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Path dependence, initial conditions, and routines in organizations

The Toyota production system re-examined

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Abstract

Purpose – The purpose of this paper is to disentangle and elaborate on the constitutive elements of the concept of path dependence (initial conditions and lock-in) for a concerted and in-depth application to the study of organizational change.

Design/methodology/approach – The approach takes the form of a combination of a longitudinal and a comparative case-study, based on secondary literature.

Findings – External initial conditions acted less as "imprinting" forces than is suggested in the literature on the genesis of the Toyota production system (TPS); a firm-specific philosophy in combination with a critical sequence of events mainly shaped and locked-in TPS.

Research limitations/implications – The empirical sources are limited to publications in English, so relevant factors explaining the path taken may not all have been included. The importance of a salient meta-routine might be firm-specific.

Practical implications – The study contributes to understanding the factors underlying corporate performance by a critical re-examination of a much heralded production system (TPS).

Originality/value – The paper highlights the use of the concept of meta-routines to connect the core elements of path dependence, that is, sensitivity to initial conditions and lock-in mechanisms.

Keywords Critical path analysis, Manufacturing systems

Paper type Research paper

The notion of path dependence was first explicitly applied to explain prevailing technologies and standards (David, 1985, Arthur, 1989). It 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,

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with the notable exception of David (1994). Only recently the interest in this field of application has expanded (Sydow *et al.*, 2005). We argue that using path dependence for the historical analysis of organizational change can be very fruitful. To do so, the key elements of path dependence – sensitivity to initial conditions and lock-in mechanisms – need to be conceptualized more precisely and linked to each other, however.

We show this by empirically re-examining the Toyota production system (TPS). 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 until now and analyze the case from a more elaborate path dependence perspective than in earlier publications on TPS. This, we argue, sheds new light on both this important empirical case as well as the conceptualization of path dependence. Our empirical analysis includes comparisons with Toyota's main Japanese rival, Nissan; a comparison that is quite frequently made in the literature.

1. Path dependence and routines

While in fields that have a more extensive history in using the concept of path dependence the precise understanding of this concept is certainly not uncontested (Schwartz, 2004; Beyer, 2005), a study of organizational change in these terms implies specific problems. This is due to the complex, multifaceted nature of organizations compared to technical artefacts. At an abstract level, a path dependence interpretation can be rather straightforward. Path dependence then consists of two, separate elements. To explain some extant phenomenon, one must first identify a moment in its relevant history for some starting point (determined by what is referred to as initial conditions) where it emerged in its basic form. Secondly, one must assess what distinct lock-in mechanisms have kept the phenomenon on track.

In this common interpretation, sensitivity to initial conditions is defined as separate from lock-in mechanisms. The latter are usually explicitly defined in the path dependence literature, albeit suggesting different degrees of determinacy. Beyer (2005), for instance, prefers to reserve the term "lock-in" for the complete absence of change of the phenomenon as initially emerged. Alternatively, he distinguishes several mechanisms creating continuity: increasing returns, sequences of events, functionality, complementarity, power, legitimacy and conformity. In vain, however, does one search for a theoretical elaboration on the nature of initial conditions other than that they form a "critical juncture" (Mahoney, 2000). 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; Dahlqvist *et al.*, 2000) or as external (Swaminathan, 1996). In the path dependence literature, specific (sequences of) events are often regarded as playing a vital role during the selection, but there is no clear consensus whether they are part of initial conditions or not. Goldstone (1998a, 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). This statement seems in line with the prevailing view that path dependence implies that the path taken is not determined by initial conditions; in this sense extreme sensitivity to initial conditions is a misplaced phrase for denoting path dependence (Page, 2006). Nevertheless, Goldstone's analysis of the British Industrial

Revolution as a path dependent phenomenon (Goldstone, 1998b) suggests that he understands initial conditions as the prevailing "social formation" at a certain point of time. This is hard to equate with a common path dependence interpretation that initial conditions themselves are very sensitive to "small influences" (Dopfer, 1991, p. 545) or "small events" (Pierson, 2004, p. 251), or in other words, are "chance-like" (Howlett and Rayner, 2006, p. 5)[1].

The critical period involved, prevailing circumstances, events, characteristics of 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, one that we aim to address, since identifying initial conditions should be an important part of the research to be carried out under the banner of path dependence (Goldstone, 1998a, p. 841). In fact, as we argue here and show below for Toyota, what conditions are salient is not self-evident 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 the initial direction a path takes is not as indeterminate as customarily assumed in the path dependence literature (Arthur, 1989; Dopfer, 1991; Mahoney, 2000; Bassanini and Dosi, 2001). Sydow *et al.* (2005, p. 28) rightly point out that the stage before a path starts "is not dominated by undirected search and random selection". To extend on this, we draw on the concept of routines to be more specific about what does the initial selecting. Organizations may fruitfully be seen as collections of routines held in common, where routines have been alternatively defined in a behavioural sense as recurrent interaction patterns or cognitively as rules (Becker, 2004). Several kinds of routines can be distinguished, for instance operational characteristics, investment rules and higher order routines (Nelson and Winter, 1982, pp. 16-17). In studying path dependence, higher order routines are of special interest, since they both modify existing routines and guide the search for and the selection of new routines (Nelson and Winter, 1982, p. 18). For convenience we denote these higher order routines as "meta-routines". These routines need not to be formalized, and we would like to avoid exclusive connotations of the term "meta-routines" with formal procedures for standardized problem-solving as has been done by Adler *et al.* (1999) or with very specific phenomena such as production lines (Szulanski and Jensen, 2004)[2]. Below we will argue that a meta-routine of "self-testing and adapting" played a central role in adopting and further developing the TPS. Following a suggestion by Becker (2004, p. 664) to link behavioural and cognitive interpretations of routines, we primarily understand meta-routines as a propensity to select particular solutions for certain types of problems. They make the adoption of certain routines much more likely than others: "A firm's search policy will be characterized as determining the probability distribution of what will be found through search . . . " (Nelson and Winter, 1982, p. 18). We thus follow a non-deterministic line of reasoning also analogous to Greif's analysis of institutions whereby:

