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# Architectural Innovation in China. The Concept and its Implications for Institutional Analysis

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**MARCUS CONLÉ:**

# Architectural Innovation in China

## The Concept and its Implications for Institutional Analysis

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**Abstract**

China's rapid economic ascent has been accompanied by brilliant institutionalist scholarship elaborating on the significance of institutional diversity for China's recent development trajectory. As valuable as these analyses are, their foundation in the transition literature seems to have resulted in their focusing mainly on offering explanations for the characteristics and the (temporary) persistence of institutional diversity rather than on providing insights about the impact of that diversity on such issues as innovation and competitive advantage. This focus has arguably contributed to both, a limited understanding of China's development model as well as a limited impact of the findings concerning China's institutional reality on the research program of the comparative capitalisms, specifically on the debate on the benefits and flaws of the so-called Varieties of Capitalism (VoC). Building on recent work on innovation in China, the present paper seeks to provide a typology of architectural innovation, a concept that was originally introduced by Rebecca Henderson and Kim Clark as an extension to the radical/ incremental innovation typology, in order to capture the main features of a pattern that appears to be found in a great number of China's (assembly) industries. After illustrating this pattern with the help of an exemplary case study of China's passenger vehicle sector, the paper will give a brief discussion of how institutional diversity and the various roles of government relate to the identified pattern of innovation.

**Keywords**

China, Varieties of Capitalism, Architectural Innovation, Assembly Industries, Passenger Vehicles

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# 1 INTRODUCTION

After more than three decades of rapid growth, China's economy has long joined the ranks of the largest countries in terms of GDP. However, the sources of the rapid growth and its sustainability remains an issue. Given the nature of China's political economy, it is certainly not surprising that the analytical efforts are usually directed towards explaining the country's growth momentum in terms of excessive investment that is propelled by the Chinese Communist Party's (CCP) relentless efforts of staying in power. Earlier explanations of the growth phenomenon have thus typically done without any notions of innovation. However, the undeniable success of some Chinese industries in the world market and the frequent challenges that global lead firms face in China's domestic market have led other researchers to question arguments that solely rely on the availability of cheap resources without considering in which ways these resources are being made and employed. More recently, an increasing number of scholars are therefore examining the specific nature of China's efforts of upgrading design and manufacturing capabilities as well as the country's innovation patterns (e.g. Butollo 2013; Herrigel et al. 2013; Nahm and Steinfeld 2014). These efforts are hitherto rendered in rather unsystematic ways. In order to make headway in defining and explaining China's mode(s) of innovation, a more structured approach is wanted that allows knowledge to evolve from the simple to the more complex.

Such an approach need not to be developed from scratch, of course. Acting on the fertile assumption that differences in national innovation patterns translate into economic performance differences relating to export specialization and sectoral competitiveness (e.g. Porter 1990; Soskice 1997; Lundvall 1998), a broad range of scholarship has addressed itself to the task of identifying national strategies of innovation and linking those strategies to the cultural, structural, and institutional characteristics of the national environment (see e.g. Jackson and Deeg 2006; Balzat and Hanusch 2013). Among the various conceptual and analytical frameworks, the Varieties of Capitalism (VoC), presented in Hall and Soskice (2001), has gained particularly strong attention for its ingeniously simple dualist structure that is primarily distilled from prior comparative research on the political economies of Germany and the United States. Emphasizing the relevance of the institutional framework for the support of the domestic firms' innovative activities, the VoC framework identifies two sets of complementary institutional configurations, the stylized liberal and coordinated market economies, as two generic types of national models and relates those two types to radical and incremental innovation strategies as the two commonly distinguished types of innovation.

The VoC framework is not only intuitive but, more importantly, its simplicity has allowed the field to focus the discussion on a number of well-definable issues. Concerning divergent institutional formations, major disagreements concern the (unconvincingly) strong restriction of viable and/or successful institutional configurations (Lane 2005; Schmidt 2009; Witt and Redding 2013), the approach toward type creation more generally (Amable 2003; Boyer 2004; Crouch 2005, Herrigel and Zeitlin 2010a), the concept of complementarity in relation to institutional configurations (Aoki 2010; Crouch 2010), the stability and change of the configurations (Streeck 2003; Streeck and Thelen 2005; Schneider and Paunescu 2012), the relevance (and the interaction) of different scales besides the national scale (Herrigel 1996; Jessop 2011; Peck and Theodore 2007), forms of within-country diversity more generally (Allen 2004; Crouch 2005), the potential impact of non-domestic institutions for domestic economic organizations (Herrmann 2008; Steinfeld 2010; Allen 2013), and the influence of sectoral factors for the coordination of economic activities (Allen and

Whitley 2011). Some criticisms also touch upon performance-related issues. They include those pertaining to the mapping of specific innovation types on broad industry sectors (Casper et al. 1999; Crouch 2005; Allen 2013), the necessity of institutional coherence for successful economic performance (Kenworthy 2006), and the identification of innovation strategies that the VoC expects to not be successful in the specific institutional settings (Amable 2003; Boyer 2004; Storz 2008). Contrary to the lively debate on institutional configurations that is repeatedly triggered by the consideration of alternative (primarily European) country cases or the reconsideration of the familiar ones, the variation of innovation strategies has so far received more limited attention within the VoC debate.

Among the major reasons for the prevalence of the dichotomy of innovation strategies is the fact that the VoC debate is typically confined to the research on the advanced economies, which are, of course, widely considered to be in charge of innovation activities. Yet, the more recent extension of the research of capitalist economies to other regions of the world economy is not only reinforcing some of the issues that have been already pointed out by the critics of the VoC approach pertaining to the institutional setting but it also requires a more serious deliberation of generic innovation strategies beyond the ones that originate from the familiar capitalist models. Especially China has proved a useful source for substantiating several of the deviant commentators' claims and for generating further refinements of the various arguments. Most fundamentally, the research on the Chinese economy unmistakably shows the relevance of institutional diversity within the national economy (Redding and Witt 2007; Tsai 2007; Krug and Hendrischke 2007; McNally 2008; Conlé 2011; Nee and Opper 2012). Going beyond this fact, researchers of the Chinese case have additionally demonstrated the limitation of understanding institutional configurations as separate – if at all, competing – formations, instead insisting on a richer set of interdependences among (possibly transient) institutional formations, especially in the development of the broader organizational structures, in which the economic activities that are performed in China are embedded. Inter alia, researchers have stressed the compensating character among institutional configurations (McNally 2012), the relevance of multi-scalar institutional constructions (Peck and Zhang 2013; ten Brink 2013; Zhang and Peck 2014), and the exploitation of institutional diversity in the (re-) combination of organizational arrangements (Ernst and Naughton 2008; Conlé 2011; Lüthje et al. 2013).

These analyses have strongly contributed to the understanding of China's complex institutional reality. As valuable as this research is, its foundation in transition and divergent capitalisms scholarship yet seems to have resulted in its focusing mainly on offering explanations for the characteristics and the persistence of institutional diversity rather than for the impact of diversity on such issues as innovation and competitive advantage. As a consequence, little attention was given to defining the nature of innovation in the Chinese setting. This neglect, in turn, is likely to limit the explanatory value of the proposed institutional typologies and analyses. Recent scholarship has started to address this problem but has encountered difficulties in bringing the innovative activities observed in China in line with the radical/incremental innovation dichotomy. As the received dichotomy appears to be too limited to discuss the features of the innovation activities that are observed in the Chinese context, new concepts have come to be explored. Among the various approaches, a very promising one that is the subject of the present paper makes reference to Henderson and Clark's (1990) extended typology of innovation (Ernst and Naughton 2008; Kaplinski et al. 2009; Conlé 2011; Nahm and Steinfeld 2014). In their influential contribution, Henderson and Clark seek to demonstrate that the traditional radical/incremental categorization of innovation that is also employed by the VoC is incomplete without including a further category, architectural innovation. Yet, although this type of innovation can be arguably applied to a large number of Chinese (assembly) industries – including, but not limited to, color TVs, air conditioners, mobile phones, and various motorized and non-motorized vehicles (Watanabe 2014) – the concept has yet to be specified more concretely in order to encourage a more focused discussion of Chinese innovation, include the analysis of architectural innovation in comparative institutional analyses, and make relevant contributions to the general VoC debate.

The objective of the present paper is to contribute to a definition of innovation that can serve to analyze China's pattern of innovation in a reasonably abstract way, ultimately allowing to relate it to its institutional context as well as to innovation patterns observed in other institutional contexts. In the following Chapter 2, the main concept of architectural innovation is introduced. Instead of viewing the concept as a simple supplement to the original dichotomy, it will be argued that it sets new focal points that require an own typology. More specifically, Chapter 2.1 will link architectural innovation to changes in the segmentation of sectoral ecosystems. A tentative framework will be developed in Chapter 2.2 in order to clarify the main aspects that numerous recent analyses of the development of various (assembly) industries generally associate with China's innovation pattern. Based on secondary sources, Chapter 3 provides a case study that seeks to illustrate this innovation pattern within a specific sectoral environment. Rather than referring to arguably more salient (fragmented) sectors such as mobile computing, the passenger mobility sector was chosen because the feature that is specifically attributed to that sector by the relevant literature – the final product's design integrality – renders the sector particularly suitable for exemplifying Chinese firms' strategies of gaining a foothold in industry sectors. Then, in Chapter 4, a number of implications for institutional analysis are discussed. This pertains, most importantly, to the nature and utility of institutional diversity and redundant capacities as well as to the role of the state in China's industry sectoral development. Finally, Chapter 5 concludes.

