Fujimoto, 1999, p.69). Typically, after a "high tech solution" implemented in its Tahara plant in 1991 resulted in only marginal savings in labor, Toyota decided to use relative simple machinery again in its greenfield Kyushi plant from 1992 (Benders and Morita, 2004, pp.435, 438). Toyota's experiment with high-tech followed a change of circumstances during the 1980s. Mounting criticism on the demanding nature of working under "lean production"

conditions, shortage of workers, and technical difficulties in production (Nohara, 1999, p. 39) forced Toyota to reconsider its production system (Benders and Morita, 2004; Hampson, 1999; Nohara, 1999). This implied that in some factories, Toyota explicitly began to accept the occurrence of buffer stocks, an illustration of its flexible, non-dogmatic approach.

6. Conclusions

Our case illustrates the necessity of opening the black box of initial conditions, and relating them to lock-in mechanisms. The re-examination of an extensively researched subject as the development of Toyota's Production System (TPS) shows that pinpointing the initial conditions and assessing their individual influence can be demanding. In an organizational context this is due to the problem of initial conditions and lock-in mechanisms being difficult to precisely separate. A production system such as TPS does not come like manna from the heavens, but rather is complex, multi-faceted. Still, using the concept of path dependence as defined in this paper forces scholars to specify the nature of the historical explanation of organizational change. A careful assessment of the exact timing of the (supposed) initial conditions helps to understand whether and how they shaped the phenomenon under study. What others have usually pointed to as the major initial conditions – postwar scarcity of raw materials, low and fragmented demand, and/or a general fashion of avoiding waste originating from the Japanese wartime economy – do not significantly explain the emergence of TPS right at this time. As organizational features are manifold phenomena the initial conditions that gave rise to them as manifold too, not only regarding their contents, but also in their timing of occurrence. To make matters even more complex, the initial conditions as assessed at a certain point of time themselves have a history that is relevant for a proper path dependence perspective. Our analysis shows how the meta-routine of "self-testing, trial and error" at Toyota Motor Company emerged even before the firm itself had been set up. The meta-routine was path dependent on the experiences and approaches developed by the first generations of (family) managers and as such highly idiosyncratic. It has had

a profound and lasting influence on its production system. We submit in this article that meta routines both initially select phenomena, and exert a "lock-in" influence thereafter by ascertaining diffusion of the chosen form and by steering search and selection processes that determine how solutions to occurring problems are developed and implemented. The Toyota meta-routine was partly self-perpetuating and has inspired the development and use of more mundane routines (such as multi-machine operating). It has allowed Toyota to deal with substantial shocks in its economic and technological environment. But also the typical path dependence element of a specific sequence of events, put in motion by a stocking and liquidity crisis in 1949, was important for locking-in Toyota to the path of JIT it had entered only shortly before. The concept of meta-routine is particularly suited to explain both the initial selection and dynamic lock-in of multi-faceted organizational phenomena, such as Toyota's Production System.

REFERENCES

Arthur, B.A. (1989), "Competing Technologies, Increasing Returns, and Lock-in by Historical Events", *Economic Journal*, Vol. 99, pp. 116–131.

Becker, M.C. (2004), "Organizational routines", *Industrial and Corporate Change*, Vol. 13, pp. 643-677.

Benders, J., Morita, M. (2004) "Changes in Toyota Motors' operations management" *International Journal of Production Research*, Vol. 42 No. 3, pp. 433-444.

Beyer, J. (2005), "Pfadabhängigkeit ist nicht gleich Pfadabhängigkeit. Wider den impliziten Konservatismus eines gängigen Konzepts", *Zeitschrift für Soziologie*, Vol. 34 No.1, pp. 5-21.

Boeker, W.P. (1988), "Organizational origins: entrepreneurial and environmental imprinting at the time of founding", in: Carrol, G.A. (ed.), *Ecological Models of Organizations*, Ballinger, Cambridge, Mass., pp. 33-51.

Cohen, J.B. (1949), *Japan's economy in war and reconstruction*, Minnesota Press, Minneapolis.