> [. . .] beliefs, norms, and organizations inherited from the past influence subsequent institutions by constituting the default in new situations, [. . .] are part of the initial conditions in the processes that influence selection among alternative new institutions (Greif, 2006, pp. 187-8; Dolfsma and Verburg, 2008).

The meta-routines can thus be a part of the initial conditions. They may be rather general in nature, may not be so explicit in what salient solution is to be opted for, and

may be un-articulated. 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). Alternatively, as firm specific meta-routines are not so easily imitated by others, imprinting will often occur at the mundane level only, and thus contribute to variety in choices of firms that are confronted with more or less similar external conditions. The term imprinting should not be taken too literally, as there are always interpretation and conscious action by agents involved (Johnson, 2007; Foray, 1997; Djelic and Quack, 2007). Arrow (1974, p. 63) poses that a "code" (for which one can read "routine") "is determined in accordance with the best *expectations* at the time of the firm's creation" (italics added). In this line, Porter (1991) argues that (internal) initial conditions partly result from earlier managerial choices in their turn reflecting a then current environment. Boeker (1988, p. 35) connects internal and external elements of initial conditions through 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". The plural is vital here, since imprinting of organizations by initial conditions is never predetermined, if only because several factors are influencing organizations at the same time. Slightly reframing a categorization made by Kriauciunas and Kale (2006), the initial conditions potentially having an imprinting effect can be grouped in three categories: environmental requirements, resources and values or philosophies. Unlike Kriauciunas and Kale (2006), we consider not only resources, but also values or philosophies as potentially both internal and external to the firm (and thus do not limit this category to the founder's general orientation). Philosophies are likely to express themselves through meta-routines. Routines as an analytical instrument bridges initial conditions and lock-in mechanisms.

Two reasons can be given 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 them. Second, organizational 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 (compare Thelen, 2004); the phenomenon under study itself is dynamic. Regarding the first consideration, as Schwartz (2004) argues, initial conditions partly act as "constant causes" (Stinchcombe, 1968). This, however, undermines the idea of path dependence as consisting of the separate mechanisms of "production" and "reproduction" (Schwartz, 2004). The second consideration implies that more than one path should be investigated, which is not incompatible with at least some interpretations of path dependence (Mahoney, 2000; Djelic and Quack, 2007), but nevertheless casts doubts on a straightforward application of the concept. Still, we think using the concept of 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 may develop over time, and exert a lasting influence on later developments. They thus conceptually provide the dynamic link between initial conditions and lock-in. Understanding meta-routines as mechanisms that modify existing routines and guide the search for and selection of new routines implies

that we understand lock-in not as rigidity, but as a dynamic element creating continuity. This implies that not only the selection mechanism, but what is selected should be conceptualized as routines. In other words, we should study path dependence of routines (Becker, 2004) as collorary to routines creating path dependence.

We thus argue that until now initial conditions have been 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 we point to has meant that the use of the concept of path dependence in a context of organizational change has not been exploited to its potential. As organizational phenomena are – unlike technical artefacts – multi-faceted, providing conceptual clarity and acknowledging that distinguishing initial conditions and lock-in mechanisms may be problematic is required. The constitutive elements of path dependence, in particular initial conditions, must be unpacked, and the interrelations between them further analyzed and conceptualized. We have argued 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? Do meta-routines meaningfully relate sensitivity to initial conditions on the one hand and lock-in mechanisms on the other? How do these routines interact with specific circumstances and (sequences of) events in selecting and locking-in certain choices?

The origin and development of the often-studied TPS seems an appropriate case for such an empirical application. Fujimoto (1999) stresses "multi-path system emergence" and the difference between the logic of the first adoption of several elements of TPS on the one hand and their subsequent diffusion through the company on the other. Likewise, Coriat (2000, p. 218) holds "... a variety of 'small' events and macro conditions ..." responsible for the emergence of just-in-time (JIT) or more general "auto-activation" at Toyota Motor shortly after the World War II. These studies, and also that by Cusumano (1985), take an implicit path dependence-perspective and so cannot fully exploit the concept as developed here. We show that one of the elements hinted at by these studies, a firm specific meta-routine, rooted in the prehistory of the Toyota Motor Company, rather than general circumstances, was predominant. This 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. We are thus steering a middle road between overly deterministic and overly voluntaristic interpretations of change of organizations (Beyer, 2005).