# 2 DEFINING ARCHITECTURAL INNOVATION

## 2.1 THE CONCEPT

The concept of innovation is intimately connected not only to novelty in the form of new and/or improved product and process technologies but also to its impact on societal and economic organization. Technological innovations may be linked to both, the reinforcement of a firm's position within the competitive order as well as the disruption of that very order. It is this double impact, the availability of new or improved technology for society at large as well as the (potential) effect on incumbent firms, that is at the core of the predominant definitions of the forms of innovation. Schumpeter's original distinction between radical and incremental innovation follows along these lines. More specifically, Tushman and Anderson (1986) associate radical innovation with infrequently occurring major technological discontinuities that, depending on the required changes to the prevailing skills, knowledge, and capabilities, may be either competence-enhancing or competence-destroying from the point of view of incumbent firms. In the latter case of a competence-destroying radical innovation, the sectoral changes that are induced by the innovation(s) might involve new market segmentations and substantial changes in the status ordering of the firms within the broader sector. The "windows of opportunity" (Perez and Soete 1988) for breaking into extant sectors, or for tearing down the segmentation among extant sectors, that are opened by competence-destroying innovations seem to lie at the core of the most salient discussions on catch-up development.

Against the backdrop of associating the failure of incumbent firms with radical innovation, Henderson and Clark (1990) advance the concept of architectural innovation. Their fundamental argument is presented in the Figure 1. According to the prior understanding, if a given sector is described in terms of its knowledge base, then larger changes of the sector's knowledge base create significant adaptive challenges for incumbent firms that might be readily exploited by unencumbered entrants with the requisite knowledge and capabilities. The thrust of Henderson and Clark's argument is that shifts in the knowledge base are indeed sufficient to explain sectoral upheavals but, contrary to the former understanding, they are not necessary. Rather, innovations that do not affect the sector's knowledge base may also have similar consequences to a sector and its incumbent firms. Henderson and Clark substantiate their argument on the basis of a matrix that is akin to the one presented in Figure 2. Focusing on product systems consisting of components and their interfaces, they distinguish between component knowledge – that is, knowledge relating to the sector's standard "toolbox" consisting of the principles and methods that may be utilized to create the product's functionality – and architectural knowledge – that is, knowledge of how the principles may be implemented in physical components. This distinction allows to differentiate between a change in the sector's toolbox and changes in the product architecture including the functional components and their interfaces. Given the distinction, radical (incremental) innovation is concretized as a fundamental (minor) change in both, the toolbox and the product architecture, while architectural innovation involves a significant change in the product architecture using the standard toolbox. As in the case of competence-destroying radical innovations, architectural innovation poses a severe challenge to incumbent firms due to the destruction of the incumbents' architectural knowledge.

***Figure 1: Types of Innovation according to their disruptive effects***

| | | Disruptive to the Sector's Status Ordering | |
|---|---|---|---|
| | | Yes | No |
| Disruptive to the Sector's Core Technologies | Yes | Radical Innovation (competence-destroying) | Radical Innovation (competence-enhancing) |
| | No | Architectural Innovation | Incremental Innovation |

The addition of a further well-established type of innovation provides an opportunity for rethinking the dichotomous approach to categorizing national innovation patterns in the VoC. In one of the incipient VoC studies, Soskice (1997) presents his reading of the findings of Porter's (1990) well-known large-scale study of national competitive advantage. He finds that Anglo-Saxon economies, the paradigmatic cases of liberal market economies in Hall and Soskice (2001), are showing an innovation pattern that is related to radical innovation in the broader sense, whereas Northern European countries, the paradigmatic cases of coordinated market economies, are excelling in incremental product and process innovation. Apparently, the selection of countries is rather limited so that it may be questioned whether the original framework is applicable to a broader range of advanced and, even more so, emerging economies. In this sense, the addition of a further type of innovation may be welcomed on grounds of adding more possibilities in the comparison of (dominant) innovation strategies across countries. Indeed, according to Nahm and Steinfeld (2014: 289), for instance, in characterizing the general thrust of innovation in China, many China scholars "bear the influence of the seminal theoretical work of Henderson and Clark [...]." However, for adopting a third type alongside the established types of incremental and radical innovation, it is indispensable to show that the newly added type does not overlap with the prior types. There certainly is no overlap

***Figure 2: Types of Innovation according to changes in knowledge***

| | | Architectural Changes | |
|---|---|---|---|
| | | Yes | No |
| Changes in the Toolbox | Yes | Radical Innovation | Modular Innovation |
| | No | Architectural Innovation | Incremental Innovation |

in Henderson and Clark's elaborate typology. Yet, the problem is that their definition of radical and incremental innovation deviates to quite some extent from the prior understanding of those concepts, and in particular, the understandings in the VoC literature. If this is so, then it is not clear whether it is a good idea to have the new concept simply amend the received typology or whether it should rather serve as a means towards setting entirely new focal points.

In order to elaborate the differences among the received dichotomy and the new concept, it is helpful to revisit the Figures 1 and 2. As was emphasized above, Henderson and Clark's ambition is to show that competitive challenges are not limited to subversive changes in a sector's knowledge base, which are brought about by radical innovation. Rather, new ways of using the sector's toolbox might be equally subversive. If they had not introduced the new concept, such instances of innovation may have had to be assigned to the incremental innovation category. Then, from the perspective of incumbent firms, incremental innovations might also be competence-enhancing or competence-destroying. Put this way, architectural innovation could be viewed simply as the competence-destroying subset of the incremental innovation concept used in the VoC. Yet, the distinction is more fundamental because it carries a subtle, but decisive change in the ways that (global) competition is conceived. The VoC interpretation apparently carries a Ricardian idea of international trade according to which countries first establish national industries that, then, enter into competition with the national industries of other countries. In this process, comparative (institutional) advantages are discovered and specialization occurs as various sectors expand, while other sectors contract, which again involves freeing resources for the expansion of the former sectors. In contrast, translating the Henderson/Clark framework to the analysis of the location of countries within the global division of labor, the analytical point of departure would be the more empirically defensible claim of given economic sectors with given internationally leading incumbent firms and business systems (that have most probably originated from various advanced economies). In order to enter the (global) economy, new firms – both, from advanced and emerging economies – need to create or exploit "windows of opportunity" in order to break into the economy typically by introducing wholly new sectors and/or by changing the segmentation of a (set of) sector(s).

The difference among the perspectives is important because the competence-destroying impact of incremental innovations on competing firms (and business systems) may be perceived to derive from a quite different source, one that is strongly emphasized in the VoC. For instance, the change in the status ordering of sectors such as automobiles and electronics that was brought about by the rise of Japan is shown to be related to a relatively broad range of organizational processes (e.g. Womack et al. 1990). From an analytical perspective, a distinction was introduced between process-based strategies and product-based strategies. The terms differ to the extent that process-based strategies involve the flexibilization of production and distribution in order to realize an efficient provision of variable products, whereas product-based strategies seek to increase product variety through the appropriate designing of product architectures, often with the intent of reducing manufacturing (and purchasing) complexity (Fisher et al. 1999).

There is no doubt that both kinds of strategies (need to) concur but the source of competitiveness may hinge on organizational structures that emphasize one of the strategies more strongly than the other. The VoC, and the comparative capitalisms literature more generally, show for good reasons a fundamental interest in process-based strategies and the related organization of work on the shop floor. Clearly, the implementation of the various process-based strategies are relevant for competitiveness (and competence destruction), but arguably especially so, when entry itself is not a problem and, additionally, competition in the sector rests on achieving efficiency by excelling in the integration of the various business activities. This was essentially the case, when countries such as Japan emerged (Steinfeld 2004).

In contrast, the turn towards products might be relevant specifically when it concerns issues of entry and the transformation of the established organizational capability structure. Processes are also important in this case, of course. But the nature of the processes arguably need to be adapted to the strategy. That might imply that wholly different kinds of processes are important than those that are spotlighted by the VoC literature with their focus on countries such as Germany and Japan. It may be quite possible, for instance, that novel approaches to markets and competitive behavior become relatively more important for the comparative success of firms and countries. Altogether, the present analysis makes a strategic shift in perspective in that it assumes i) that there exists a complementarity between specific product-based and process-based strategies, ii) that product-based architectural strategies are coming first as they are important for a successful entry, and iii) that incremental innovation – as a competence-enhancing activity – is directed in the sense that it serves to introduce processes and product offerings that are adapted to the changes that occur to a sector as a consequence of architectural innovation. As a side note, ("imitative") upgrading efforts relating to products and processes can be only usefully seen as instances of incremental innovations in the current sense as far as they translate existing processes and products to a new sectoral reality.

A clearly controversial effect of the change in perspective is that the strong emphasis of design activities comes at the expense of implementation. Again, this change is not meant to deny the potential relevance, for instance, of manufacturing (or marketing) in design and product innovation. Just to the contrary, it assumes that design and manufacturing typically belong together (Herrigel and Zeitlin 2010b). Rather, a stronger design perspective is particularly amenable to exploiting the relationship between product architectures and "industry architectures" that are reflected in the status ordering of a sector (Jacobides et al. 2006; Zirpoli and Camuffo 2009). Contrary to the cognate literature on Henderson and Clark's (1990) so-called "mirroring hypothesis"[1] that focuses primarily on a static mapping of product structures onto sectoral/firm structures (Cabigiosu and Camuffo 2012; MacCormack et al. 2012; Sanchez and Mahoney 2013), the idea pursued in the present paper is a dynamic one involving the change of an industry architecture as a consequence of architecture-based innovation strategies. These strategies may be considered to deliberately manipulate product architectures in order to exploit the (potential) existence or lack of various capabilities within a larger sectoral business system. Different institutional and organizational settings are expected to provide (entering) firms with different means and incentives to pursue the various strategies. In turn, the success of the strategies in terms of value capture and development opportunities is the outcome of the changed sectoral segmentations that are induced by the various strategies, which

1 The mirroring hypothesis concerns following remark made by Henderson and Clark (1990: 27): "We have assumed that organizations are boundedly rational and, hence, that their knowledge and information-processing structure come to mirror the internal structure of the product they are designing."

are implemented within the broader sector. The architectural innovation concept that is advocated here differs from the Henderson/Clark concept particularly due to its focus on competing entrants rather than the (relatively) inertial incumbents and in its endeavor to transcend the product-technological terminology that it is built on. Accordingly, architectural innovation first and foremost involves a change (vis-à-vis the sector's common practices) in the ways product design is organized within and across firms. A larger number of firms might thus be involved collectively in architectural innovation. In effect, there is not one single type of architecture-based innovation strategies but, rather, a number of them that need to be compared along several dimensions.

