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CONCRETE INNOVATIONS: PREFABRICATION IN DENMARK AND FRANCE

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Abstract

The point of departure for this paper is an interesting divergence in the market creation for prefabricated elements in Denmark and France. This technology, regarded as highly innovative in the 1950s, lost market shares in France in the late 1950s and 1960s while the market for it continued to grow in Denmark in the same period. We explore five hypotheses for this outcome: the dominant institutional logic, local conditions of production, path-dependency, national legislation, and the agency of professionals. The findings point to interaction among the last four variables with professionals playing an important role in the market formation. Professionals appeared to harness the other factors to advance their own interests.

Acknowledgements

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How is a market created for an innovation? A common conviction is that markets form when there is sufficient evidence for the technical merit of an innovation. However, most innovations have an ambiguous status when they are first introduced. This was the case, for instance, when Edison introduced electrical lighting. Consumers preferred gas lamps until Edison adapted his innovation of electrical light to appear essentially similar to gas lighting, only slightly stronger in lumination (Hargadon & Douglas 2001). Even when innovations are regarded as promising and exciting, exemplied by nano-technology, solid evidence of superior technical performance is often lacking. Whether the initial reaction is scepticism or excitement, the technical merit of an innovation is certainly insufficient to explain market formation.

The literature on the creation of markets suggests that markets can be organized in a number of ways (Dobbin 2004; Fligstein 2001). Markets may even be designed. Some researchers talk, therefore, about the *architecture* of markets. Market architectures can be created and recreated, which imply that actors who have a stake in the outcome may engage in contestation, promotion or negotiation of a new market. Not only does market creation involve social interaction, but it also draw in material elements (Callon & Caliskan 2006). Physical objects, documents, technological instruments and visual representations can all play a role in the process of market creation, whether their appearance results from deliberate action or from mere coincidence. Less material elements, such as institutionalized behaviour, social values and norms, legal measures, and shared convictions also impact powerfully on the creation of markets (Hargadon & Douglas 2001). Our theoretical ambition is to arrive at a better understanding of the dynamics of market formation.

To illuminate how the market for an innovation forms, we have undertaken a comparative study of market creation. Our study examines how the market for the same innovation formed in two countries. The innovation is prefabricated elements. Prefabricated elements refer to the factory production of concrete building blocks that are transported to the construction site where they are assembled into buildings. The market for this innovation took form in the early 1950s and it consolidated in the 1960s. Denmark and France were among the first countries to create a market for prefabricated elements. They make for an interesting comparison because of a striking market divergence around 1960 (see Figure 1). The use of prefabricated elements lost market shares in France from 1958 to 1968, while it, during the same period, rapidly gained market shares in Denmark We compare the market failure in France with the market success in Denmark to identify factors that may impact on market creation.

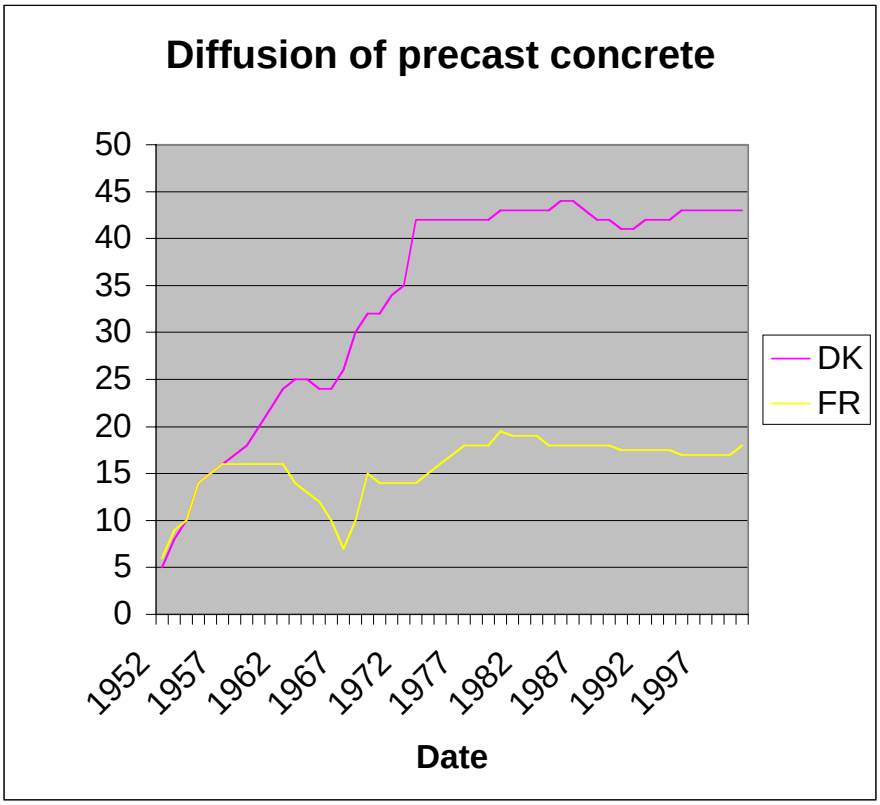

Figure 1: Frequency of using pre-fabricated elements relative to other concrete technologies in Denmark and France, 1952-2000 (Source: CEMBUREAU)

The graphic illustration of the market for prefabricated elements in Denmark and France (Figure 1) reveals more than a divergence around 1960. It also shows that there were long-term effects of this divergence. After the market for prefabricated elements had formed, which it did during the 1950s and 1960s, it then stabilized at a certain level. Prefabricated elements obtained, and still have, 40-45 percent of the market for concrete in Denmark, which is one of the highest market shares in Europe. In contrast, prefabricated elements only reached 15-20 percent of that market in France, slightly below the European average.

This stabilization suggests that the market formation follows a typical process of institutionalization. Institutionalization occurs when an innovation spread over a longer period of time and give rise to new practices that then stabilize as they come to be taken for granted (Rogers, 2003). Institutionalized practices are eventually replaced, or they become more marginal, as other innovations lead to yet new practices. According to the model of institutionalization developed Greenwood, Suddaby and Hinings (2002), the institutionalization process comprises several steps. At later stages, an innovative practice is theorized, i.e. generalized in rational terms, and actively diffused within an industry. This process result in one of two outcomes: either the new practice is institutionalized as a best practice, or it fades into the margins as the latest fashion (ibid). The interesting question, the one we set out to explore, is which factors determine the outcome at this important juncture in the process of institutionalization.

Analytically, we engage in an inductive comparison. Our ambition is to identify variables that can explain why the institutionalization of prefabricated elements unfolded so differently in Denmark and France. We explore the entire period from 1945 to 1968 to identify explanatory variables. In the present version of the paper, we present data to explore five plausible hypotheses for the divergence that occurred around 1960. They are

the dominant institutional logic, local conditions of production, path-dependency, national legislation, and the agency of professionals. Among these hypotheses, we are particularly interested in the role of professionals. The reason is that professionals have been identified in previous research as a deliberate actor in institutional change (e.g., Greenwood et al., 2002).