2. Methodology and data

Our case-study is a combination of a within case-analysis of TPS and, to a lesser degree, a cross-case-analysis of Toyota's and Nissan's production systems (George and Bennett, 2005). The case-analysis is based on secondary literature. We traced around 80 journal articles, books and book chapters on the evolution primarily of Toyota, but also of Nissan and the Japanese car industry as a whole through searching in electronic databases and checking references. This collection includes a few journalistic accounts

and several (auto)biographies of Toyota and its leaders. Popular accounts of the Toyota system, sometimes containing hagiographic descriptions, and manuals on how to implement the system were largely ignored. We also consulted some selected historical publications on the leading US car manufacturers' production systems and a few general works on the development of the Japanese economy. All publications used are written in English, including translations from the Japanese. To the best of our knowledge, some major publications, including recent ones (Wada and Yui, 2000; Hino, 2006), have not been earlier used in scientific analyses of the evolution of TPS published in the English. Our analysis here thus builds on the broadest possible collection of internationally available material.

We focused on identifying long-term historical influence of certain circumstances and events, both internal and external to the company, on the evolution of TPS. "Process tracing" (George and Bennett, 2005) was applied to identify in particular the causal mechanisms through which meta-routines tended to select and lock-in certain features of the TPS. We notably concentrated, however, on the development of the internal side of TPS since relations with the preceding activities of Toyota's managers were more embracing and salient than in regard to the company's famous multi-tiered supplier system. Some caution was needed when using the descriptions and analyses published by Toyota's former leaders themselves or the official Toyota history. At appropriate places, we have put these expositions into perspective. When the sources contain contradictory information on certain important facts, we have indicated this in the text or in footnotes. We dealt with differences in interpretations in the literature by carefully weighing their plausibility and empirical base, in particular in regards to the supposed temporal order of "cause" and "effect" at vital "turning points in the causal chain" (George and Bennett, 2005, p. 92).

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, pp. 21-7). After the Kanto earthquake from 1923, demand for buses and trucks boomed, and the leading US car makers Ford (1925) and General Motors (GM) (Chevrolet in 1927) opened so-called knock-down plants on Japanese soil, driving the domestic producers from the market (Odaka *et al.*, 1988, p. 27). In May 1936, however, several 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, Table I). 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 United Motors (later called Isuzu) in 1939. Nissan pioneered domestic large-scale production of private 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 passenger car production. This ban was finally removed in October 1949, more than four years after Japan's defeat in World War II. After Toyota had almost gone bankrupt due to capital shortage, the Korea War saved

Date	Environment	Date	Toyota
September 1931	Japan invades Manchuria		
May 1936	Japan virtually prohibits imports of cars		
		1937	Founding of Toyota Motor Company
		1938	JIT-production at Koromo plant
1939	Ford and GM discontinue car production in Japan		
July 1941	Full the USA-British-Dutch embargo on Japanese imports		
August 1945	Japan surrenders to allied powers		
		c. 1947	Start multi-machine handling in machine shop
		c. 1948	Start JIT in machine shop
April 1949	Anti-inflation measures (Dodge Line)		
October 1949	Ban on producing private cars lifted	End of 1949	Toyota faces bankruptcy
		April 1950	Split Toyota Motor and Sales
June 1950	Start Korea War; US place mass orders for trucks	June 1950	Lay-offs of c. 2,000 workers; Kiichiro Toyoda resigns
		1955	Toyota issues first passenger car to be produced at a substantial scale

Table I.
Important events external and internal to Toyota (1931-1955)

the Japanese auto industry from extinction: the US 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 TPS. Its two closely related main elements are:

(1) "lean production", of which small-lot size production using a JIT-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.

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 routine of "self-testing and adapting". 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 GM.

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 lean production at Toyota presented below accordingly. The initial conditions to be considered are grouped in the three categories mentioned above:

(1) requirements (demand);

(2) resources (material, financial and labour); and

(3) philosophies (meta-routines).

This strategy illustrates what we see as the way forward for path dependence approaches to understanding organizational change, specifying the complex nature of initial conditions, both in contents and timing.

4.1 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 in September 1938 (Wada and Yui, 2002, pp. 278-9). He actually installed a JIT-system in this Toyota factory, the first new one built for automobile production (Toyota Motor Corporation, 1988, pp. 70-3). 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. 288-9). 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). Toyota then was far removed from the ideal of minimizing intermediate stocks, even before the war circumstances made it increasingly impossible to apply this philosophy (Toyota Motor Corporation, 1988, p. 142). The person often considered to be the founding father of TPS, engineer Taiichi Ohno, reintroduced lean production-practices at Toyota in the years 1947-1949[3]. In hindsight, this was the start of a diffusion of lean production across Toyota's factories and those of its external suppliers. The best choice for dating the initial conditions is thus most probably the years 1947-1949, but they were preceded by events that foreshadowed the phenomenon.