## 2.2 ARCHITECTURE-BASED INNOVATION STRATEGIES

The existence of differences among countries, primarily Japan and the USA, with regard to the use of product architectures has certainly not been missed (e.g. Langlois and Robertson 1995; Sako and Murray 2000). Above all, Fujimoto (2007) has pioneered an architecture-based perspective on national competitive advantage that involves a version of Henderson and Clark's mirroring hypothesis for the comparison of national innovation patterns. In doing so, he adopts the common definitions from the modularity literature: Product architecture is defined as a scheme consisting of the decomposition of the product's overall functionality into discrete functional elements (e.g. "store data"), the assignment of the functional elements to a number of physical components (e.g. a data storage component), and the specification of the components' interfaces (Ulrich 1995; Baldwin and Clark 1997).[2] Fujimoto also adopts the two conventional distinctions between modular and integral as well as open and closed product architectures. Modularity concerns the codification and standardization of interface specifications with the intent of increasing the decomposability and the configurability (the ability to "mix and match") of the overall product system. In turn, openness refers to the creation and sharing of interface specifications of a firm's product with other firms in its larger ecosystem (Sanchez and Collins 2001). Fujimoto combines these two dichotomies to arrive at three distinct types of product architectures: closed-integral, closed-modular, and open-modular. His proposition is that whereas Japan leads in closed-integral architectures, the USA has a competitive advantage in open-modular architectures.

In line with the mirroring hypothesis, Fujimoto thus seeks to simultaneously state something about both, the design outcome and the design process. However, drawing on Nobeoka (2005), two problems with those comparative assessments need to be pointed out: To begin with, while Japan appears to be good in designing integral product architectures, Japanese companies have obviously no problems of coming up with admirable modular product designs. Representing all the modular electronic products made in Japan, the Sony Walkman is easily among the most cited modular products in the vast modularity literature (e.g. Sanderson and Uzumeri 1995; Ulrich 1995; Sanchez and Mahoney 1996). The second problem is that the "dominant designs" (Abernathy and Utterback 1978) of industry sectors tend to change over time. As the current approach suggests, it is these design changes that will likely bring about the biggest disruption to existing sectoral structures. In some sectors, movements from modular to integral architectures have been observed (e.g. Ernst 2005). An illustrative example of this shift is the Japanese bicycle component producer Shimano's transforming a formerly competitive market into a near monopoly by introducing a more integral architecture (Fixson and Park 2008). On the other hand, various sectors

2 Sanchez (2002) notes six different kinds of interfaces between components that require specification: attachment interfaces, spatial interfaces, transfer interfaces, control and communication interfaces, user interfaces, and environmental interfaces.

that have traditionally featured more integral designs – including the automotive sector that will be used as an example in the present paper – have recently experienced a trend towards more modular architectures. Some evolutionary theorists, most forcefully Langlois (Langlois and Robertson 1995; Langlois 2003), see modularity even as a general driving force in the overall evolution of industry. If national patterns are associated with specific types of architectures, incumbent Japanese firms in those sectors would be assumed to fail simply for their incapacity to increase the modularity of their architectures. However, this scenario does not only seriously understate the design capabilities of many Japanese firms but it also seems to underestimate the plurality of possibilities to partition product architectures (and sectors).

The point that has to be emphasized here is that the differences between firms of various national institutional environments are arguably most pronounced in their specific approaches towards supplanting a sector's type of architecture, that is, their specific approaches towards modularization or integration, rather than in the essential nature of their products' architectures, that is, the property of modularity or integrality.[3] This point needs to be worked out more carefully by revisiting the design-based perspective. Appealing to Fujimoto's framework, new architecture-based approaches are introduced, when they either change the configuration of design tasks (the level of "modularity") and/or the organizational locus of the provision of particular design tasks (the level of "openness"). The first dimension, the extent of design task decomposition, refers to the ways that tasks are specified and assigned to particular organizations (or their subunits). Tasks may be clearly specified and circumscribed so as to allow an independent search for solutions for the separate tasks, or they may be more discretionarily managed in order to solve the problems emanating from the interdependences among the tasks involved. In the case of a high degree of design task decomposition, the tasks are thus structured in a way that minimizes the amount of information and other resources that need to be transferred among the tasks. On the other hand, the task externalization dimension pertains to the extent that tasks are outsourced to unrelated others rather than vertically controlled by the focal organization. If the degree of task externalization is low, then the design tasks are integrated within a single organization, whereas, at the other end of the spectrum, the implementation of tasks are bought "off-the-shelf" as ready-made solutions from specialized suppliers.

Apart from the degrees of design task decomposition and externalization that are specifically highlighted in Fujimoto's framework, the scope of the changes arguably need to be also considered. Relating to the decomposition of tasks, scope refers to the extent that tasks are decomposed and assigned. If the scope of task decomposition is low, then only a few marginal tasks are partitioned, while there remains a rather strong discretionary overlap with regard to the more pivotal design tasks. In contrast, a high scope of design task decomposition implies that all the tasks are carefully specified and strictly partitioned according to an overall scheme. A structural match between "modular" and "integral" product design, on the one hand, and organization design, on the other hand, is typically assumed, when there are either relatively strongly interacting/integrated teams or independent teams working on component design and system integration virtually on their own. These organizational choices do not necessarily have to be preceded or accompanied by outsourcing decisions. As in the case of task decomposition, the scope of task externalization pertains to the extent that core tasks are provided by a party that is external to the focal organization. In the case of a high scope of design task

3 MacDuffie (2013) uses this distinction to describe architectural change in the global automotive industry. See also Sako (2003) with a similar argument on the relationship between organizational architecture and product architecture.

externalization, even the design tasks relating to the product's core components are purchased from specialized suppliers. If the scope is low, however, then merely a few peripheral, usually low-value tasks are outsourced. Considering that not all combinations of attributes across the four variables are feasible, it is now possible to limit the attention to five different kinds of strategies. These strategies are illustrated in Table 1.

Among the two strategies featuring more informal task decompositions, the first one is a craft-based strategy that is commonly associated with the industrial districts that already Alfred Marshall has noted in his treatises. In the generic scenario, specialized firms (or households) are collectively involved in the design process as the various actors contribute their knowledge in discretionary ways. The extent of task decomposition is comparatively low due to the fact that the specialized suppliers are the main carriers of the knowledge about the materials (rather than more sophisticated functional modules), which they are supplying, regarding their malleability and their interaction with the other parts of the product. Accordingly, the suppliers' knowledge needs to be brought to bear in the (detailed) design phase in order to realize a marketable product. Integral strategies differ from the latter one in that the different tasks are internalized within an organization rather than being provided by (fully) independent specialists. This kind of strategy may allow a more well-coordinated and structured product development approach and the establishment of organizational capabilities in order to deal with an increasing complexity of the discretionary organization and its product outcomes. Closed(-modular) system strategies, in turn, are similarly internalizing the various tasks within an organization. But instead of employing a rather integrated design approach, the closed-system approach seeks to partition tasks and define "thin crossing-points" (Baldwin 2008) for simplifying the (re-)integration of the outcome of the partitioned tasks within a common product. If it is successful, a closed-system strategy does not only allow the various teams to come up with independently developed component variations but also helps the overall organization to learn how to reduce complexity in products and organization (Sanchez and Collins 2001). Open-system strategies differ from closed ones in that the task and interface specifications are communicated to external providers in order to invite them to perform sets of activities according to the task partitions that were pre-developed by the sponsoring organization. This approach is seen to be advantageous for accessing knowledge that the firm is not able or ready to provide. Finally, modular markets differ from the open-system strategies in that the system integrators do not necessarily control the core design tasks. In this case, the providers of core components to the overall product might have a similar or even more important impact on the design of the final product.

The last point is important for a sector's dynamics because the changes of the industry architecture may be shaped by organizational actors that, broadly speaking, induce either an upward or a downward movement in the strategies of Table 1. Whereas an upward movement

***Table 1: Five Types of Design Systems***

| System Type | Extent of Task Decomposition | | Extent of Task Externalization | |
|---|---|---|---|---|
| | Degree | Scope | Degree | Scope |
| Integral | Low | Low | Low | Low |
| Closed-System | Considerable | Considerable | Low | Some |
| Open-System | High | Considerable | Considerable | Some |
| Modular Market | High | High | High | High |
| Craft-Based | Some | Some | High | Considerable |

essentially boils down to introducing a more vertically structured industry architecture, a downward movement might lead to a more horizontal architecture. This far-reaching proposition requires explanation. By arguing that individual strategies are inducing sectoral trends, it is done so based on the assumption that not all strategies can coexist in a common sector. At least some form of segmentation thus needs to occur for the various strategies to survive. As has been already argued in the preceding section, architectural innovations – that is, new architecture-based strategies – are disrupting sectors by changing the ways tasks are coordinated. In this sense, it is arguably justifiable to speak of sectoral trends towards vertical structures or horizontal strategies without indicating that the architecture-based strategies that are explored within a sector at a particular time and space need to be strictly identical. The strategies might simply rest on a slight variation of the variables in the table, particularly those characteristics that are framed in Table 1.