The paper is structured around the exploration of hypotheses. We first introduce the construction industry in the 1950s and the concrete technologies of the time. We then introduce the analytical procedures and outline the five hypotheses for why the market for prefabricated elements may have dwindled in France while it continued to grow in Denmark. After presenting empirical evidence for the five hypotheses, we discuss our findings and conclude with our interpretation of these findings. Basically, we propose that professionals shaped the market formation for prefabricated elements by harnessing the institutional factors that impacted most significantly upon this market.

THE CONSTRUCTION INDUSTRY

The beginning of the 1950s was a bustling period of innovations in the European construction industry. New ideas emerged in architecture, engineering and total contracting, inspired by the movements of Modernism and Scientific Management. The willingness to experiment with new construction materials was remarkable and concrete became an exciting new alternative to bricks in the construction of appartment blocks, or ‘skyscrapers’ as they were called at the time. Along with new materials came new construction techniques. One innovation in construction technique, inspired by recent successes in the automobile industry, was to industrialize construction processes, making them as rationally and efficient as possible. Prefabrication was the epitomy of this trend. Prefabricated elements refers to the factory production of concrete building

blocks such as walls, floors and staircases, which are then transported to the construction site and assembled into houses and appartment blocks. Prefabrication was celebrated as a very promising avenue for increasing the speed and lowering the costs of construction. These parameters were particularly important in the 1950s because of a dramatic increase in the demand for new dwellings. Rapid population growth, particularly in cities, and the need for post-war reconstruction stimulated an unequalled demand for new dwellings. It was believed that prefabrication could alleviate the demand faster and cheaper than any alternative technologies. In other words, prefabrication was considered to be a best practice in the 1950s.

Concrete techniques

Concrete is a liquid substance made of gravel, sand, water and cement, the latter being the ingredient that binds the elements together and gives concrete its unique strength and hardness. Concrete sets (become hard) in about six hours, but it takes weeks before it fully hardens and gains resilience. All techniques for building with concrete involve some variation of casting and curing. Casting refers to the pouring of concrete into forms that are made of wood, metal or plastic. Because cement requires time to hydrate, concrete must be cured after casting. Curing is the process that makes concrete hard and resilient. It occurs when concrete is kept in a moist environment at a controlled temperature until hydration is relatively complete, which takes several weeks.

There are different techniques for casting and curing concrete. Prefabrication consists in pouring concrete into standardized, reusable forms in a factory and curing the concrete elements in a controlled environment. The prefabricated elements are then transported to the construction site, where they are lifted into place and assembled into buildings. The competing techniques is cast-in-place concrete walls (CIPCW), which

refers to the pouring of concrete between frames on the construction site (shuttered concrete). The concrete substance is either mixed in a factory (ready-mix) or on-site, and it is then cast and cured on-site. The latter technique is more common, meaning that it has a larger market share of the market for concrete in the construction industry.

METHODS

Selection of markets

Our empirical setting is the construction industry, which encompasses a large field of activities that range from the construction of new housing and public utilities to the renovation and destruction of them. We limit our scope to the construction of new collective housing, a highly prioritized activity from 1950 to 1970 due to the general shortage of city dwellings. Many initiatives were taken to build new collective housing in this period.

The construction industry is also interesting because groups of professionals have historically played a very important role in this industry. We can track the activities of architects, engineers, masons and carpenters for centuries. First gathered within medieval corporations, they gradually, and to different degrees, became professions in the 19th and 20th centuries. It is possible to analyze the entire history of the industry through the lens of professional rivalries and their efforts to redefine professional identity and redraw professional boundaries to gain more control over the chain of production.

Selection of hypotheses

The literature contains very many hypotheses as to why a practice is abandoned or retained after it has been selected and implemented in organizational practice. Functionalists would suggest that the causality resides in the practice itself. If the practice

is more cost-efficient than the available alternatives, then it will be selected and retained. Only practices that give organizations a competitive advantage will prevail in the long run. Institutionalists, finding this argument incomplete, point to the environmental context as a core ingredient in the selection and retention of practices. Practices have competitive advantage, they argue, when they allow organizations to adapt to their organizational environment. Ultimately, it is therefore the organizational environment, and not the practice itself, that holds the explanation.

Institutional theory comes in many variants and it is not possible to investigate causal variables from all of its branches. We narrow the focus to sociological or organizational institutionalism, which in itself contains several accounts of why widely diffused practices are sometimes abandoned and at other times retained. We identified five hypotheses for why the construction practice in question was abandoned in France and retained in Denmark. These selected variables resonated with sociological or organizational institutionalism and with secondary data sources on the development of the construction industry in Denmark and France.

Data sources and analysis

We first conducted retrospective interviews with experienced members of the construction industry in each country. These interviews gave us a sense of the historical development in each field, which helped identify similarities and differences between the construction industries in the two countries. We also collected secondary material on the historical development of the Danish and French construction industry as well as internationally. From these sources we generated a list of potential explanatory variables. These variables were then juxtaposed with the institutional literature, which helped us formulate the hypotheses.

Data to support the five hypotheses were found in governmental archives and other relevant archives. We identified procedures, practices, workgroups, policies and laws that were operational during the period of study and contrasted them with one another across the two cases (see Appendix 3 for a list of primary sources). These data sources are not sufficient to make strong inferences about the explanatory power of the five hypotheses, but they permit an exploration of rich, comparative data. We use this exploration in a theory-building perspective to identify salient interactions among variables.

HYPOTHESES

Below we present five hypotheses from neo-institutional theory for why the use of prefabricated elements had such a different destiny in Denmark and France. We are particularly interested in the period around 1960 when the path started to diverge, leading Denmark to institutionalize the practice and France to abandon it. What can explain this dramatic juncture at such a crucial step in the institutionalization process?

1. Institutional Logics

Institutional theory proposes that variance in two fields can be explained by the dominant institutional logic in the field. An institutional logic is an overarching frame that stipulates which goals are worth pursuing and how to legitimately and effectively pursue them. Organizational fields are characterized by a dominant institutional logic that determines which practices are construed as valuable and legitimate. The hypothesis is that only practices that fit the dominant institutional logic will be selected and retained. Dobbin (1994) found support for this hypothesis in his study of the railway industry in three countries. He found that practices varied from one country to another because of

persistent differences in the dominant institutional logic that governed the railway industry in each country. In their study of institutional change in the academic publishing industry, Thornton and Ocasio (1999) also showed that organizational practices hinged on the dominant institutional logic.

2: Local Conditions of Production

Some of the early institutionalist literature makes a distinction between the local environment and the institutional elements within that environment (e.g., Selznick 1957; Meyer & Rowan 1977, Kraatz & Zajac 1996). The local environment is understood as factors that constrain or enable action without being socially constructed and institutionalized. Local conditions of production include factors like demography, geography, and economic conditions. While such factors can certainly be subject to institutionalization, they also shape organizational activities in their raw form. For instance, when there is a lack of manpower in a geographic region, it can lead to a slow-down in production. Poor economic conditions may also generate some restrictions regardless of the institutional order. Major disruptions in the local conditions of production can weaken the chain of production, or even break it, resulting in disruptions that have potentially detrimental effects on organizations.