4.2 Nature of demand

Dating the initial conditions is highly relevant, since it determines our conclusions on the importance of the timing of circumstances influencing the adoption and diffusion of lean production at Toyota. Leading studies on the Japanese auto industry suggest that a low, fragmented demand and scarce resources in combination should have invited for a specific Japanese organization of car production. (Cusumano, 1985; Fujimoto, 1999; Coriat, 2000; Odaka *et al.*, 1988, pp. 39-40). Low levels of demand already prevailed before the war. 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, 1987, p. 226). Toyota, however, was not a priori conforming to these market conditions. In the 1930s Kiichiro Toyoda, driven by his ambition to compete head-on with the US car makers, unlike Nissan, opted for a 3,000 cc "people car" in stead of a small car (Wada and Yui, 2002, pp. 239-41). His first prototype automobile was based on American models (Odaka *et al.*, 1988, p. 125; Wada and Yui,

2002, p. 247); as noted, Kiichiro was forced to let Toyota almost exclusively produce military trucks at the Koromo factory. Only immediately after the war, did he define producing a small car of between 1,000 and 1,500 cc as an aim for his company (Toyota Motor Corporation, 1988, pp. 100-1). Ohno has empathically mentioned that the post-war 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, facing a very low demand for private cars. The Japanese government was subservient to the US Supreme Commander of Allied Powers or General Head Quarters (GHQ) between 1945 and 1952. In continuing Japanese war policy, scarce resources were to be directed to necessary goods, in particular the heavy industry. GHQ lifted the ban on domestic production of passenger 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 US cars that were far superior in quality (Cusumano, 1985, p. 7). Post-war demand was thus initially low indeed, but not particularly diverse. Toyota produced some 20,000 trucks and buses and a few hundreds passenger cars between 1947 and 1949 (Toyota Motor Corporation, 1988, p. 461); this production mainly consisted of civilian trucks of a similar type (Cusumano, 1985, p. 266). There was no both low and fragmented demand to imprint Toyota's lean production between 1947 and 1949, just like Toyota's first application of JIT by Kiichiro Toyoda almost exclusively concerned manufacturing military trucks rather than vehicles of a diverse kind.

4.3 Availability of material and financial resources

The same qualification applies to an imprint on the TPS by an initial scarcity of material resources that is often suggested in the literature. For instance, a group of Toyota officials has labelled 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 raw materials as a circumstance peculiar to the first post-war years, stimulating Japanese companies to search for material-saving working methods. Scarcity of raw materials actually plagued the Japanese economy, including Toyota (Toyota Motor Corporation, 1988, pp. 75-6 and 99-100), in particular from 1941, when the allied forces blocked shipments to Japan, and in the initial post-war years when the victors put the Japanese economy on short rations (Cohen, 1949). Still, the literature does not contain any reference to specific empirical data indicating that scarcity of raw materials actually stimulated or even necessitated the (re)introduction of JIT-production at Toyota in the first post-war years. Around 1948, when Ohno was beginning his experiments, Toyota often had to wait for parts from its suppliers until the middle of the month, forcing it to realize its planned monthly production in just two weeks (Cusumano, 1985, p. 278). Shortage of materials thus prevented JIT-production, just like Kiichiro Toyoda had experienced since 1939. Cusumano (1985, p. 264) offers a more plausible version of an explanation in terms of material resources:

> The Japanese, reacting originally to *shortages of space* and low production volume, developed the practice of consolidating various shops under one roof rather than building separate facilities for casting, body stamping, final assembly, or other distinct operations (italics added).

Still, consolidation does not necessary imply JIT-production. A lean production system characterized by multi-purpose equipment, low intermediate inventories and a minimum of warehouse space, makes at least as much sense from a perspective of limiting investments as of minimizing the use of materials. More relevant therefore were perhaps the limited financial means available to Toyota that – like Nissan – during this period had great difficulty to remain in business (Fujimoto, 1999; Cusumano, 1985).

4.4 Availability of labour resources

Characteristically, Ohno himself stressed the importance of JIT for the identification and avoidance of "waste" in the shape of idle labour – rather than of raw materials (Ohno, 1988, p. 13; Shingo, 1989; Williams *et al.*, 1994). This despite the abundance of labour in the first post-war years, when production for the military had stopped and many skilled workers were available on the labour market (Gordon, 1985, pp. 334 and 346). 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 post-war 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. In the same year, 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 was later denoted by the company 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. 147-9; Okayama, 1987, pp. 178-9; Fujimoto, 1999, p. 64). Toyota's first post-war application of lean production thus owed more to a strategic consideration to depend less on skilled labour than to an "imprinting" by the external condition of scarcity in material resources.

4.5 Meta-routines as selection mechanism

The common focus on specific external economic initial conditions as the main imprinting factor of the emergence of lean production at Toyota does not pass the empirical test. The adoption of JIT has also been related however to an economy-wide: "wartime passion for avoiding the waste of resources [which] laid the foundations of one of post-war 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 among Japanese car manufacturers. The fact that Toyota and Nissan reacted differently to largely identical external initial circumstances, where Nissan did not early-on try to develop 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 Datsun cars in 1933. Aikawa admired US big business and had worked in the USA between 1905 and 1907 and spent several months there also to buy machines in 1908 and 1909 (Cusumano, 1985, p. 30). Although he deliberately started his working life at the shop-floor (Odaka *et al.*, 1988, p. 93), he is described as someone "... who was more interested in building empires than cars ..." (Cusumano, 1985, p. 52). Nissan produced Datsun cars and parts for the US 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 US engineers dating back to 1920 (Odaka *et al.*, 1988, pp. 95-6). When after a few years Nissan shifted its focus to truck production in response 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 orientation 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 Sakichi Toyoda (1867-1930), the father of Toyota's founder (Mass and Robertson, 1996; 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 in the Aichi region. Sakichi specialized in developing and improving looms, he gained his first patent in 1891, culminating in the 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 his death in 1930. 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, pp. 26-7) taught Sakichi to develop and test his innovations under (his own) mill conditions (Mass and Robertson, 1996, p. 6; Toyota Motor Corporation, 1988, p. 30).