In arguing that there are dominant industry architectures and sectoral development trends, it is thus not implied that the organizational structures are identical across countries. Founded on their specific history of industrial development, countries typically feature different kinds of organizations and face different challenges in making inroads into the sector. According to the central argument of the present contribution, the different institutional and organizational settings provide firms with the means and incentives to explore specific architecture-based strategies in order to create opportunities for entering a sector and/or pulling ahead of their competitors. The following chapter will present a case study of the automotive industry in order to illustrate the type of architectural innovation observed in the ecologies of many Chinese assembly sectors in comparison with the strategies of firms from different institutional settings. That is, while the case study focuses on a sector that has recently enjoyed particular attention within the literature, it is argued that the strategies observed in that sector can be also observed in a range of other salient Chinese industries.

Anticipating the key points, China's architecture-based strategies are argued to have evolved from the craft-based strategies of the low-tech sectors (e.g. pocket lighters) to modular-market strategies for sectors featuring more complex technologies such as, for instance, passenger mobility as well as information and communication technologies. In this development, the increasing access to specialized component suppliers has played a major role. The modular-market strategy is characterized by a group of assemblers/integrators that purchase various components, including the product's core components, from specialized firms and concentrate on developing designs that are able to accommodate various combinations of the components that are available through the market. The definition of a component's functions and their physical design are hence largely specified by the suppliers rather than the integrators.[4] On the one hand, the Chinese market has hence provided various component suppliers with ample opportunities to make fuller use of their design capabilities than in other institutional settings, while the accessibility of those suppliers allowed firms with little design capabilities and relevant experience to enter the sector as system integrators. As the architecture-based strategies increase their impact on the economy, the demand for components of varying quality allows more component suppliers to survive in the market. It is particularly the presence of less sophisticated specialized integrators that allows new component suppliers the time to upgrade their capabilities and possibly come up with incremental innovations in their offerings for the

4 Provided that the specific roles of the suppliers are the outcome of prior task partition decisions by incumbent integrators, the ultimate decision was made by the latter firms, of course. However, an important feature of modular-market strategies is that, while component suppliers are rarely able to fundamentally change the existing task partitions, they can certainly come up with changes in the organizational integration of sets of tasks.

new breed of system integrators. As the Chinese market gradually becomes a major stage for the latest organizational developments within the sector and a benchmark for providing value-adding design contributions, component suppliers of various origin can no longer afford to not try their products in the Chinese setting. As such a process becomes reinforced, it is likely to have strong implications for the overall industry architecture.

# 3 INNOVATION IN CHINA'S PASSENGER VEHICLE INDUSTRY: AN EXEMPLARY CASE STUDY

## 3.1 THE SECTORAL SETTING

The automotive industry is at present specifically associated with the development of the internal combustion engine (ICE) and the model case for an industry featuring integral product designs. Yet, both features have only gradually come to characterize the industry, and the likelihood has lately increased that the very features may be abandoned in the future. When the automotive industry emerged in the late 19th century, competition initially came to be based on modular designs accommodating a wide range of components from existing segments of the passenger transport sector such as bicycles, horse carriages, and locomotives. The core concept of the emergent industry was still in flux and a large number of competitors were probing the feasibility of carriage-like (the dominant US approach) and locomotive-like (the succeeding French approach) designs in addition to different types of powertrain technologies encompassing the eventually triumphant ICE as well as electric motors and steam engine propulsion systems (Langlois and Robertson 1989; Mowery and Rosenberg 1998). Massive entry into the sector provided an increasing source of creative opportunities and competition. Particularly the United States stood out with an initially steady increase in the number of entering firms, typically with a background in bicycle manufacture, and a consistently large population of considerably over a hundred auto firms until well into the 1920s (Klepper 2002).

After the automobile sector had settled on an ICE-based dominant design, a number of connected shifts in product and process technologies have gradually transformed the sector, first, from one featuring an open-modular to a closed-modular and, then, to a closed-integral product architecture. The original shift is closely associated with Henry Ford's introduction of the Model T, a car that was pushing modularity a step further by pioneering the use of a platform design. Consisting of a common product underbody and a customized body, the platform allowed a high level of standardized component usage, a strong focus on manufacturability, and a (albeit limited) capacity for customizing the product through the variation of selected parts and components (Alizon et al. 2009). The related cost savings allowed Ford to tap the large low-income demand of his fellow citizens. As the Model T evolved, the manufacture of an increasing number of components were brought in-house. Concurrent with similar changes going on at Ford's major competitors, most notably General Motors, the American auto industry made a strong move towards closed-system approaches (Langlois and Robertson 1989). A similar tendency towards integration was observed in the other major auto-producing countries but the forms of integration – the extent of "ownership integration" and "coordination integration" to utilize the two dimensions of integration that are introduced in Langlois and Robertson (1995) and refined in Whitley's (2007) business systems framework – differed in decisive ways (e.g. Hemmert 1999). Concomitantly, the source of competitive success in the automobile sector changed from designs for easing component access and scale-up towards performance-related designs concerning, inter alia, velocity, safety, and drivability. As performance issues came to the fore, more integral design approaches came to enjoy an advantage over strategies featuring a higher extent of task decomposition. Especially Japan's successful entry and expansion in the global auto industry is associated with the integrative coordinative capabilities that are embedded in its organizational forms.

More recently, the sector experienced increased modularization efforts. Interestingly, these efforts seem to resemble the ones that were already rendered by Henry Ford as they were specifically aimed at driving down production costs through the simplification of production processes and the exploitation of economies of scale at the component level. Yet, in contrast to these early initiatives, the vastly increased possibilities permitted by computer-aided design and manufacturing methodologies raised expectations that modularization would bring about a strong increase in mass customization options (Pine 1993). As a new cognitive frame (MacDuffie 2013), this time modularity entered the automobile sector as a promise of a low-cost approach towards increasing product variety as well as a feasible option for increasing outsourcing in order to reduce costs and tap external sources of design knowledge. While the highly visible development of the computer industry has contributed to the emergence of the cognitive frame, other stimuli in the immediate sectoral context have also played a significant part in its emergence and diffusion. First of all, after decades of incremental improvements in performance, there appears to be little to be gained in terms of customer appreciation from further improvements in the performance of the classical functions such as, for instance, an increase in velocity. Rather, adaptability to environmental changes in demand and technology have gained an increasing degree of attention. In advanced (primarily Western) economies, a new generation of (especially urban) consumers with different lifestyles and different attitudes towards car usage and ownership appears to have formed, while developments in emerging economies have given rise to a large pool of potential customers. On the other hand, concerns about air pollution and climate change have provided for expectations of a radical technological change of the core powertrain technology. Finally, the diffusion of information and communication technologies throughout the economy is expected to continue to change the design and functions of the car.

As expected, companies from various regions have shown a different pattern and inclination with regard to modularization (Takeishi and Fujimoto 2001; Sako 2003). While American and European firms tend to embrace modularization specifically as a means towards raising the extent of task externalization, Japanese companies appear reluctant to change the structure of their quasi-vertical organizational forms opting instead for a higher extent of task decomposition. Consistent with the motivation for outsourcing, modularization in the USA and Europe proceeded from a separation of subassembly lines from the main assembly within the company to the outsourcing of the operation of these subassemblies to supplier firms typically co-located in the very vicinity of the carmakers, in some instances (e.g. Volkswagen's Resende plant) even in the same factory (Collins et al. 1997). The original motivation for reducing costs through outsourcing has left a strong imprint in the sector-specific definition of modules as "a chunk of physically proximate components that are subassembled indepently from the rest of the vehicle, tested for functionality, and installed in a single step in final assembly" (MacDuffie 2013: 17). The approach to modularization was accompanied by organizational restructuring in the USA (as well as France and Italy) where General Motors (GM) and Ford spun off two large "turn-key suppliers" (Sturgeon 2002), Delphi and Visteon, respectively. The Japanese and German organizational forms, on the other hand, had never shown a comparatively high level of ownership integration, although Japanese suppliers such as Denso remain de-facto integrated within their business group. However, the supplier firms of those regions such as, for instance, Denso and Bosch have also reacted to the changes in the demand conditions by seeking to extend their customer base. As a consequence of the recent sectoral development, a transnational population of competing independent supplier firms emerged (Sturgeon et al. 2009). While, in principle, the appearance of highly knowledgeable supplier firms allows a relatively strong decentralization of design activities, the persistent integrality of the auto – as evidenced by the high functional interdependence among the spatially defined physical modules – and, perhaps even more so, the carmakers' determination to keep control of the product systems (and preclude "Intel inside"-type sectoral trajectories) appear to inhibit a more independent design part by the suppliers as it is typical for modular designers in the ICT sector (Zirpoli and Camuffo 2009; Cabigiosu et al. 2013; MacDuffie 2013).

Generally speaking, the increasingly uncertain state of the sectoral competitive order, and the sectoral environment more generally, has created ample space for divergent innovation strategies. As it was pointed out above already, observers of the automobile industry have discerned noteworthy differences among (networks of) firms from different countries. Simplifying a bit, Japanese firms have tended to cling to their successful integral strategies or, if at all, have moved a little into the direction of a type of closed-system strategies. German firms, representing another major auto country, stand out in their aggressive pursuit of modularized platform designs for reducing the main assembly, mass customization, and adaptation to the technological uncertainties. Volkswagen's (VW's) novel toolkit, for instance, spans several of the VW Group member firms' platforms and does not only provide the customer with a range of choices based on a minimum of component variations but it can accommodate a groundbreaking number of different propulsion systems (Altenburg 2014). Notably, VW's modularization strategy involves a centralized effort to internalize within the VW Group the economies of scale from component sharing. As in the case of US automakers, the German firms source many car modules from the leading supplier firms. In contrast to their US rivals who have been particularly responsive to core-competence slogans, the German firms, however, have kept a larger range of capabilities in-house. Moreover, whereas US firms are known for their antagonistic supplier relations (Liker and Choi 2004), at least according to the typical VoC literature, German firms might entertain more collaborative ties to their strategic suppliers.