The construction industry is labor intensive and hence affected by the availability of construction workers and construction professionals. On the supply side, a shortage of labour in a particular profession or skilled job can halt the whole construction process. Similarly, on the demand side, the economic conditions of a society will likely increase the demand, particularly if it coincides with demographic growth. The nature and intensity of the demand increase when the population grows and the economy improves. New buildings, collective housing in particular, are large and risky projects that are only

initiated if the local conditions of production seem conducive to the demand. The hypothesis is that the same practice will fare differently in two fields whose local conditions of production are dissimilar.

3: Path-dependency

When a new model of practice is introduced in an organizational field, it is *translated* into practice. The translation process has been conceptualized as consisting in the three consecutive steps of selection, objectification and materialization (Czarniawska & Joerges 1996). The first step, s*election,* occurs when individuals choose an idea that seems promising for alleviating an organizational problem. "Organizational actors, like a collective ant-eater, catch many, spit out most, and savor some [ideas], presumably on the grounds of relevance to some organizational problem" (ibid: 25). The second step, *objectification,* consists in assigning a label to a selected idea so that it can be understood collectively. "The simplest way of objectifying ideas is turning them into linguistic artifacts by a repetitive use in an unchanged form" (ibid: 32) because ideas crystallize somewhat when they acquire a fixed terminology. Finally, the last stage is that of *materialization,* which is when objectified ideas turn into quasi-objects, i.e. "this magic moment when words become deeds" (ibid: 41). A construction practice is a quasi-object.

Translation, not least the last step of materialization, consists in refitting and combining the new model of practice with what is already there in terms of existing practice. Refitting is important to assure continuity and meaningfulness for actors and legitimacy for the new practice. Translation occurs even when organizations try hard to imitate each other (Strang & Meyer 1994; Sahlin-Anderson 1996) because individuals invariably imitate some elements of unfamiliar practices and disregard other elements when they try to imitate them (ibid: 48). Empirical studies lend support to the role of

path-dependency in the translation of new models of practice (Boxenbaum 2006; Lippi 2000). The hypothesis here is that construction practices that existed prior to the introduction of prefabricated elements explain the variance between the two fields.

4. National Legislation

One of the three pillars of institutional pressure for conformity is the pillar of regulation (Scott 1995). The other two are norms and beliefs. Regulation asserts institutional pressure on organizations by imposing formal sanctions on them if they do not conform to the rules. National legislation is particularly potent in this regard. It permits the state to impose fines on organizations that misbehave and to exclude organizations that do not conform to certain rules. In this sense, legislation is a powerful tool to change the organizational behavior in a field. There is indication that regulatory pressure is more effective than normative pressure in provoking field-level change (Tolbert & Zucker 1983), yet it is also true that behavioral change is more superficial if actors are forced to adopt new behaviors (Kostova & Roth 2002). Over time, legislation can cause real change in organizational practice (Edelman 1992) to an equal or greater extent than new norms and new beliefs.

The construction industry was certainly subject to new legislation in the period under study. There was new legislation on how to use the aid that Europe received from the Marshall plan between 1948 and 1952 to reconstruct buildings that had been destroyed in WWII and to improve its infrastructure. Legislation governed the granting of state loans to construct new collective housing in cities as well. The hypothesis here is that different legislation in Denmark and France explain the respective destiny that the use of prefabricated elements had in the two fields.

5. Agency of Professionals

DiMaggio and Powell (1983) proposes that professions generate normative institutional pressure in an organization field. The argument is that professionals are better organized than so many other organizational actors and better positioned to proactively shape the process of institutionalization. Empirical research demonstrates that professionals do play an active role at various stages of the institutionalization process. Firstly, they sometimes initiate new practices by engaging in interorganizational collaboration (Lawrence et al. 2002) or by importing foreign practices into the field (Djelic 1998; Boxenbaum & Battilana 2005). Secondly, through their professional organizations, they deliberately theorize and diffuse new practices in the field (Greenwood et al. 2002). Actors also influence the decision to implement or decouple a new practice when they engage in strategic with organizations in the same industry (Lounsbury 2001). By extension, it is plausible that deliberate action on the part of professionals explains the last stage of the institutionalization process as well. The hypothesis is that professionals determine whether a widely diffused and implemented practice is abandoned as a fad and fashion or whether it proceeds to become fully institutionalized.

RESULTS

1. Institutional Logics

The French and the Danish construction industry were both guided by the institutional logic of modernism/ functionalism in the mid 20th century. The core principle of modernism/ functionalism is that form should follow function. This principle, which has been attributed to American architect Louis Sullivan, emphasizes rationality and advocates a minimalist style of architecture that avoids purely decorative elements. It

also endorses the social value that all people should benefit from basic qualities of life, such as sunshine, light, and an unobtrusive view from good, functional apartments. When this logic was introduced in architecture in the early 20th century, it represented a sharp break with the previous preference for buildings that had very elaborate decorations and ornaments.

Le Corbusier pioneered the modernism/functionalism movement in French architecture in the 1920s. A classical example is Villa Savoye that he completed in the late 1920s (see Figure 3). He also designed concrete apartment blocks as novel architectural solutions to the growing slum in French cities. Another pioneer of this movement was Mies van der Rohe from the Bauhaus School in Germany. One of his pioneering works is Villa Tugendhat, which clearly shares many architectural features with the work of Le Corbusier (see Figure 3). Their modernist/functionalist architecture was soon theorized and they diffused it to other architects at workshops and international conferences. It reached Scandinavian architects at a conference in Stockholm in 1930 (Danish Ministry of Foreign Affairs, 2003). Within a few years, Arne Jacobsen, a young Danish architect, applied their ideas to build the residential complex of *Bellavista*, which later became internationally recognized (see Figure 3).

Villa Savoye by Le Corbusier, France, 1929-1930.

Villa Tugendhat, by Mies van der Rohe, Czech Republic, 1930.

Bellavista by Arne Jacobsen, Denmark, 1933-1934.

Figure 3: Pioneering modernist/ functionalist architecture.

During the 1930s and 1940s, modernist/ functionalist architecture gained wide recognition in both France and Denmark. Few construction projects were initiated during this period, however, because of economic conditions during the depression and the Second World War. The major breakthrough came around 1950 when the economy improved and many new construction projects were initiated. Modernism/ functionalism gained dominance in the Danish and French construction industry in this period (see Figure 4), and the rational principles of functionalism/ modernism inspired not only architects but also engineers. New construction technologies emerged during this period and new building materials such as iron, steel, concrete and glass became popular. The construction process was organized in a more rational and efficient manner that corresponded to the ideas of scientific management.

Cite Radieuse de Marseille, by Le Corbusier, France, 1947-1952.

Bellahøjhusene, by Kristensen, Heiberg, Buhl, Larsen, Fink and Petersen, Denmark, 1951-1956.

La Duchère, collective work, Lyon, France, 1958.

Høje Gladsaxe, by Hoff and Windinge, Denmark, 1964.

Figure 4: Modernist/functionalist architecture in France and Denmark, 1950-1965.