This was the germ of what Fear (2001, p. 172) calls tinkering, or the "self-testing and adapting" 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 (Toyoda, 1987, p. 22). Similarly, Heikichi's son, Eiji Toyoda, 18 years younger than Kiichiro, also went to the university and graduated as an engineer in 1936. From 1921, Kiichiro was mainly responsible for technical improvements in his father's businesses (Mass and Robertson, 1996, p. 25). Toyoda Automatic Loom acted as seedbed of Toyota automotive production (Mass and Robertson, 1996, 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 – who had also been adopted by him – became president, but Kiichiro as vice-president in fact ran the company. Unlike Nissan, that relied heavily on US 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, pp. 125-30). Between September 1933 and May 1935 not a single car 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 should be seen against the background of the meta-routine of "self-testing and adapting". Kiichiro Toyoda's early attempt to use a JIT-system at the Koromo plant as a device to identify bottlenecks in production was in line with this general focus on unabated testing and adapting. Similarly, it fitted well with Ohno's permanent obsession with removing "waste". For routines to exert an influence over long periods of time, "transmission mechanisms" are needed that should be identified by process tracing. 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, p. 10) and was vital for the transfer of experience on all kinds of practices to other (later) Toyota managers and workers (Hino, 2006; Toyoda, 1987). In the case of Toyota, the transmission by personal interaction was probably at least equally important (Hino, 2006, pp. 28-9). 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 of "actually trying comes first" (Wada and Yui, 2002, p. 130; Toyota Motor Corporation, 1988, p. 38). Taiichi Ohno (1912-1990), the architect of TPS who started to work at Toyoda Spinning and Weaving in 1933, came to adhere to this conviction too. Characteristically, after an extensive study of textbooks and articles on the latest American management methods in 1937-1938, he decided that "the best way to improve the Toyoda factory was to put the textbooks aside, go to the shopfloor, and study the plant and workers in operation" (Cusumano, 1985, p. 272). Later, Toyota's top-management consistently supported Ohno in his innovations.

As noted, path dependence in the development of organizations is a multi-faceted phenomenon, where several interacting paths may be identified. Evidently, Kiichiro's early experiments with JIT-production directly inspired Ohno's post-war approach. The latter's experiences at Toyoda Spinning and Weaving were crucial for his shaping of the production system after he moved to Toyota in 1943. In this regard, there is at least one intriguing example of a creative replication of a template that can be considered as an earlier, idiosyncratic outcome of the application of the routine of "self-testing and adapting". Multi-machine operating (see above) had been common already at Toyoda Weaving and Spinning before it was applied at Toyota from around 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 Motor Corporation, 1988, p. 142). This quotation may contain some romanticizing, but the similarity is striking nonetheless. It should be stressed that the empiricist meta-routine adopted by Toyota's key managers also implied that they were receptive for American management methods[4]. Like Sakichi, Kiichiro visited the USA and Great Britain, in 1921 and 1929/1930, studying operations in textile and machinery firms. He urged his collaborators to read Henry Ford's *My Life and Work* (Toyota Motor Corporation, 1988, p. 42). For his part, Ohno was a great admirer of both Ford and Frederick Taylor; in his obsession to reduce "waste", he extensively used of time-and-motion studies (Ohno, 1988). Ohno (1988) also emphatically mentions 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.

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 arbitrary. Toyota's meta-routine also had an enduring effect long after the emergence of the first lean production applications at the firm, by acting as a "constant cause", rather than only having a "one shot" impact during a critical juncture (initial conditions), as we will show in the last part of this section. As "lock-in" was expressed at Toyota in a steadily wider application and improvement of lean production, we should consider it a dynamic phenomenon. Next to a meta-routine, specific circumstances arising after the initial adaptation of a form of lean production, in a comparative short period of the years 1949-1950, locked-in Toyota to lean production. These vital circumstances were related 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 several factors under one subheading.

5.1 Shifts in demands, shortage of capital and lay-offs

Shortly after Toyota's first post-war experiments with lean production, a sequence of events committed the company firmer to the path of small-lot size and JIT-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, Japanese auto makers sharply increased their output (Toyota Motor Corporation, 1988, pp. 92 and 104-105). 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, as the number of unsold cars rose sharply, brought Toyota to the verge of bankruptcy by the end of 1949 (Toyota Motor Corporation, 1988, p. 105). This episode proved to be a turning point in Toyota's history (Coriat, 2000). 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 April 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 in the future. This dramatic episode made Toyota's leaders acutely aware of the importance of balancing production and sales (Fujimoto, 1999, pp. 60-1).