Apart from the different strategies of the existing carmakers, the US case differs in another way. In contrast to other advanced economies, the USA has lately experienced a few entries, entry attempts, and entry rumors. Among these firms are those from (potentially) related sectors that are exploring the opportunity structure within the passenger transport sector based on their existing capability profile. Companies from the electronics and information technology sectors appear to be in a particularly good position given that the electronics and information content of automobiles has increased tremendously in the past decades. The internet giant Google, for instance, is engaged in the development of vehicular automation technologies for driverless cars (e.g. Markoff 2010). While Google appears not to enter into competition with incumbent carmakers, according to various rumors (e.g. Wakabayashi and Ramsey 2015), the consumer electronics pioneer Apple seems to be probing the feasibility of bringing to market an own-branded electric passenger vehicle. The company would follow in the footsteps of Silicon Valley company Tesla Motors. Like similar (but not equally successful) companies (such as Fisker Automotive, for instance), Tesla has strived to create a niche in the luxury auto segment. At least at the outset, it has (re-)introduced a decentralized, modular-market approach that relies on the (external) design capabilities of other companies. Tesla's first car, the Roadster, was based on a combination mainly of Tesla's proprietary electric powertrain and a chassis that was designed and provided by Lotus Cars (e.g. Davies 2010).

As MacDuffie and Fujimoto (2010) point out, the complexity of a modern car serves as an almost insurmountable barrier to entry so that it is natural to conclude that present industry leaders will not likely be displaced by entrants, regardless of their capabilities in specific activities. However, this verdict depends heavily on the assumption that the concept of the car remains the same despite the significant technological changes facing the sector. While, as yet, this seems unlikely, firms such as Tesla and Apple might well challenge the very car concept and the relative importance of various functions, components, and – given that electric cars may be more prone to modularization (e.g. Christensen 2011) – product architectures. More importantly, their entry into the sector might provide opportunities for component makers (including some of the entrants themselves) to extend the range of their design activities, their value capture possibilities, and the overall division of labor. Indeed, a more realistic scenario to that of entrants challenging the Japanese and German incumbents in the high-end segments would be one, in which sophisticated component producers increase their share of the value by supplying assemblers targeting the low-end segments of the market (factually introducing "Intel inside" through the backdoor). The latter scenario might be happening in China, where new entrants heavily rely on the component makers' increasing capabilities and their innovative packaged goods. If this is so, then it is not difficult to imagine a future for the sector that resembles the wristwatch sector, which has settled on two groups of (sophisticated high-end and simple low-end) final product makers.

## 3.2 DEVELOPMENT AND CHANGE IN CHINA'S AUTO INDUSTRY

China has a comparatively brief history of automotive development. While various small auto shops existed (predominately in Shanghai) before the establishment of the People's Republic in 1949, the mass production of vehicles started only in 1956 in the wake of the establishment of the No. 1 Motor Vehicle Manufacturing Plant (now First Auto Works, FAW), one of the most important Sino-Soviet development projects. Since then, the history can be roughly divided into three periods (see Xi et al. 2009). The first period starts with the initiation of FAW and ends in the beginning of the 1980s. During that period, the politicized investment and manufacturing decisions were strongly affected by the vicissitudes of internal political struggles, including the Great Leap and the Cultural Revolution, as well as external political developments, above all the demise of Sino-Soviet relations and the related war preparations (the so-called "Third-Front" movement). Then, in 1984, the establishment of the joint venture (JV) between German Volkswagen (VW) and Shanghai Automotive Industry Corporation (SAIC) marks the second period.[5] Concurrent with China's gradual conversion towards consumer goods production, the joint venture is related to the change of development focus from truck to passenger car production. While entry within the passenger car segment was heavily regulated throughout the period, entry, specifically by foreign companies, into the auto component sector was encouraged. China's component manufacturing capabilities increased tremendously as a consequence of local content clauses and (locally varying) technology upgrading efforts (Thun 2006). Finally, the third period starts with China's accession to the World Trade Association (WTO) in 2001. Consequently, entry to the passenger car segment was relaxed allowing the forward integration of component manufacturing firms and the horizontal diversification of related vehicle manufacturers into the sedan segment. Increased labor mobili-

5 Already in 1983, Beijing Jeep was established as a joint venture by American Motors Corporation (AMC). As this joint venture was not even close to being as successful as Shanghai Volkswagen, the latter JV is typically taken as the starting point, or the model, for later JV development. See e.g. Noble et al. (2005); Nam (2011).

ty, access to design houses, and aggressive use of modularization allowed new entrants to make inroads especially into the low-end segment. In that segment, a ferment of diverse companies with similar mix-and-match architectural strategies has formed that seems to reconceptualize the car for a low-income demand that is located at "the bottom of the pyramid" (Prahalad 2006) and lacks a strong "automobile culture" (Kimble and Wang 2013; Tyfield et al. 2014).

When China started automobile manufacturing, the collaboration with the Soviet Union resulted in China adopting a "vertically divided division of labor" (Marukawa 1995). This strategy implied that firms were specializing in a very narrow range of end products, while they were insisting on carrying out in-house the major upstream activities such as machining, metal stamping, casting, and forging. As a consequence, economies of scale relating to the various activities could not be reaped. This problem was aggravated as Chinese auto companies multiplied, especially during the major decentralization phases of the Great Leap and the Cultural Revolution. About a handful companies, most specifically the mentioned SAIC, entered during, and survived the abandonment of, the Great Leap. Numerous further firms entered the sector in the 1970s several of which turned into viable companies. As Lyons' (1987) careful analysis indicates, at the start of the 1980s, the Chinese auto industry featured more than a hundred assembly plants with similarly thin product foci but highly diverging capacities and production methods. Among them, the No. 1 Plant accounted for about a third of overall national manufacturing output, while the No. 2 Plant (now Dongfeng Motor), a Third-Front project that was established in a mountainous region of inland Hubei province, had not achieved regular operations until the late 1970s. While FAW and Dongfeng were mainly involved in the production of heavy trucks, two provincial-level plants, SAIC and Nanjing Auto (now a subsidiary of SAIC) had emerged as manufacturers of light vehicles. Additionally, more than 2,000 manufacturing units were involved in vehicle parts production. The locus of coordination and control of all these manufacturing and assembly units was scattered among different ministries, ministerial bureaus, organizations of the People's Liberation Army (PLA), provincial and local-level bureaus as well as rural communes (Lyons 1987; Noble et al. 2005).

When the passenger car segment became the key focus of the Chinese government in the 1980s, two measures appeared to signal a departure from the previous development trajectory. First of all, entry to the passenger car segment became more strongly regulated as only eight manufacturers received a license to operate in that segment. Moreover, the VW-SAIC joint venture heralded the beginning of the "market access for technology" approach towards international development cooperation that has since characterized several other medium to high-technology sectors, particularly in the 1990s (e.g. Kroll et al. 2008). Until the turn of the century, the selected Chinese passenger car companies were matched with all relevant foreign transnational car manufacturers that were flocking to China in order to participate in the emerging market. The influx of the dominating international car companies had particularly positive effects on the development of component manufacturing as well as the supplier firms' organizational development including their project execution capabilities (Thun 2006; Nam 2011). The most popular car models of the late 1990s – the (Shanghai VW) Santana, the (FAW Tianjin) Xiali, the (FAW-VW) Jetta, and the (Dongfeng Peugeot-Citroen) Fukang – achieved localization rates of more than 80 percent (Xi et al. 2009). Yet, if the development of indigenous design capabilities had been the primary motivation, then the performance was bleaker. SAIC, for instance, soon began to concentrate on the highly profitable joint venture(s) with VW (and later also with GM). While Volkswagen expressly prohibited incremental innovations on its proprietary technologies, SAIC only reluctantly and unimaginatively resumed own development efforts, partly seeking a shortcut by acquiring a controlling interest in Korean car company Ssangyong in 2004 and the key assets of British MG Rover (partly via its now subsidiary Nanjing Auto) in 2007 (Liu and Tylecote 2009).

Due to the efforts of the Chinese government at both national and local levels, the output of passenger vehicle production increased tremendously. Above all, a vibrant domestic car component industry developed and strongly simplified the local sourcing of parts and components. Especially the Yangtze River Delta gained from the early VW-SAIC JV and the concerted effort of Volkswagen and the Shanghai government to develop a functioning value chain (Thun 2006). Yet, the contours of Chinese innovation arguably emerged in the less regulated vehicle segments such as light vans and trucks as well as motorcycles. In these segments, competition soon grew fierce as defacto industry standards developed through an early government-sponsored diffusion of truck technology in the 1970s, the uncontrolled diffusion of licensed technology from the Japanese companies Suzuki and Daihatsu in trucks (and small cars) as well as the drainage of licensed technology from the leading Japanese motorcycle companies Honda, Suzuki, and Yamaha (Ge and Fujimoto 2004; Noble et al. 2005; Marukawa 2013). New companies predominately entered those segments by relying on the established supply chains of the incumbent vehicle makers. Apart from the entry of new firms, the large numbers of existing firms were now free to explore new forms of specialization in order to realize some of the economies that had been foregone before. The component manufacturers, moreover, increasingly reacted by broadening their product offerings in order to extend the range of their customers. Initially, the availability of components for competing firms was mainly due to a widespread practice among Chinese firms to run a company with a similar product profile next to their joint ventures with foreign companies. This practice allowed those component firms to exploit the emergent demand from new entrants by offering similar components at customized price-quality ratios (Brandt and Thun 2010).