In the late 1960s, critique of modernist/functionalist architecture started to mount. The new high rises were said to encourage ghetto formation and to foster a sentiment of anonymity and sadness. As early as 1959, the French Minister for Construction announced that: "*I must admit I have been shocked during recent travels in France by so many obvious architectural failures. Some 'Grands ensembles', similar to hundreds of meters long concrete walls and 12 stocks high, are destroying the human side of construction*." (Vayssières 1988). The American postmodern architect, Charles Jencks, has claimed that modernism died the day in 1972 when the Pruitt-Igoe housing project was demolished. This large housing complex was a symbol of modernist/ functionalist architecture.

The old logic was soon replaced by postmodernism. The special features of postmodern architecture include attention to the unique expression of buildings and their correspondence with the local environment. The shift to postmodernism meant that particularism and contextualism replaced the universalism and rationalism of the functionalist-modernist logic. French postmodern architecture praised complexity and advocated local adaptation instead of universal design. Architects also rediscovered the symbolic values of forms, such as those from the Art Deco movement, and made the

commercial value of buildings an objective in the conception phase. Danish postmodern architecture favoured low, dense housing that encouraged communal values. *Tinggården* is recognized as the first decisive break with modernist architecture. It represented an alternative residential environment that reflected the ideal of small, intimate residential enclaves in touch with nature (Denmark.dk). Figure 5 provides examples of postmodern architecture in the two countries.

The data that we presented here shows that the institutional logic of functionalism/ modernism had a similar life cycle in France and Denmark. The logic emerged and became popular at about the same time and it manifested in similar architecture in the two countries. In addition, it was replaced with the same institutional logic of postmodernism at about the same period in time, reflecting a general trend in the western countries at the time. Our point is that the institutional logic was similar in Denmark and France when the variation occurred in the use of prefabricated elements. The institutional logic also shifted in the same direction at the same time in the two institutional fields. Hence the variation in the fate of this construction practice cannot be attributed to differences in the dominant institutional logic in the two fields.

La Cour d'angle, Saint-Denis, 1981 by Henri Ciriani

Maurepas, 1974, by Henri Gaudin

Quartier des hauts de forme, Paris, 1979, by Christian de Portzamparc

Tinggården, Denmark, 1978, by Tegnestuen Vandkunsten.

Figure 5: Postmodernist architecture in France and Denmark.

1. Local conditions of production

Two conditions of production seem to have impacted importantly on the construction industry in the period from 1945 to 1975. One of them was a strong demand for more city dwellings when the economic conditions improved after WWII and agriculture became industrialized. The other condition was a shortage of labour supply to meet the high demand for new construction of collective housing. Below we explore if there were differences in demand or supply that can explain the divergence in the use of prefabricated elements in the two fields.

Demand

After the Second World War, both countries experienced a strong demand for new collective housing. In France, around 460.000 buildings had been destroyed during the war and 1.65 million had been damaged. The need for replacements was urging. In addition, many apartment blocks were old and in a very bad shape due to a national regulation that froze rental increases between the two wars and thus discouraged private investments in real estate. A collective representation of the problem emerged at the beginning of the 1950s. In 1954, the priest Abbé Pierre became notorious for his protest in favor of the ill-dwelled. The same year, a census used a new evaluation standard for housing and revealed the poor standard of French housing: only 10% had a bathroom,

only 25% had a toilet. As a result, 100.000 buildings were torn down every year between 1954 and 1962, rising to 150.000 a year between 1962 and 1975.

The rural exodus, rising immigration, and the baby boom also sustained a high demand for new housings in France. In 1954, 27% of the population worked as peasants. When the migration from the countryside to cities stabilized in 1975, only 9% of the population was still employed in agriculture. Some had emigrated, but the majority had moved to cities where they increased the demand for urban housing. Immigration into France also added to the demand for housing in cities. Immigration accelerated around 1955 and remained considerable until 1974. The demand for new city housing in France was thus very considerable from 1950 to 1975.

Danish dwellings had not been destroyed to the same extent during the war, but they were not in good shape either. This problem was overshadowed, however, by the exodus from the countryside in response to industrialization. From 1930 to 1970, the population in the Danish countryside decreased from 1.5 million people to 1 million people (Danmarks Statistik, 2000). In combination with the baby boom, the rural exodus meant significant demand on housing in cities. A governmental report from 1945, *Det fremtidige boligbyggeri*, estimated that the cities were already short of 50.000 homes and that 1.5 million additional homes were needed before 1976.

The demand for new housing was so significant that the State became actively involved in the construction industry. Denmark launched a Ministry of Housing in 1947 and established a research unit, *Statens Byggeforskningsinstitut* (SBI), at about the same time. The Ministry formed various committees with members from the construction industry who produced recommendations that then informed governmental policies and initiatives. By 1953, a coherent and ambitious governmental program had been conceived to facilitate the construction of new collective housing in cities. Financing came in part

from the Marshall Program, which offered American products to Europe from 1948 to 1952. These products were sold to generate financing for (re)construction. Many city dwellings were constructed in the 1950s and 1960s to meet the demand. The production was record high in the 1960s. The city population doubled from two million people in 1930 to four million people in 1970 (Danmarks Statistik 2000).

The French State took similar initiatives in 1953 to actively support and to finance the construction of new housing in the 1950s and 1960s. Construction projects need a high amount of investment and rest heavily on the conditions of access to capital. As explained earlier, private investment has been deterred before WWII due to poor market conditions. The 1950s were marked by the very large domination of the state in the financing of housing projects. For instance, in 1958, 90% of the completed housing was financed with public funds. The state-owned bank "Caisse des dépôts et consignations" played a central role in the financing of French housing projects. In the 1960s, private investors gradually entered the collective-housing market, aided by development of bank subsidiaries that were dedicated to real estate. Table 2 illustrates the rapid growth in the construction of new housing in France in the 1950 and 1960s.

New housing	**1950**	**1956**	**1958**	**1964**	**1972 (peak)**
Total	80 000	320 000	400 000	430 000	550 000
Social housing	7 500	72 000	85 000	95 000	214 000

Table 2: New housing constructions in France (source: INSEE)

The growth in new constructions peaked in the early 1970s in both countries and then declined. The abrupt halt in new constructions of collective housing occurred simultaneously in Denmark and France in 1973 as shown in Figures 6 and 7.