Coriat, B. (2000) "The 'Abominable Ohno Production System'. Competences, Monitoring, and Routines in Japanese Production Systems", in: Dosi, G, Nelson, R.R. and Winter, S.G. (eds.) *The Nature and Dynamics of Organizational Capabilities*, Oxford: Oxford University Press, 2000, 213-243.

Cusumano, M.A. (1985), *The Japanese Automobile Industry,* Harvard UP, Cambridge Mass.

Dahlqvist, J, Davidsson, P., Wiklund, J., "Initial Conditions as Predictors of New Venture Performance: A Replication and Extension of the Cooper et al.study", *Enterprise & Innovation Management Studies*, Vol. 1 No. 1, pp. 1-17.

Daito, E. (2000) "Automation and the Organization of Production in the Japanese Automobile Industry" *Enterprise & Society*, Vol. 1, March, pp. 139-178.

David, P.A. (1985) "Clio and the Economics of QWERTY" *American Economic Review*, Vol. 75, No. 2, pp. 332-37.

----, (1994) "Why are institutions the 'carriers of history'? Path dependence and the evolution of conventions, organizations *and* institutions" *Structural Change and Economic Dynamics*, Vol. 5, pp. 205-220.

Djelic, M.-L., Quack, S. (2007), "Overcoming path dependency: path generation in open systems", *Theory and Society*, Vol. 36, pp. 161–186.

Dopfer, K. (1991) "Toward a Theory of Economic Institutions: Synergy and Path Dependency", *Journal of Economic Issues*, Vol. 25 No.2, pp. 535-550.

Doz, Y.L, "The Evolution of Cooperation in Strategic Alliances: Initial Conditions or Learning Processes?", *Strategic Management Journal*, Vol. 17, Summer, Special Issue, pp. 55-83.

Fujimoto, T. (1999), *The Evolution of a Manufacturing System at Toyota*, Oxford UP, Oxford.

Goldstone, J. (1991), *Revolution and Rebellion in the Early Modern World*, University of California Press, Berkeley and Los Angeles.

Goldstone, J, 1998, "Initial conditions, general laws, path-dependence, and explanation in historical sociology", *American Journal of Sociology*, Vol. 104, pp. 829–845.

Grønning (1997), "The Emergence and Institutionalization of Toyotism: Subdivision and integration of the Labour Force at the Toyota Motor Corporation from the 1950s to the 1970s", *Economic and Industrial Democracy*, Vol. 18, pp. 423-455.

Hampson, I. (1999), "Lean Production and the Toyota Production System" *Economic and Industrial Democracy*, Vol. 20, pp. 369-91.

Hino, S. (2006), *Inside the Mind of Toyota*, New York: Productivity Press, 2006 (original Japanese edition from 2002)

Howlett, M., Rayner, J (2006), "Understanding the historical turn in the policy sciences: A critique of stochastic, narrative, path dependency and process-sequencing models of policy-making over time", *Policy Sciences*, Vol. 39 No.1, pp. 1–18.

Iammarino, S., "An evolutionary integrated view of Regional Systems of Innovation: Concepts, measures and historical perspectives", *European Planning Studies*, Vol. 13 No. 4, pp. 497-519.

Johnson, V., "What is Organizational Imprinting? Cultural Entrepreneurship in the Founding of the Paris Opera", *American Journal of Sociology*, Vol. 113 No. 1, pp. 97-117.

Kanban just-in-time at Toyota : management begins at the workplace (1986), edited by the Japan Management Association, Productivity Press, Stamford.

Kenney, M. von Burg, U. (1999), "Technology, Entrepreneurship and Path Dependence: Industrial Clustering in Silicon Valley and Route 128", *Industrial and Corporate Change* Vol. 8 No. 1, pp. 67-103.

Kogut, B., Zander, U. (1996), "What do firms do?", *Organization Science* Vol. 7 No. 5, pp. 502-518.

Mahoney, J. (2000), "Path dependence in historical sociology", *Theory and Society*, Vol. 29, pp. 507-548.