The secondary segments of the motor vehicle sector have entered the spotlight after the accession to the WTO in 2001. In fact, when regulation on entry into the passenger car segment was eased, several Chinese companies had already begun with the production of those cars. Now they were granted licenses, although some entrants pursued the reasonably common strategy of entering into ownership relations with a firm to acquire (or share) the production license. Among the most salient entrants, two companies were integrating forwards from component manufacturing. In the first case, Chery Automobile, the company was established from scratch in 1997 by a municipal and the provincial government of the relatively backward Anhui province. Aggressive recruiting of staff from the firm's competitors FAW-VW and Dongfeng allowed the company to assemble its first engine quickly. Buying technology from SEAT in Spain, the company went over to car assembly by using the Santana production network that was built up by the VW-SAIC JV (Luo 2005). In a somewhat similar vein, BYD, a company that had first ventured into rechargeable battery manufacturing to become the largest producer of nickel-cadmium (NiCd) and lithium-ion (Li-ion) batteries, had integrated horizontally into battery electric motors and then integrated forward into passenger car manufacturing.

Another company, Geely Auto, yet provides a more common blueprint of the development strategies of new domestic entrants to the passenger car sector. Similar to later entrants such as Lifan Industry, Geely started with motorcycle production and then moved horizontally into four-wheel passenger cars. In doing so, the company used a then popular Chinese car, the FAW Xiali (itself based on the Daihatsu Charade), as a "reference design" for producing its own car. According to Wang (2008), Geely's first model shared about 70 percent of the components with the archetype model. Like Chery, Geely was able to purchase most of the components from the original producer's (FAW Tianjin's) fully developed supplier network. But unlike the former company,[6] and in stark contrast to the leading foreign companies (Marukawa 2014), Geely even (out-)sourced the core component, the engine, from FAW Xiali's supplier, Tianjin Toyota Automotive Engine, a joint venture between Toyota and Tianjin Auto. Only later, when it succeeded in the market and Toyota sought to limit the technological externalities, Geely integrated backward into core component manufacturing (Wang 2008). This strategy appears to be pervasive in the Chinese auto industry after the turn of the century. As Marukawa (2013, 2014) explains, in 2004, more than half of the numerous auto manufacturers fully lacked engine design and manufacturing capabilities and sourced all of their engines from the market. Shenyang Aerospace Mitsubishi Engine (SAME), a Mitsubishi JV, for instance, supplied engines to more than twenty companies. Increasingly, foreign companies have started to see the trend of the industry architecture as a large opportunity for exploiting their design capabilities in ways that are still frustrated by the transnational auto companies. For instance, whereas in transactions with foreign firms, Visteon merely supplies modules based on their customers' instructions, it is requested to design the modules for their Chinese customers itself. Component manufacturers such as SAME have also turned to offer (integral) sets of interacting components (for instance, engines and transmissions) (Marukawa 2014). Other firms such as Delphi have specifically reworked the interfaces of their engine management systems in order to increase the matching capacity of their product with the market-dominating SAME engines (Wang and Kimble 2010). These decentralized design activities by (often international) component manufacturers are supplemented by the entry of national and international design houses.[7]

The adoption of designs from international competitors, component manufacturers, and design houses is yet merely part of the story. In order to make extensive use of components from the market, complementary changes in product and industry architectures need to occur. As Geely's car manufacture expanded, for instance, the product architecture was designed with the explicit intent of increasing the possibilities for mixing and matching components to be sourced from the market. In his case study of the company, Wang (2008) emphasizes the problems Geely encountered when it started to mix components from two separate (integral) cars and the provisions the company made to reduce the component selectivity of its own platform.[8] Accordingly, the modularization process in the Chinese passenger car segment does not only consist of (knowledgeable) component manufacturers adapting and extending their products to penetrate the upstream market consisting of experienced and (many more) less experienced system integrators. While the technological sophistication of the domestic system integrators is clearly inferior to that of their (international) suppliers (Marukawa 2014), the domestic integrators still perform an important task in the process by seeking ways (with the help of design

6 According to Marukawa (2014), Chery initially only built one (1596 cc) engine and sourced all other engines from companies such as SAME, Harbin Dongan (both of them Mitsubishi JVs), FAW-Daewoo, and Tritec Motors (a Brazilian BMW-Chrysler JV). Only gradually, it developed more indigenous engines with the help of Austrian engineering company AVL.

7 Harbin Hafei Auto, a car company with a background in military vehicle manufacturing and a daughter of Changan Auto since 2009, appears to have been the first company to outsource the product design, in this case to the Italian design house Pininfarina. Already in the mid-1990s, the Italian company started the cooperation by helping to design a new model of a truck based on the diffused Daihatsu platform. Later, Hafei also outsourced the chassis design to British company Lotus Cars (Xi et al. 2009). Many other companies followed suit.

8 Wang (2008) quotes a manager who explains, for instance, that the architecture of the Maple car series was adapted to accommodate a broad range of different engines from various suppliers.

houses) to increase the parts and components to choose from. These efforts become especially interesting as some new (re-)combinations are being probed by companies entering the sector from unexpected pathways. The widening of technological possibilities through the increased questioning of the ICE technology and the growing (re-)consideration of electric mobility has added to a growing vehicle variety in the Chinese setting, particularly in the mini and microcar segment.

In the case of China, the recent entry into the electric microcar segment has predominately come from firms integrating horizontally by literally increasing their vehicles' number of wheels. As has already been mentioned, Geely is not the only motorcycle company that has tried to venture into passenger cars. Some motorcycle firms have yet taken a detour to the vibrant electric bike segment that has taken off since the mid-1990s. The Chinese production of e-bikes has virtually exploded increasing from 40,000 in 1998 to ten million in 2005 and accounting for more than 90 percent of the global market (Weinert et al. 2007; Tyfield et al. 2014).[9] Having left a mark on the e-bike architectures, the entrants' origin of traditional bikes or motorcycle manufacture is represented in the generic e-bike forms: as bicycle or scooter style e-bikes (Weinert et al. 2007). As Marukawa (2014) has observed, while firms in advanced economies would start by developing the major components, typically in collaboration with selected suppliers, the Chinese e-bike makers have simply experimented with existing bicycle and motorcycle parts and adding existing component (e.g. battery) technology. Moreover, when conventional parts did not perform their function in connection with other functions of the bike (e.g. when brakes would not perform at higher speed), then the component manufacturers would be approached to search for appropriate solutions. Until recently, the evolution of the open-modular architecture of the e-bike has brought a number of changes and upgrades in the components, which have vastly increased the functionality and decreased the price of the overall product (Weinert et al. 2007; Weinert et al. 2008).

In addition to e-bikes, another Chinese approach to the passenger vehicle sector is via so-called "low-speed vehicles" (LSV). While the e-bike makers target the urban population, and specifically the growing number of commuters of China's expanding cities, the low-speed vehicles have mainly emerged from agriculturally related utility vehicles. Apart from low-speed trucks, three-wheelers constitute the major form of this kind of vehicles. In contrast to the two-wheeler segment, the three-wheeler market is strongly concentrated with the top three firms Shandong Shifeng, Shandong Wuzheng, and Henan Benma accounting for almost 90 percent of total sales in 2012 (CATARC 2013). Some of the three-wheeler firms have experimented with electric propulsion systems early on. As both, two-wheeler and three-wheeler firms have more recently sought to expand into the electric microcar segment, they have done so under the low-speed (electric) vehicle banner. Kimble and Wang (2013) explain the basic parameters of those cars. Accordingly, LSVs are cars with strongly simplified powertrains, typically lacking a vehicle controller, energy management unit, and auxiliary subsystems. Instead, the simple motor that is powered by the battery pack is often directly connected to the accelerator. Rather than using sophisticated battery technology, the cars employ conventional batteries that have the advantage of being

9 The emergence of China's electric bike industry can be traced to Shanghai Cranes Electric Vehicle, a company that derived from an R&D project firm that was financed by a local government venture capital vehicle in an effort to access the resources related to a national-level R&D program for electric vehicle technology. When the team lost the bid to a team from Guangzhou in 1994, the Shanghai firm turned to the development of electric bikes that had just appeared in Japan. As the company proved the viability of producing such vehicles, a large number of firms, mainly from the neighboring provinces Jiangsu and Zhejiang, rapidly entered the sector to exploit the opportunities (Fairley 2005; Weinert et al. 2007; Tyfield et al. 2014).

chargeable from an ordinary household 220-volt power outlet.

In their basic version, their product architecture is broadly similar with that of the street-legal golf carts that mainly constitute the LSV segment in the USA.[10] However, the level of sectoral variety creation is arguably much higher, and less restricted, in China than in other countries. In fact, Chinese LSV producers have not only experimented with golf cart designs but have also probed other kinds of architectures. This has also brought LSV makers closer to the minicar segment. Exploring the feasibility of creating simplified versions of prevalent minicars, LSV makers have come up with several models that share some similarities with the SMART or, more often, the vastly popular Chery QQ, which is itself similar to the Daewoo Matiz/Chevrolet Spark. Again, the use of common component manufacturers may account for some similarities. On the other hand, the value that is created by Chinese microcar makers derives from creating different combinations of (generic) components (with different functions and/or different quality-price ratios). International design houses and core components from international suppliers are also key in the development of that segment. As the LSV makers are inspired by the minicar market, these two segments are destined to converge in terms of performance and dominant designs. In turn, the expansion of the segment is destined to drive complementary changes in China's component markets, specifically the battery technology market. Certainly, these developments are not made to challenge the position of the leading carmakers in Japan and Germany. However, if not impeded further by the central government, the expansion of the China's industry – not only within the country but extending to a large number of countries with less affluent populations – will likely have an impact on the segmentation of the overall sector. If these developments lead to rapid increases in quality and performance, the cars will ultimately become a choice for consumer in advanced countries, especially in connection with car-sharing offers.