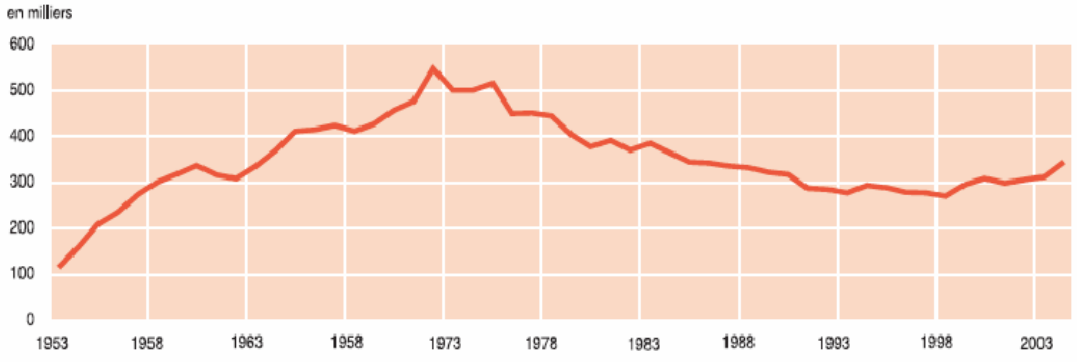

Figure 6: New constructions of housing in France (Source: Ministry of equipment)

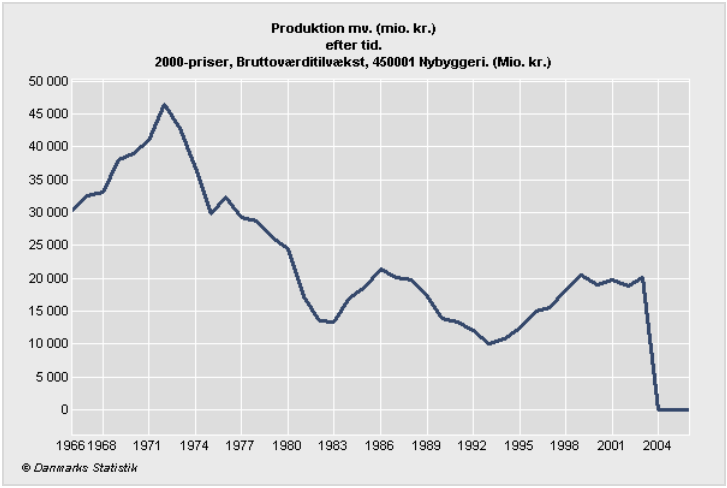

Figure 7: Brutto value growth of new constructions in Denmark (Source: Danish National Statistics)

This drop in demand correlated with a saturation of the market in both Denmark and France. However, the very sudden drop in 1973 is probably an effect of the oil crisis in 1973, which slowed down the construction industry in other countries as well. The construction industry may have been more affected than so many other industries because of relatively heavy oil consumption in the industrialized construction process. Figure 8

and 9 show a similar pattern in the two countries. The production in the construction industry surpassed that of the economy as a whole in the 1950s and 1960s, and then fell below this threshold after 1972. The different parameters of the two graphs introduce some uncertainty, but it seems that the discrepancy is more amplified in the Danish case. Denmark seemed to have a relatively higher productivity in 1960s and to experience a relatively larger drop after 1972. It is plausible in light of the fact that the use of prefabricated elements requires a high level of industrialization.

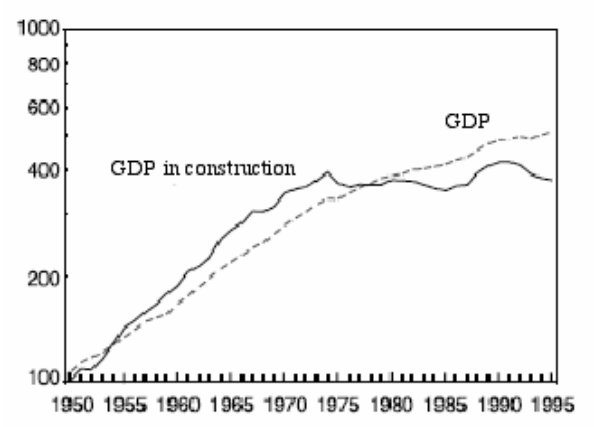

Figure 8: GDP in the French construction industry and in society as a whole (1950-1995) (source: INSEE)

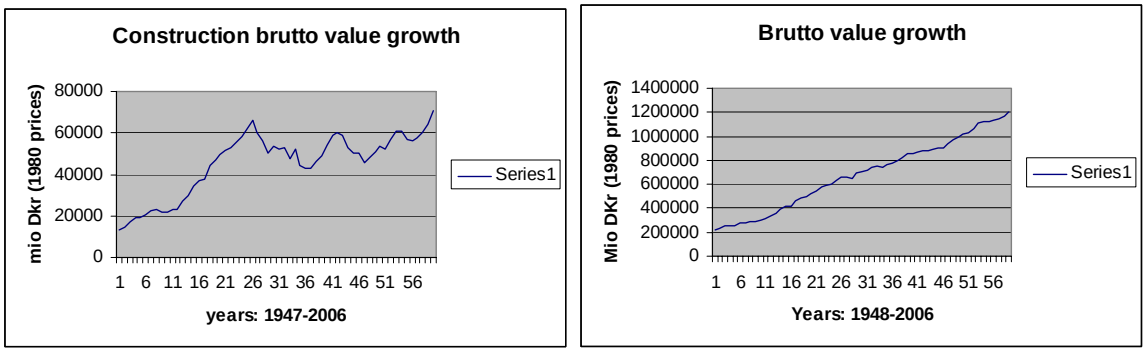

Figure 9: GDP-type indicator of the Danish construction industry and in society as a whole (1947-2006) (Source: Danish Statistics, Adam's Index). [Peaks: 1972, 1987; Lows: 1983, 1993]

In sum, the demand for new collective housing does not seem to explain the variance in the use of prefabricated elements in the 1960s. There was very high demand

for new collective housing in both fields between 1950 and 1970, and the State facilitated the construction of new dwellings in both countries. Hence, there is little on the demand side to explain why prefabricated elements fared differently in the two fields.

Supply

The construction industry is labour intensive and thus highly dependent on its workforce. Is it possible that differences in the workforce explain the divergence? In fact, the labour supply was a problem. When the demand for new housing increased, the insufficient supply of skilled construction workers became a bottleneck. Masons, in particular, came in short supply. They were traditionally very central to the construction of new buildings but were in too short supply to respond to the sudden increase in demand. The problem was similar in France and Denmark, yet they envisaged slightly different solutions.

In Denmark, the rural migration into cities brought about a large pool of unskilled workers that needed work. Migration from the Danish countryside to the greater Copenhagen area accelerated and peaked right after the war and continued thereafter at a steady rate (Statistical Department, yearbooks from Danish Statistics). Figure 10 shows that approximately 10.000 rural residents moved to larger Copenhagen in 1945-1946 and that they were joined by about 2.500 people every year until 1953. They represented a pool of unskilled workers that could potentially be employed in the construction industry. Only problem was the resistance of skilled workers to share their *de facto* monopoly over particular work domains with low-cost, unskilled labour. Skilled workers did not want unskilled labour inserted in their part of the production chain.

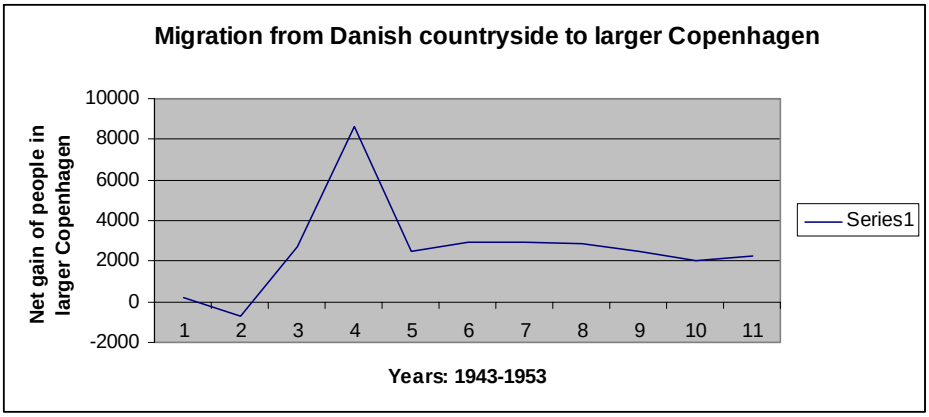

Figure 10: Migration from rural areas to Greater Copenhagen 1943-1953 (Source: Statistical Department, Danish Statistics).