In fact, extending Ohno's infant JIT-system in the machine shop to Toyota's production as a whole was particularly suited to what the banks asked for (Togo and Wartman, 1993, p. 103). Application of a JIT-system was accustomed to the still low-volume, but increasingly diverse demand for cars that developed in Japan in the 1950s (Cusumano, 1985, p. 266), that is, after the period that we have defined as initial conditions.

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 vehicles in May 1950 (Toyota Motor Corporation, 1988, p. 109). The banks pressed Toyota – belatedly following the example of Nissan – to undertake mass lay-offs, despite an earlier promise to the unions not to do this. After prolonged disputes with the union and a long strike, in the summer of 1950, Toyota-founder Kiichiro resigned from his post and around 2,000 workers (one-third of the workforce) lost their job (Cusumano, 1985, p. 147; Okayama, 1987, p. 175; Toyota Motor Corporation, 1988, pp. 106-10)[5]. Precisely at the time, an exogenous event in the shape of the Korea War saved the Japanese car industry from extinction: the US 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 Motor Corporation, 1988, pp. 110-11) along the lines already pioneered by Ohno.

The episode also contributed to breaking the power of the industry wide union of auto workers. A new industry-wide strike in 1953 ended with a settlement at Toyota and Isuzu within two months, but culminated in a long and bitter power struggle at Nissan, which finally led to the collapse of the industry union (Okayama, 1987, pp. 176-7; Cusumano, 1985, pp. 149-54). In the end, this left Toyota with a more cooperative company union than Nissan (for details, see Saga and Hanada, 1999; Cusumano, 1985, pp. 180-3 and p. 309; Halberstam, 1986; Gronning, 1997). This was vital, since Ohno – perhaps exaggerating his own performance – stressed the vivid resistance of both workers and lower managers he encountered in applying his lean production approach (Ohno, 1988).

5.2 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 an overstocking crisis rather than enduring post-war 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. 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 was JIT put into operation in all Toyota plants.

The prevailing meta-routine made Toyota much more receptive for such an approach than Nissan, which still largely faced the same external 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, with whom he had collaborated until 1944, Asahara considered technology as something

you bought (Cusumano, 1985, p. 90). In line with this, in 1952 Nissan picked up the thread of its pre-war policy by forging an alliance with British carmaker Austin whose blueprints for production were followed to the letter as much as possible (Cusumano, 1985, p. 100). Despite the fact that the Japanese government stimulated cooperation with foreign car manufacturers, Toyota was the only Japanese car maker that did not forge a tie-up. In its official history, Toyota suggests that it did not needed this because it had started making prototypes of private cars even before the prohibition of producing passenger cars was lifted. These and other preparations for mass production of private cars culminated in the introduction of the Crown in January 1955 (Toyota Motor Corporation, 1988, p. 134; Kamiya, 1976, pp. 60-3). Still, as noted, Ohno's thinking was heavily influenced by both Taylor and Ford, and like Eiji Toyoda (1950), he visited USA and British automotive companies after the war. In fact, both in 1939 and after the war, Kiichiro Toyoda favoured cooperation with Ford (Wada and Yui, 2002, pp. 292-4). Plans for a tie-up with Ford were cancelled at the last moment early in 1939 and in June 1950 by intervention of the Japanese and the US government, respectively, (Kamiya, 1976, pp. 71-2; Toyota Motor Corporation, 1988, p. 113)[6]. There is more reason to qualify the tie-ups as distinguishing the other car makers from Toyota, as – in line with the Japanese government's policy – complete "domestication" of production by Nissan, Isuzu and Hino was reached by 1958 (Odaka *et al.*, 1988, p. 45). On the other hand, Toyota, too, adopted American-made specialized tools from the 1950s onwards (Okayama, 1987, 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 the Sakichi-loom functioned as a template:

> 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, protected from foreign competition by the Japanese government, boomed. Toyota's production of passenger 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. Although in-house final assembly of its first passenger models occurred in dedicated production lines from 1959 (Shiomi, 1995), Toyota later largely avoided the typical US practice of long production runs of single components and cars (Cusumano, 1985, pp. 280-1). By means of technical adjustments of existing machinery, Ohno *et al.* succeeded in reducing set-up times for stamping dies, from 2 to 3 h before 1955, to not more than a 3 min by 1971 (Cusumano, 1985, p. 284). This enabled "mixed production" of short production runs, which kept inventories low and made Toyota relatively flexible in dealing with the trend among car manufacturers to increase the number of models and with the slump in demand in the 1970s, when Toyota quickly made an end to exceptions to the company policy of producing more than one type of car per factory (Togo and Wartman, 1993, p. 189; Toyota Motor Corporation, 1988, pp. 326-7). Above we have suggested that among the initial conditions a lack of financial means was possibly the most constraining resource. Remaining faithful to the doctrine of lean production was certainly not for lack of financial resources: the company accumulated enough means to have financed 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, pp. 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, 108-9). 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). This of course, does not necessarily prove the superiority of TPS: its distribution and marketing approach shaped by Shotaro Kamiya, first appointed at Toyoda Automatic Loom in 1935, is to be credited too (Kamiya, 1976; Toyota Motor Corporation, 1988, pp. 62, 99; Kawahara, 1997; Williams *et al.*, 1994, pp. 117-19). Still the 1973 oil crisis and the subsequent worldwide depression put TPS (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).