# 4 SOME IMPLICATIONS FOR INSTITUTIONAL ANALYSIS

If the definition of architectural innovation and its application to the Chinese case is accepted, then the next step is to discuss the institutional structures that support the selection of the particular innovation strategy. The present paper will certainly not be able to provide a comprehensive analysis.[11] Instead, two important points will be highlighted. First of all, this pertains to the relationship between the specific innovation strategy and the mentioned interdependences between different institutional configurations that are emphasized in the recent institutional literature on China. As might be evident after reading the prior sections, the point is to be made that the interdependences among the institutional configurations relate to the fragmentation of the design activities. Second, a tentative evaluation

10 See, for instance, Saporito (2011) for LSVs in the USA. Whereas LSVs (USA) and "motorized quadricycles" (EU) are allowed to use designated streets with specific speed limits, Chinese national laws still prohibit LSVs from using public roads. Only Shandong province – the province, in which three-fourths of all three-wheeler production took place in 2012 (CATARC 2013) – has made some arrangements to bring LSVs on the road (Kimble and Wang 2013). However, as with e-bikes that featured explosive growth despite efforts to ban them (Fairley 2005), the sales of LSVs outstrip by far the conventional electric cars that are available in China. According to Wang (2015), over 300,000 LSVs were sold in China in 2014. If the Chinese government's prior history of pragmatic policy-making provides any indication for the future, then the government's opposition to the emergence of the LSV sector will not last long.

11 For a comprehensive analysis of China's contemporary institutional trajectory, see Conlé (2011).

of the various roles of the state is given. As will be argued, the Chinese state is simultaneously encouraging and impeding Chinese-style architectural innovation. Whereas, on the one hand, it strongly encourages the entry of component suppliers and is also otherwise forthcoming in its establishing the foundations for the entry of new system integrators, the state's continuing insistence of creating modern business systems results in a continuing struggle for control among (both, central and local) government and non-government integrators. In effect, Chinese-style architectural innovation persists in conflict with – rather than being compensated by – the Chinese government's desperate attempts at imitating advanced country business systems.

The description and explanation of institutional diversity and its change arguably constitutes the central item of scholarly investigation of China's post-Mao political economy. Since some of the key political changes coincide with the large-scale transformations of the political-economic regimes in Eastern Europe and the (now former) Soviet Union, it seemed obvious to treat all the changes in a comparative manner, assuming that the sequences and intensities of change differed among the various countries, but not the general direction and ultimate outcome of change. In line with the intellectual climate of the day, a private character of firms and a transient nature of market interaction were considered in the transition literature as the two emblems of capitalist economic organization. The particular approach to investigating institutional diversity in China follows this underlying logic. It strongly emphasizes the initial differences among organizations of different ownership forms (that is, state, collective, and private forms) and examines whether the expected convergent movement towards a single privately organized form obtains. As a consequence, major discussions have centered, for instance, on the problematic use of ownership registration (instead of de facto ownership arrangements) as a proxy for a firm's organizational membership, the prediction of outcome changes (e.g. productivity increases) following de iure ownership changes, and the persistence of non-private economic organization (e.g Huang 2008; Breslin 2012). Moreover, comprehending China as a "regionally decentralized" authoritarian regime (Xu 2011) consisting of localities with initially widely differing distributions of ownership forms allowed scholars to understand ownership dynamics as being brought about by a sort of yardstick competition among local states (e.g. Cao et al. 1999; Maskin et al. 2000; Sun 2000). In turn, the co-persistence of non-private forms of organization and local variation have been interpreted as being facilitated by the emergence of institutional niches for different organizational forms (Redding and Witt 2007). Partially, these niches seem to overlap with different industrial sectors (Ernst and Naughton 2008).

Although the research agenda of the transition literature has beyond doubt produced a lot of relevant insights about China's development trajectory, the overly strong focus on ownership arguably presents an obstacle for the analysis of innovation in China. This does not mean that ownership is not of importance. Rather, the organizational populations founded on the basis of ownership are not providing interesting links to the forms of innovation that are observed in the Chinese setting. The rationale for appealing to ownership is that state and private organizations are assumed to feature completely different systems of control and coordination as well as different institutional environments (Redding and Witt 2007; Nee and Opper 2012; Walter and Zhang 2012). This may correspond to observations of the Western market economies but in the context of an authoritarian political regime, it is naïve to believe in such a rigid separation. Instead, the boundaries between the private and the political remain indefinite (Meyer and Lu 2005). While the intrusiveness of the state might seriously impede some private economic activities, it also allows some private-state interactions that are hardly imaginable in other institutional settings. If so, then clinging to the conventional beliefs will arguably undermine an understanding of China's capitalist system as much as it misrepresents the role of the state in China's (architectural) innovation activities.

In order to appreciate the institutional foundations of innovation in China, the present argument calls for an analytical distinction between component design (and production) tasks on the one hand and system integration (and assembly) tasks on the other. While several important Chinese firms may have (by now) integrated both of these activities in a single corporation, the most salient of China's industry sectors typically have comparatively disaggregated structures. In sectors such as, for instance, the passenger mobility sector that was described above, the information and communication or the wind power sectors, some of the most important design parameters are developed by the component designers rather than the system integrators (see Watanabe 2014). In the case of reasonably modularized product architectures, the various components of a product system constitute different horizontal market segments of the overall sector. Summarizing the insights from various industry case studies, firms of different ownership forms apparently coexist in most of these segments and seem to face relatively similar market environments. In contrast, the system integrators of several of the most salient sectors, specifically those deemed "strategically relevant" by China's central government, face a much more restricted environment. Until the corporations gain a position of legitimacy with the central government, the corporations survive on the basis of local government support and, more importantly, by minimizing the amount and maximizing the flexibility of the employed resources.

Whereas the provision of peripheral components is mostly left alone by the state and foreign investors, the markets for the components embodying the final products' core technologies are experiencing a quite different environment. These segments are specifically encouraged by China's governments at central and local level. Notably, ownership does only superficially play a role. The Chinese state, represented by a plethora of independently performing agencies,[12] heavily invests in design activities related to chosen technologies. However, it spreads the funds over all the firms that the various decision makers consider to have the potential of becoming competitive relative to the multinational incumbents. The firms that are typically chosen derive from four different origins that apparently function as a signal for those political decision makers: First of all, there are, of course, the large firms – most of which are traditional state-owned enterprises whose foundation can be traced back to the period before the 1980s – with a history of development activities in related tasks, a comparatively well-educated staff, and a suitable infrastructure for design activities. Then, there are firms that are (partially) owned and (persistently) backed by academic institutions, in particular China's most prestigious universities and public research institutes (see Gu 1999). More recently, start-ups by Chinese "returned" entrepreneurs with a background in research and development conducted at major multinational corporations and research institutions in advanced countries, particularly the USA, have replaced the domestic academic entrepreneurs as pets of Chinese government agencies and foreign investors. Finally, domestic firms that have managed to link with multinational technology leaders in the sector are also relevant in this respect. Generally speaking, all of these firms – accessing knowledge from either domestic academia or foreign sources – can hope to receive investments by government investment vehicles (which effectively turns them into some sort of state-owned or state-affiliated enterprise, if they are not already belonging to the state), R&D funding from programs such as the National High-tech R&D (863) Program, bank loans (typically following the inclusion in the technology programs), and so on. Moreover, it is these firms that are in the

12 Observers of China's "national innovation system" have emphasized the fragmentation of the bureaucracy in charge of providing state funding for science and technology. See, for instance, Kroll et al. (2008).

position to enjoy the benefits of institutional outsourcing (as defined by Allen 2013), especially the ready access to foreign stock markets (such as NASDAQ).

The horizontal and vertical integration of economic tasks and activities appears to be a more contested ground. Depending on the sector, several different coordination regimes compete for the ability to enforce their own way of organizing tasks and activities. Among those regimes, the most important ones are these: First of all, emulating the (then!) successful development models of Japan and South Korea, the central government – and, in a similar fashion, the provincial-level governments – sought to found a number of (mostly sectorally specialized) business groups (see Nolan 2001). Following the establishment of the State-owned Assets Supervision and Administration Commission (SASAC), the agency has excelled in the blackboard construction of some of the most complicated pyramidal business groups the world has ever encountered featuring lower-level business groups, listed companies, and other units that vie with the top tier for control. The value networks of multinational companies partly overlap with the state-organized business groups and add a further source of conflict as regards the locus of coordination and control. Low-level (rural) governments had originally tried to follow suit but, during the 1990s, the success of industrial districts particularly in Guangdong and Zhejiang provinces has resulted in the abandonment of the approach (see Conlé 2011). In its stead, cluster approaches, which have become strongly popular in policy circles throughout the globe, have been pursued with rigor by local governments – or, more exactly, the agencies in charge of managing the newly established parks and industrial bases – meticulously seeking to localize each and every task in a targeted sector's generic value chain. While the jury is still out on the success of either government strategy, it is far from evident that these strategies have generated more than a number of firm agglomerations with variously defined boundaries. Rather, their largest contribution appears to be a vastly simplified access to specialized knowledge and capital for firms wherever they are located.