The slot for unskilled labour was found in new technologies where no particular group had acquired superior competency. Since no construction workers had experience with prefabrication, groups of skilled labour could not claim monopoly over their assembly. Policy makers seized this opportunity in 1953 to formally endorse and financially encourage the use of alternative technologies. The government struck a deal with representatives of labour and business to promote the use of unskilled labour in the construction industry for the benefit of the national economy (Arbejdsmarkedskommissionen 1952). The objection of skilled construction workers was thus overruled at higher levels of negotiation. This intervention had the effect of promoting the use of alternative technologies that were manageable for unskilled labour. Prefabricated elements belonged to this category, and so did other new construction technologies that gained popularity in the 1950s. This explanation is thus partial at most.

In France, it was immigrants that came to compensate for the short supply of skilled labour in the construction industry. Foreign immigration was eased in 1945 but immigration remained low until 1955. Then, it speeded up due to a number of concomitant events, not least the Rome Treaty and decolonization. Italians were the first to establish an important community in France at the end of the 1950s, followed by the Spanish (agreement in 1961), the Algerian (end of the war and decolonization in 1962),

the Portuguese (agreement in 1963) and then more largely by people from North Africa and sub-Saharan Africa. This intense immigration pattern coincided in time with the abandonment of prefabricated elements. Perhaps these immigrant groups possessed certain characteristics or competencies that influenced the prevalence of prefabrication?

Some interviews and secondary data converge on the interpretation that the European immigrants that were hired in the construction industry possessed competencies in masonry that made them more inclined to use CIPCW technology than to use prefabrication. However, Myriam Campinos-Dubernet, whose work on the construction workforce in this period is widely recognized, contradicts the competency argument. She acknowledges that the hiring of immigrant workers correlated with a reinforcement of CIPCW technology relative to the use of prefabricated elements, but her argument is that it was because of its low cost and its indifference to new operating procedures, not because of higher competency among immigrants in this particular technology. Her evidence is that the massive hiring of immigrants in the industry only began around 1962 (Campinos-Dubernet 1984: 208) that is to say after CIPCW had already started to become more prevalent than prefabrication. Competencies among immigrants may certainly have been a reinforcing factor but it is unlikely to be a sufficient explanation for why France abandoned prefabrication at a time when Denmark reinforced it.

3. Path-dependency

The rise of modernism/ functionalism gave rise to a number of new construction practices that were more technical and industrialized in nature than the previous low-tech methods of construction. There was wide experimentation with new technologies and new construction processes in the 1950s. Concrete became very popular and the

construction industry experimented with a range of different technologies where concrete was a core ingredient.

The traditional construction practice in Denmark used bricks for the walls and tile for the roof. Like prefabricated elements, bricks and tile are standardized building blocks that were prefabricated off-site and transported to the building site where they were assembled by construction workers. Restrictions were imposed on many building materials during WWII, including tile and wood, until 1956 (Bertelsen 1997:16). There was thus an incentive to experiment with new building materials in the early years of the construction boom. Concrete was interesting because the ingredients were inexpensive and readily available. Relative to other technologies with concrete, prefabricated elements were perhaps closer to previous practice. The building blocks were certainly larger and the equipment to assemble them heavier, but the practice of assembling rather than fabricating was continuous with previous practice. At the same time, the use of prefabricated elements required the creation of new factories, rigid work procedures and extensive technical support that were far from path-dependent.

In France, concrete had been invented by French engineers in the 19th century and been promoted as a good substitute for wood, stones, bricks and steel. Acclaimed engineers like Lebrun and Coignet experimented with the construction of concrete houses before the turn of the century. Between the two world wars, the new technology was employed in architectural experiments with functionalism/ modernism. In fact, Le Corbusier used concrete extensively and conceptualized a procedure very close to CIPCW when he projected in 1920 that "*houses made of liquid concrete …are poured from the top as if we would fill up an empty bottle with liquid cement*" (Le Corbusier, 1920, p 190). During this period of experimentation, a new category of mason emerged:

the formwork handler that creates wooden frames and pours concrete into them. Their skill may have influenced the later adoption of CIPCW in France.

At the beginning of the 1950s when public companies redirected their efforts to the production of dwellings, the construction industry already possessed competencies in the use of concrete. There was extensive experimentation with different technologies in this period. Shuttered concrete techniques competed with prefabrication, for instance in the Strasbourg contest in 1950. The State exclusively supported prefabrication in its official competitions and public tenders, however. A notable exception is Coffreur-Bret who won accreditation from the State in 1958 for a shuttered concrete procedure based on very large formworks (tunnel formworks). Around 1960, these experiments ended and the construction industry retained the technology of pouring concrete into forms on-site.

The initial endowment of competencies in the use of concrete may explain in part why the technology of cast-in-place concrete walls was selected over prefabrication in France. The technology was already well developed and routine procedure whereas prefabrication was a rather novel technique. However, this account is not sufficient to explain the abandonment of prefabrication in France. First of all, concrete is the core ingredient in both technologies so familiarity with concrete should not favour one technology over the other. Secondly, prefabrication diffused widely in the 1950s before it became marginalized. Had path-dependency been the explanatory factor, then prefabrication would not have diffused in the first place. Yet, it is plausible that the longer tradition of cast-in-place concrete walls favoured its retention after the experimental years of the 1950s. Hence, we find partial support in both cases for the hypothesis of path-dependency.

4. National legislation

The construction industry in both Denmark and France depended heavily on state intervention to respond to the sudden and strong demand for new housing after WWII. Most financing of collective housing came from the public sector, and through this channel, the state impacted significantly on activities in the construction industry. State priorities were conveyed in criteria for obtaining state loans and in the qualification parameters for public tenders. The vision of public policy was reinforced in law and formal guidelines. Clients were thus conditioned by legislation to buy certain construction products.

The Danish state made state loans conditional upon the use of new technologies that required an absolute minimum of masons to partake in the construction process. This principle was adopted by the Ministry of Housing in 1947 and it was rigorously enforced when state loans were made available in 1953 for non-traditional construction (Law no. 288 of June 14 1951). Non-traditional construction was defined as projects that relied on new building materials and employed no more than 15% of the usual need for skilled masons (Bertelsen 1997). This was a drastic measure to promote new concrete-based technologies. Technical support was made available to facilitate the transition to new technologies.