Lock-in by meta-routines does not, to reiterate, mean that a rigid or static organizational system ensues: "efforts of definitively nailing down the TPS are constantly stymied by Toyota's annoying habit of ceaselessly developing and improving its own practice" (New, 2007, p. 3547). 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. 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)[7] 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 are aligned with Toyota's meta-routine of self-testing and adapting. 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 routine of self-testing and adapting.

The meta-routine of Toyota originating from Sakichi Toyoda is still identifiable in recent times. Two authors claim that four rules form the "DNA" of TPS; they all prescribe that "activities, connections and flow paths have built-in tests to signal problems automatically" (Spear and Bowen, 1999, p. 98). Stated otherwise, this DNA implies "integration of problem identification and problem solving procedures into the actual work processes" (Towill, 2007, p. 3620). As late as the mid 1980s, Toyota's efforts in continuously improving operations were still more oriented to 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 labour, Toyota decided to use relative simple machinery again in its green-field 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, a not so revolutionary change as it might seem since "zero-inventories" has never been a core element of TPS (Pil and Fujimoto, 2007).

6. Discussion

The re-examination of an extensively researched subject as the development of TPS shows that pinpointing the initial conditions and assessing their individual influence can be demanding. In an organizational context this is complicated by 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 as organizations are multi-faceted. Initial conditions are complex and interlocking too, not only regarding their contents, but also in their timing of occurrence. What others have usually pointed to as the major initial conditions – low and fragmented demand, scarcity of raw materials, and/or a general fashion of avoiding waste originating from the Japanese wartime economy – upon closer examination do not significantly explain the emergence of TPS right after the World War II. From among the three elements to be theoretically distinguished as initial conditions for paths of organization change – environmental requirements, resources, and value or philosophies – the first two mentioned undoubtedly constrained choice, but Toyota's specific philosophy arguable was the major imprinting force.

This indicates that the initial conditions as assessed at a certain point of time themselves may have a history that is relevant for a proper path dependence perspective. Our analysis shows how the philosophy expressed in a meta-routine of "self-testing and adapting" at Toyota Motor Company emerged before the firm itself had been set up. The meta-routine at Toyota itself resulted from a path dependent process as the experiences and approaches developed by the first generations of (family) managers was highly idiosyncratic. It has had a profound and lasting influence on its production system. We argue in this paper 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. Toyota's meta-routine did not make the development of TPS an unavoidable choice, only a much more salient one. The meta-routine has inspired the development and use of more mundane routines, such as multi-machine operating. In addition, the typical path dependence element of a specific sequence of events, put in motion by a overstocking and liquidity crisis in 1949, was important for locking-in Toyota to the path it had entered only shortly before. A combination of a separation of production and sales activities into two distinct firms, reducing the labour force and a sudden boom in demand "resonated" with a still infant system suited to lean, demand-induced production.

The Toyota meta-routine was perpetuated in particular through the extensive and systematic use of formal documentation of factory experiences introduced by founder

Kiichiro Toyoda and the consistent support by Toyota top management of the innovations of Taiichi Ohno. Other car makers, both domestic and foreign, could imitate Toyota's systematic reliance on testing as well as specific JIT-elements, but much less the underlying commitment and rigor in implementation: "What Toyota could do better than its rivals seems to be not so much rational calculations before the trials as systematization and institutionalization *after* the trials" (Fujimoto, 1995, p. 212, italics in original). Toyota's meta-routine was important in continuing its dedication to a production system characterized by small lot sizes and multi-purpose machines, despite the disappearance of financial bottlenecks in the 1960s (Gronning, 1997, p. 428). Some even sense an ideology at work:

> The insistence of the Japanese assemblers on the reproduction of the just-in-time system worked against profits in the short run, since it made the expense of international expansion ever so much greater (Schwartz and Fish, 1998, p. 66).

It is interesting to contrast this with the large Detroit car makers, which abandoned an early JIT-type of production system from the late 1930s since they no longer considered it the best cost-reducing device (Schwartz and Fish, 1998, p. 66).

This explanation heavily relying on a firm specific meta-routine interfering with sequences of events has its limitations. The effects of meta-routines on factory practices cannot be directly observed in a study based on secondary sources. We focused on the most salient meta-routine identifiable in the secondary literature. The development of TPS was influenced from many different directions (Fujimoto, 1999); other possibly relevant meta-routines, either specific to Toyota or more generally spread in Japanese business, we have not focused on. What is more, the "self-testing and adapting" orientation did not prevent Toyota from prematurely introducing the defect-ridden models on the market until the early 1960s, in particular of several versions of the Corona car (Togo and Wartman, 1993).