Marquis, C. (2003), "The Pressure of the Past: Network Imprinting in Intercorporate Communities", *Administrative Science Quarterly*, Vol. 48, pp. 655-689.

Mass, W. and Robertson, A. (1996), "From Textiles to Automobiles: Mechanical and

Organizational Innovation in the Toyoda Enterprises, 1895-1933", *Business and Economic History*, Vol. 25 No. 2, pp. 1-37.

Morris-Suzuki, T. (1994), *The technological transformation of Japan,* Cambridge UP, Cambridge.

Nohara, H. (1999), "The Historic Reversal of the Division of Labour?", in: Durand, J.P., Stewart, P., Castillo, J.J. (eds.), *Teamwork in the Automobile Industry,* Macmillan, Houndmills, pp. 37-53.

Odaka, K., Ono, K., Adachi, F. (1988), *The Automobile Industry in Japan*, Kinokuniya Company Ltd, Tokyo.

Okayama, R. (1987), "Industrial relations in the Japanese automobile industry 1945-1970: the Case of Toyota", Tolliday, S. and Zeitlin, J. (eds.), *The automobile industry and its Workers,* St. Martin's Press, New York, pp. 168-189.

Ohno, T. (1988) *Toyota Production System.* Cambridge, MA: Productivity Press (transl. from Japanese ed. of 1978).

Pierson, P (2004), *Politics in Time*, Princeton University Press, Princeton and Oxford.

Porter, M.E. (1991), "Towards a Dynamic Theory of Strategy", *Strategic Management Journal*, Vol. 12, Winter, Special Issue, pp. 95-117.

Schwartz, H. (200x), "Down the Wrong Path: Path Dependence, Increasing Returns, and Historical Institutionalism", unpublished paper**,** Department of Politics, University of Virginia (http://people.virginia.edu/~hms2f/Path.pdf).

Shingo, S. (1989), *A study of the Toyota production system from an industrial engineering viewpoint*, Productivity Press, Cambridge Mass..

Shimokawa, K. (1994) *The Japanese automobile industry: a business history.* London.

Stinchcombe, A.L. (1965), "Social Structure and Organizations" in: March J.G. (ed.), *Handbook of Organizations,* Rand McNally, Chicago, pp.142-193.

Stinchcombe, A. (1968), *Constructing Social Theories*, Harcourt Brace, New York.

Sugimori, Y. et al., 1977, "Toyota production system and Kanban system" *International Journal of Production* Research, Vol. 15 No. 6, pp. 553-564.

Swaminathan, A. (1996), "Environmental Conditions at Founding and Organizational Mortality: A Trial-by-Fire Model", *The Academy of Management Journal*, Vol. 39 No. 5, pp. 1350-1377.

Sydow J, Schreyögg, G, Koch, J, "Organisational Paths: Path Dependency and beyond", paper to the 21st EGOS Colloquium, June 30 – July 2, 2005, Berlin, Germany

Totsuka, H. (1995) "The transformation of Japanese Industrial Relations: A Case Study of the

Automobile Industry" in: Babson, S. (ed.), *Lean Work. Empowerment and exploitation in the global auto industry*, Wayne State University Press, Detroit, pp. 108-128.

Toyota Fifty Years in Motion. An autobiography by the Chairman Eiji Toyoda (1987), Kodansha International, Tokyo and New York (translation of Japanese edition of 1985).

Toyota. A History of the First 50 years (1988), Toyota Motor Corporation, Toyota City, (translation).

Wada, K. and Yui, T. (2002) *Courage and Change. The life of Kiichiro Toyoda*, Toyota Motor Corporation, Toyota City (translation).

Wada, K. (2006), "The fable of the birth of the Japanese automobile industry: A reconsideration of the Toyoda-Platt agreement of 1929", *Business History*, Vol. 48 No. 1, pp. 90 – 118.

Womack, J.P., Jones D.T., Jones, D. (1990), *The Machine that Changed the World*, MacMillan, New York.