In 1960, national legislation consolidated the use of pre-fabricated elements. It became mandatory in 1961 to facilitate their application in the construction of rental apartment blocks (Law no 246 of June 10 1960). The distance between floors in new apartment blocks was set to 2.80 meter which made it easier to work with standard measures. It was not obligatory to *use* prefabricated elements in the beginning, only to make it possible. The new national construction law from 1960 stipulated that construction measures had to be compatible with the size of standard prefabricated elements and that new technology should be favoured. Once the production system was

running smoothly, it became obligatory to use prefabricated elements in the construction of public buildings, including schools, hospitals and retirement homes as well (Bertelsen, 1997).

At a first glance, France introduced similar legislation as Denmark. In 1953, the French State possessed the economic resources to facilitate the construction of collective housing. It promoted industrialized techniques by financing large projects with more than 300 dwellings and facilitating access to capital for innovative construction projects. The State was directly involved in the process in as much as it organized contests and selected the most innovative projects. Public tenders in the 1950s favoured prefabrication techniques. For instance, in 1952, the winner of a contest for 4000 dwellings employed the CAMUS procedure, a technique that gave birth to the first prefabrication plant in Montesson.

Other legislation is introduced in France around 1960 (see Appendix 1), but in contrast to the Danish case, no preference is given to a particular technology at the legislative level. Without legislative reinforcement of prefabrication, it became impossible to attain the economies of scale that made this technology so cost-efficient in Denmark in the 1960s. Hence, the absence of reinforcing legislation in France may have contributed to the disillusionment with prefabrication and the subsequent abandonment of this practice in France.

5. Agency of Professionals

The construction industry is organized around two professions, architects and engineers, who interact at many steps of the construction process. The process starts with the expression of client need and ends with the delivery of the product.

Architects

Architects play an important role in the promulgation of new streams of ideas in the construction industry. They carry out the intellectual work of translating conceptual principles into blue prints and they do the artistic work of assuring that the final product is aesthetic and responsive to client needs. Architects are traditionally the first professionals to enter into contact with the client. This privileged position gives them an advantage over engineers in terms of giving form to new ideas and shaping client demand. They can set parameters that shape and restrict the subsequent construction process in important ways.

French architects have had a strong artistic orientation since the creation of the first national school of architecture, the Royal Academy, which was founded in 1671. The initial mission of architects was to carry out prestigious aesthetic work ordered by the Royal Academy, leaving the conception of common buildings to civil work engineers (Champy 1999; Barjot 1991). In some periods of time, architects became involved in the technical part of construction and worked more closely with masons, but they readily left more complicated technologies like steel and concrete in the hands of engineers while they attended to the conception phase (Champy 1999). The artistic mission of architects is still protected in the institutional order today. Architects are the responsibility of the Ministry of Culture and not of the Ministry of Equipment, which govern the activities of other actors of the construction process. Their education is said to lack technical knowledge (Champy 1999, Carassus 2003).

French architects established two professional organizations in the 19th century: "Société Centrale des Architectes" in 1840 and the "Société des Architectes diplômés du gouvernement in 1877. Both claim to protect the cultural value of architecture and the artistic vocation of architects, and both of them received recognition as a public utility

association in 1915 (Rodriguez Tomé 2006). A law from December 1940 gave French architects a precise definition of their profession and established some organizational rules. For instance, clients now had to choose their architect on a list of "charted" architects. The law of 1940 emphasized their artistic vocation and their independence from other actors of the construction process. Appendix 2 shows important dates and events in the history of the profession.

In Denmark, architects have never received formal recognition as a profession but convey their status as architects through membership of a professional organization called "Academic Architects". The Danish school of architecture was created under the Royal Academy of Arts in 1754 and its educational orientation has shifted between artistic and technical competency. In the late 19th century, a professional organization was created to promote good architecture. Only much later, in 1951, did architects organize to protect their professional interests. In 1952, their proposal to protect the title of architect was refused and they still operate today without a protected title and without the status of professionals.

Engineers

Engineers, civil engineers in particular, are the technical experts in the construction process. They turn architectural blueprints turn into solid buildings, using the most appropriate technologies and materials available. They also invent new technologies and materials and make financial projections of architectural drawings during the conception phase. At times they also manage the production phase of a construction project although it is common to delegate this task to a total enterprise. Civil engineers have a long academic education and are specialized in construction.

In France, the first school of engineering, the "Ecole Nationale des Ponts et Chaussées" opened in 1747. During the 19th century, civil engineers experimented with

the use of new materials like steel and, to a lesser degree, concrete. They conceptualized the advantages of concrete and steel as efficient new construction techniques and promoted them through their interest groups (Guillerme 1995). Until 1950, the main activity of civil engineers was to carry out construction projects for the public sector.

French engineers organized as early as 1716 in “Corps des Ponts et Chaussées” and civil engineers belong to the engineer corporation “Grands Corps” whether they work for private companies or the public administration. In 1906, they created a union devoted specifically to constructions in concrete and industrial processes (SNBATI). This union came into play when pioneering architects experimented with the modernist conception of architecture and the aesthetics of new building materials in the 1920s. The union also contributed to theorize and diffuse new construction technologies in the 1930s and 1940s prior to their becoming widespread in the 1950s. The French corporation of civil engineers even established a subdivision in Denmark in 1930.

The French State promoted the market for prefabricated buildings by giving large projects (between 300 and 4000 dwellings) to certified duos of architects-engineers or to trios of architects-design offices-engineers that demonstrated technical ability. Each duo or trio specialized in a few types of buildings and became competent and efficient in those styles. Hence, multiple techniques involving concrete co-existed side by side in the 1950s. However, the overwhelming demand for collective housing made it easier for new players to enter the market to compete with former civil engineering companies. One of them was Martin Bouygues who, without any previous experience in the industry, founded a construction company in 1952 (Campagnac 1987). Thirty years later, his company, Bouygues Construction, had become the largest construction company worldwide.

Bouygues was the only company to break the rules of the French construction industry in the 1950s. The company initially invested in a prefabrication unit and used this technology in the 1950s. But from 1959, Bouygues became a loud opponent of prefabrication and radically changed strategy. He introduced new operating procedures, reorganized the building site, and developed a company-specific corporation of masons in line with traditional masonry. In advocating the use of shuttered concrete on-site, Bouygues valued the competency of masons and allowed more flexibility in the construction process. In 1966 he won the PPL contest (Programmes Pluriannuels de Logement) for his flexible version of formworks for shuttered concrete. The technique was not original, but it appealed to some segments of the construction industry. The contest had very large media coverage and thus gave positive attention to shuttered concrete at the expense of prefabricated elements.

These chains of events suggest that coalitions and agency may have contributed to the abandonment of prefabrication in France. It is important to note, however, that Bouygues was not a professional. He circumvented professional agency through strategic alliance with other actors in the construction industry. Certainly, in the 1960s, there was a coalition of interests around the use of CIPCW as a better technology than prefabrication. This coalition gathered young architects, new housings construction companies and even masons that gained more autonomy. The relative power of key actors is represented in Figure 11.

BUILDING Construction technology (material)	19th century Traditional (stone-wood-brick)	1900-1945 Intermediary (steel-wood-stone-concrete for pillars)	1952-1965 Prefabrication (concrete)	From 1965 Shuttered concrete (concrete)
Engineer	-	+	++	++
Architects	+	+	-	+
Masons	++	++	-	+

Figure 11: Repartition of power among key players in the French construction industry, divided by dominant construction techniques since the 19th century.