Still, the firm dedication to its meta-routine differentiated Toyota from its main domestic competitor, Nissan, not only in regards to the internal development of production. A concise analysis of the second pillar of TPS, a reliance on a both flexible and integrated multi-tiered supplier system (Dyer and Nobeoka, 2000; Ueda, 1997; Shiomi, 1995), reveals striking similarities with our path dependence-account of the genesis and development of lean production. Dearth of material resources during and after the wartime economy is unlikely to have been decisive in imprinting Toyota's outsourcing policy. In fact, from 1939 Toyota reoriented itself again toward more in-house production, in particular because suppliers could not offer the quality demanded (Wada and Yui, 2002, pp. 282-6). Similar to Morris-Suzuki's interpretation of the historical foundations of JIT, the Japanese wartime economy between 1931 and 1945 is considered to have left "... a range of institutional prototypes on which the post-war evolution of Japanese subcontracting is based" (Nishiguchi, 1994, p. 31). However, again, the quoted study does not specify what precisely these institutional prototypes were and how they shaped post-war developments. Toyota's approach, adopted early on, of making long-term commitments with suppliers (Toyota Motor Corporation, 1988, p. 76), irrespective of the immediate payoff, can be better considered an outflow of its typical meta-routine. Kiichiro's drive of gaining intricate knowledge of major processes in car production led him to follow the example his father had set at Toyoda Automatic Loom:

> Kiichiro began by setting up departments or factories to specialize in particular products or functions such as steel, electrical components, machine tools or body stamping. Later, he incorporated these factories as nonconsolidated subsidiaries, since this format offered greater possibilities for expansion and fund-raising than maintaining them as in-house departments (Cusumano, 1985, p. 248).

Thus, as we have seen before, the meta-routine of "self-testing and adapting" affected its influence in combination with a more specific template originating from Sakichi Toyoda's entrepreneurial activities – developing first and then spinning-off for strategic and financial reasons. In addition, and again similar to the internal development of TPS, the 1949 financial crisis was a major event that contributed to locking-in Toyota to its developing supplier system, since it forced Toyota to spin-offs, among other things, of its main ancillary company Nippondenso (Fruin, 1992, pp. 365-6; Fujimoto, 1999). In all, this early history of outsourcing clearly had a path dependent effect: all but one of Toyota's main subsidiaries as they existed in the mid-1980s were founded by Kiichiro (Cusumano, 1985), as is not fully recognized in one of the latest historical studies of this subject (Sako, 2004).

More recently, Toyota has began shifting towards a more arm's length approach in dealing with suppliers (Ahmadjian and Lincoln, 2001). This would bring Toyota closer to Nissan's position in outsourcing. The move is in line with a more "aggressive" policy adopted by Toyota top management in 1995, when Hiroshi Okuda became CEO. This policy change was partly contested by members of the Toyoda family (Hino, 2006). It shows that Toyota's meta-routine is not immune from erosion: philosophies at the top are starting to change, weakening one of the existing meta-routines and possibly replacing it with another. The current CEO, Katsuaki Watanabe, recently has begun to speak about a "kakushin" (revolution) needed at Toyota, as opposed to the traditional "kaizen"-approach of incremental improvement (Stewart and Raman, 2007). There is reason for concern, since, at the point of becoming the largest car producer in the world, Toyota is dealing with serious quality problems in car production (Anonymous, 2007).

7. Conclusion

In this paper, we re-examine the TPS from a perspective of the rapidly developing literature on organizational change as a path dependence phenomenon. In doing so, we argue for the necessity of opening the black box of initial conditions as part of a path dependence analysis, and relating them to mechanisms creating lock-in. The two elements, largely discussed in the literature as strictly separate, are in fact intricately related conceptually and empirically. Using the concept of path dependence as defined in this paper forces scholars to specify the nature of the historical explanation of change of organizations. A careful assessment of the exact timing and plausible effect of the (supposed) initial conditions helps to understand whether and how they shaped the phenomenon under study. Meta-routines are of particular relevance both in imprinting organizational features during initial conditions and in creating dynamic lock-in, interacting with specific sequences of events. Although competitors imitated many features of the TPS, the incessant application of an underlying meta-routine has given Toyota's way of producing a special dynamic nature.

Notes

1. In fact, Goldstone himself in an earlier publication (Goldstone, 1991, p. 60) defines events as constituting initial conditions.
2. Kogut and 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.
3. Ohno (1988, p. 31) writes that he made the first step towards JIT in 1949-1950; the timeline on the inside cover of this book mentions the start of "withdrawal by subsequent processes" in 1948, while two-machine handling was introduced as early as 1947. Cusumano (1985, pp. 262-307), who interviewed Ohno, mentions 1948 as the start of his innovations.
4. A well-documented study shows that Toyota did not invent JIT-production, but that such a "hand-to-mouth" system, originating from c. 1905, was applied by the large American car makers in the 1920s and 1930s on a large-scale to be abandoned soon after (Schwartz and Fish, 1998; Williams *et al.*, 1995, pp. 33, 35; Cusumano, 1985, p. xx).
5. In 1952, when there were serious plans for his return to the company, Kiichiro unexpectedly died.
6. As the managing director of TMS, Kamiya had first-hand knowledge about the aborted cooperative effort of June 1950. Fruin (1992, p. 296) referring to documents in the possession of a Ford executive, however, writes that the Japanese government vetoed such a cooperation in the early post-war years.
7. The bottom-up or "democratic" nature of decision-making at Toyota should not be idealized. In relation to its development of electronics capabilities Toyota felt: "... that only a top-to-bottom Japanese-style program of learning-by-doing could infuse its entire organization with the skills and values essential to making electronics a genuine 'core competence' ..." (Ahmadjian and Lincoln, 2001, p. 689).

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