The ready access to complementary specialized knowledge rendered possible by the evidently loose coupling of the particular firms embodying that knowledge within the various (government-sponsored) agglomeration projects has opened up opportunities for the entry of a new breed of product assemblers/system integrators that rearrange the task systems to their advantage. It is the outcome of the interplay between the activities of the new entrants, which consists of realizing new combinations of available technologies, and those of the component suppliers, which change their offerings to adapt to the pull of the novel demand segment, that has been dubbed architectural innovation in the preceding chapters. Similar to the (relatively neglected) producers of peripheral parts and components (and some core component producers that fail to obtain more encompassing government support due to their lack of the right signals), the system integrators benefit from the local governments' various cluster initiatives. The most important environmental support yet stems from the institutionalized flexibility of the employed resources (Watanabe 2014). Apart from the supplies that are readily available through the markets, this pertains specifically to the labor input.[13] In order to manage design and development, the input from knowledgeable suppliers and from the services of independent design houses is obviously important, while the contribution of the ordinary

13 For comprehensive analyses on labor relations and work systems see Butollo (2014) and Lüthje (Lüthje et al. 2013; Lüthje 2014). Note that many authors unilaterally focus on employer commitment to distinguish between institutional contexts. However, the development of Chinese industrial relations is to a good extent driven by a lack of employee commitment induced by skyrocketing (skilled) labor demand (rather than the lack of employer commitment). Poaching is common as the Chery Auto example of Chapter 3.2 illustrates. There is reason to believe that it is difficult to introduce labor market rigidities (usually monopsonist demand structures) in strongly dynamic contexts.

workforce seems negligible. Unfortunately, there exists so far little knowledge about the general design integration process, although some authors have provided a few insights into that process for a few selected sectors.[14] These studies suggest that the development teams are rather small.

Appealing to the proposed perspective on Chinese innovation conflicts with some prior analysis. In contrast to the early institutional analyses on China that highlight separate institutional spheres existing at various scales (between different localities at the same scale or between local, national, and international scales) or at different locations within the state-private continuum (see the introduction), the current presentation emphasizes their connectedness. On the one hand, the institutional configurations supporting firms in specific sectoral positions are composed of institutional resources that are produced at various scales, while, on the other hand, the institutional configurations are connected through the firms' participation in common task systems. The perspective thus follows, extends, and refocuses the propositions of scholars including McNally (2012), who sees compensating institutional arrangements and redundant capacities at work in the development of China's capitalist economy. By the same token, despite its seeming obviousness given the nature of the Chinese state, the notion of state-organized (or state-led) capitalism that some authors find appropriate to describe the Chinese case (e. g. Walter and Zhang 2012) appears of rather limited value for the explanation of Chinese-style innovation, although it certainly has its merits in explaining the emergence of all the uninspiring Chinese corporations among the global Fortune 500. On the single-technology level, the Chinese state pursues strategies that are similar to those of other countries but, in contrast to those countries (the USA, for instance, that itself is seldom categorized as state-organized), the degree of organization is arguably more limited due to the high fragmentation of the support structure. In turn, the coordination and control of activities encompassing combinations of technological components is contested but virtually all the interesting occurrences of economic innovation derive from decentralized interaction.

Finally, the perspective appears to be at odds with other recent illustrations of innovation in China that emphasize manufacturing over design activities (Bonvillian 2013; Herrigel et al. 2013; Nahm and Steinfeld 2014). In some ways, the discrepancies seem to stem from a different treatment of process-based and product-based strategies. Simplifying the design of a given product in order to increase the manufacturability for a firm's internal manufacturing unit or an external contractual partner firm might be considered a design and/or a manufacturing issue. Relatedly, when authors such as Nahm and Steinfeld (2014) highlight the scaling capabilities of Chinese firms, this may apply to both, the flexibility of the manufacturing units in producing a range of customized (intermediate) product varieties as well as to the ease of sourcing and integrating generic components into a working product. However, as the authors are strongly economizing on descriptions of innovative manufacturing processes, there is little to avert the suspicion that the manufacturing processes themselves are rather conventional for economies with the prevailing factor endowments. That is, the process-based strategies are expected to be complementary to the product-based strategies in that relatively labor-intensive processes prevail, while the specific designs are to reduce the need for worker participation on the shop floor. Moreover, simple learning by doing allows firms that manage to stay in the market ample upgrading opportunities, specifically in managing and processing orders from sophisticated customers. At this point, attention needs to be called to the fact that upgrading itself cannot be considered an innovative activity. While learning (by doing) is almost inevitable, the nature of

14 See, for instance, Wang (2008) on the integration work of a new Chinese auto maker, Imai and Shiu (2007) as well as Zhu and Shi (2010) on mobile handset makers, and Lu and Mu (2011) on the digital video player industry.

the learning opportunities is relevant here. Once again, the specific division of design labor arguably allows participating firms to learn things that are not learned in other institutional settings, even in the same industry. These learning opportunities, in turn, are a valuable asset that firms – also multinational companies! – forego when they leave the domestic market.[15]

## 5 CONCLUSIONS

A lot of recent scholarship follows Perez and Soete's (1988) argument that it is new technological domains that primarily provide windows of opportunity for innovation and catch-up development by firms and countries. The notion of architectural innovation, as it was defined in the present contribution, seeks to broaden the perspective by pointing out that fundamentally new knowledge is important but not necessary to induce consequential changes in the segmentation and status ordering of sectors. Instead, changes in the division of labor may evolve autonomously in specific institutional settings and change the way given technology is created and implemented. Not all of these changes may (immediately) conform to the subjective attributions of technological progress entertained by economic observers. In the example of the passenger vehicle industry, China has been quite successful in two-, three- and, more recently, four-wheel vehicles. However, from an engineering (not a consumer) point of view, these vehicles are clearly not competitive. In fact, the Chinese government (or parts of it) seeks to restrict the development of the spontaneous market interactions underlying the emergence of the so-called low-speed vehicles, (for now) apparently feeling embarrassed about the technological mediocrity of the cars. This judgment notwithstanding, the sectoral ecology that is developing in China appears to be rife with co-adapting initiatives by an immense number of firms set to drive the innovation in the sector. While it would be far-fetched to argue that this ecology could displace the leading Japanese and German technology leaders, it would be grossly negligent to underestimate its effect on the vertical (high/low price) segmentation of the sector and, even more interestingly, on the position of component suppliers in the sector's dominant division of labor. In the dynamic sectoral setting, new domestic competitors – be it component suppliers, system assemblers or even integrators – may emerge suddenly without warning.

As Steinfeld (2010) has rightly argued, China is playing a game that was introduced by Western countries, specifically the USA. But he, and most scholars with him, only gradually come to acknowledge that China has changed, and continues to change, the way that very game is played. Unfortunately, the characteristics of the (innovation) "strategy", the particular organizational patterns and technological trajectories that have evolved from the activities of a broad range of firms and individual entrepreneurs, are still poorly understood. Therefore, all of the most interesting issues such as those concerning the further effects of China's rise on the global division of labor, potential pressures on the industri-

15 Note that, in the present exposition, foreign subsidiaries were treated primarily as domestic market participants differing above all in their origin and, hence, their access to some institutional resources. This perspective differs from a more nationalist one that considers the subsidiaries of multinational companies primarily as foreign invaders that take development opportunities from domestic companies but contribute little to both, the host country and the multinational corporation as a whole (e.g. Steinfeld 2004; Xiao et al. 2013). Seconding authors such as Herrigel et al. (2013), the current argument yet seeks to suggest that the domestic sectoral developments, including the activities of the multinational companies' subsidiaries, provide various learning economies that are shared by all relevant actors in the domestic industry. It is these learning economies that arguably keep multinational firms from pursuing short-term exploitative "hit and run" strategies.

al relation and capital market systems of other countries as well as the future of China's state capitalism are difficult to tackle without a proper understanding of these evolutionary processes. The previous failure to identify the relevant business structures (with the possible exception of state business groups) is partly due to the fact that scholars have primarily focused on populations of firms that were typically clustered on the basis of ownership rather than look at the effective interactions among firms in the provision and innovation of final products. While this approach doubtlessly made sense in the context of the large-scale transformations of the late 1980s and early 1990s, it has arguably outgrown its usefulness.

Attracted by the stunning developments of several Chinese industries, most of them assembly industries, scholars have recently turned towards the examination of broader sectoral ecologies, focusing specifically on focal firms' various external (market) interactions. Veering away from the prior literature that has looked at market interaction in China under the sole consideration of local state protectionism, the recent approaches emphasize the technological foundation of market processes and interfaces. The focus on sectoral ecosystems rather than on firm populations that are defined according to statistical and legal artifacts (that is, ownership measures) has served to move the research closer to the business systems (and the innovation systems) literature. In order to understand and explain the dynamics of China's industry sectors, it seems advantageous to focus specifically on the distinctive patterns of entry into a sector. The concept of architectural innovation that was discussed in the present paper was introduced as a means to develop a tentative framework for capturing variations in the ways firms develop and/or access the requisite (design) capabilities for entering specific industry sectors and market segments. Defining China's innovation strategy on the basis of that framework and exemplifying the strategy by means of a selected case study reveals some caveats that hopefully motivate further research. Among those issues that need to be further addressed and brought together more systematically are the organization and methodologies of design integration teams, typical approaches to supplier identification and selection processes, the nature and origin of the flexibilities of supplier and assembler firm responses to (changing) market demands, the distribution of value within the value networks, and analyses of the institutional environment based on a proper understanding of the sectoral ecologies. Finally, the tentative framework that was introduced in this paper is to mark the beginning rather than the end point concerning the development of an analytical framework that allows the Chinese case to fertilize the VoC debate, and the comparative capitalisms more broadly.

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