In Denmark, the first school of civil engineering, "Polyteknisk Læreanstalt", was founded in 1829. It was modeled after the French Ecole Polytechnique and had a highly theoretical orientation (www.dtu.dk). During the rise of industrialization in the 1870s, civil engineers became involved in industry and public work. They established their first association in 1892 through which they promoted the profession and their professional interests. This association was instrumental, for instance, in making house construction a domain of civil engineering. The organization simply collected contributions from its members to pay the salary of a professor in this domain when the State refused to finance this expansion.

In the first two centuries of the 20th century, civil engineers gained expertise and recognition in the construction of houses. They also experimented with new technologies in the 1930s and 1940s, probably in interaction with French engineers who, as we saw earlier, established a Danish subdivision of their corporation. Engineers were quite proactive in this period. In 1948, the Danish Engineering Consortium launched a rationalization committee to explore possibilities for modernizing the construction process. Its report from 1951 made suggestions for how to simplify the process of constructing new dwellings. One of its suggestions was to introduce a vertical standard of 280 cm between floors in all new apartment blocks.

Inspired by the report, the Ministry of Building launched its own rationalization committee in 1951. Many members reappeared in the ministerial committee, which was mainly composed of civil engineers although some prominent architects were also involved (Bertelsen 1997). The ministerial committee was renamed "productivity-fund-committee" and received financial resources from the Marshall Program in 1953 to

promote the construction of new housing. Through this committee, prominent civil engineers came to influence public policy and legislation in the construction industry. In fact, an insider to the industry suggests that the use of prefabricated elements in open systems was pushed strongly by one or two civil engineers in the group, particularly P.E. Malmstrøm, one of the developers behind a non-patented prefabrication system (Bertelsen 1997). If so, this supports the hypothesis that professional agency was a determinant factor in the institutionalization of prefabricated elements in Denmark.

CONCLUSION

We started this paper with a curiosity about the differential use of prefabricated elements in Denmark and France. After experimenting widely with the practice in the 1950s, the Danish construction industry adopted it wholeheartedly in the 1960s while the French construction industry discarded it as a myth. In other words, the innovative practice was institutionalized in Denmark while it faded away as a fad and fashion in France. This situation is interesting theoretically because the practice had followed a similar trajectory at earlier stages of the institutionalization process. Why did the path diverge at the very last stage? The neo-institutional literature contains a number of hypotheses but little empirical work on the factors that cause a practice to be retained after it has been theorized and widely diffused in an organizational field. The last stage of the institutionalization process is an area of relative neglect in this literature.

We explored five different hypotheses, all drawn from the neo-institutional literature, which could potentially account for the observed variance. These hypotheses were the dominant institutional logic in the field, the local conditions of production, path-dependency in practice and technology, national legislation, and the agency of professionals. We found no support for the institutional logic thesis and partial support

for the other four hypotheses. The variance seems to result from an interaction between local conditions of production (labour supply), path-dependency, national legislation, and professional agency. In fact, the agency of actors, not only of professionals, seemed to carry much weight in this equation. Key actors with interests in the outcome created coalitions with other key actors to advance their own interests, using the local conditions of production, path-dependency and national legislation as bargaining power. The first four factors restricted the options significantly, but when it came to selecting among the available options, agency was a determinant factor. Those actors who were able to harness the first four factors could, and did, advance their own interests. The agency of professionals was particularly salient in the Danish case. The civil engineers were instrumental in pushing the institutionalization of prefabricated elements in Denmark. They met little resistance from the architects, who were poorly organized and without professional status, in sharp contrast to the architects in France.

Our findings from this double case study lead us to propose that the causal explanation for the institutionalization of a diffused practice should be found in a combination of variables at the field level and individual level of analysis. We propose that further research into this topic investigates how the selection process is narrowed down, step by step, by different factors that each restricts the options in some way. The agency of professionals should be given more attention in this selection process but not in a manner that is detached from the institutional, macro-level forces that set the stage for strategizing and select the props that actors use to pursue their interests. Institutional forces are powerful entities but not so powerful that they disable professionals from deliberately influencing which new practices become institutionalized and which ones become fads and fashions.

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Appendix 1: Legislation in France

Date	Name	Influence on	Description
1952	"Secteur industrialisé"	▪ Demand ▪ Techniques	12 x 1000 housings / year are attributed to projects with special technical requirements (use of a design office…)
1953	Plan Courant	▪ Demand ▪ Techniques	An objective of 300 000 housing/year Public tenders are conditioned to the use of patented technologies
1954	Loi Minjoz (livret A)	▪ Financing	Financing mechanism to collect funds for social housing
1956	Economie de main d'oeuvre	▪ Demand ▪ Techniques	40 x 300 housings/year for projects based on 20 selected techniques
1956	Marchés triennaux	▪ Financing	Financial assurance by the State on 3 – year programs
1958	ZUP (zone urbaine prioritaire)	▪ Demand	Creation of special urbanization areas of high importance. 500 housings/year minimum. Beginning of the "Grands ensembles" policy
1958	Main d'oeuvre qualifiée	▪ Techniques	Official recommendation to use non-qualified work-force
1967	ZAC (zone d'aménagement concerté)	▪ Demand	Creation of special urbanization areas whose objectives are quality of life and social diversity.
1971 / 1973	Circulaires Guichard		End of the "Grands Ensembles" policy (1958)
1972	Plan construction	▪ Techniques	High priority to architectural innovations
1973	Décret sur la maîtrise d'oeuvre	▪ Organization	Distance is necessary between architects and customers. The construction process should be organized according to functions and not professions. Architects should be paid with fixed conditions

Appendix 2: Dates and events in the history of the profession of architects in France

Date	Event/ laws	Content
1671	Creation of the Royal Academy and the Rome Prize	First national school Artistic quality is valued
1819	The Royal Academy becomes the Ecole Nationale des Beaux Arts	Artistic quality is valued
1840	Création of Société Centrale des Architectes (SCA)	Prof. Association promotes: cultural value liberal organization meritocracy
1867	State degrees (DADG)	
1877	Société des Architectes Diplomés du Gouvernement (SADG)	Prof. Association promotes: cultural value liberal organization meritocracy
1915	SCA and SADG recognized as public utility	Cultural value of architecture
1940	Law on architecture Defines Architecture as a profession Ordre des architectes	Art. 3: Architects can only be paid by the client or contracting authority. Thes profession of architect is not compatible with the one of construction companies, material suppliers…
1968	Suppression of the “Ecole Nationale des Beaux Arts” Creation of decentralized independent schools	
1969	Suppression of the Rome prize	
1973	Law on prime contractors in construction	Clients should define their need with no interaction with architects Architects should engage their responsibility on the
1977 – 1980	Law on architecture and its application	Art.2 (1980) « the vocation of architects is to participate at the art of building ». His mission is to define architectural projects. But he may also participate in various activities from program elaboration, preparation of tenders and selection of contractors to the management of execution phases.

Appendix 3: List of primary sources

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