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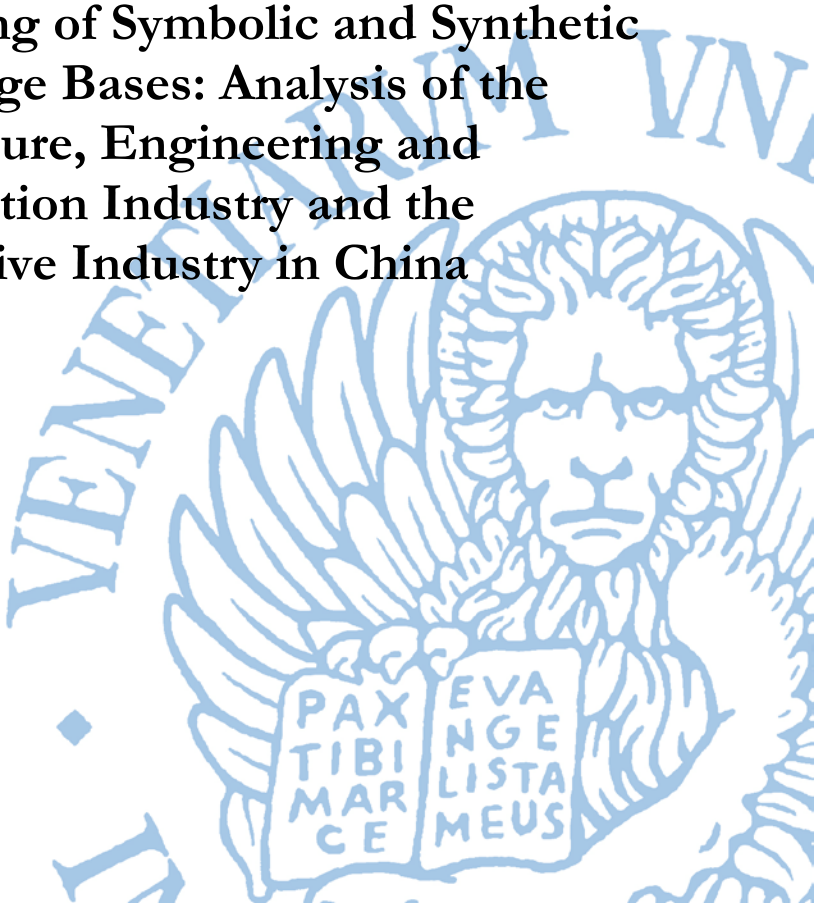

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Upgrading of Symbolic and Synthetic Knowledge Bases: Analysis of the Architecture, Engineering and Construction industry and the Automotive Industry in China.

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Abstract The degree and the way of upgrading differ widely per industry. This article tries to give some new insights in these differences by linking the concept of upgrading to that of the knowledge base. Moreover, we try to identify barriers to upgrading as well as the appropriate spatial scale on which upgrading takes place, again for different knowledge bases. We support our argument by analysing the process of upgrading in two industries in China: the AEC industry (in Beijing and Shanghai) and the automotive industry (in Shanghai). Within these industries we focus on upgrading on two levels: within firms and within projects. Our findings for both industries suggest that the principal ways of upgrading of the symbolic knowledge base are joint brainstorming in internal and external project teams and labour mobility. Major factors that hinder the upgrading of symbolic knowledge include the development stage of China, the Chinese educational system and tensions about duplication of western designs. Upgrading of the synthetic knowledge base takes mainly place via inter-company training programmes of foreign firms, technology transfer and labour mobility on the long run. A possible barrier for upgrading of synthetic knowledge, especially in the automotive industry, is that foreign firms tend to keep certain engineering activities in their home base because of the risk of knowledge leakage. However, this is changing quickly as many foreign car makers and their suppliers invest in engineering centres in China due to an increasing demand for cars, to governmental regulations and to intensifying competition.

Keywords Urban development, upgrading, automotive industry, AEC industry, knowledge economy, China.

JEL Codes L2, R00, R3, O3

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1. Introduction[1]

China is one of the fastest growing economies of the world. The economic dragon is already the second largest economy in the world. Since 1980, the average annual GDP growth was 8%, real GDP growth quadrupled in the 1980-2001 period (Li and Oberheitmann, 2009), and between 1985-2005 its exports rose from $50 billion to $798, making it the world's largest trading nation (Kaplinsky and Messner, 2008). Besides 'quantitative' growth of the economy, China increasingly aims to realise 'qualitative' growth, expressed in its' ambition to change from the mere 'made in China' to 'designed and developed in China'. Therefore, it invests heavily in R&D and human capital and has various strategies to 'upgrade' its economy. In fact, its annual spending on R&D has increased more than 20% since 1999, and in 2005, it reached 1.3% of the GDP from 0.7% in 1998 (Wilkonsdon and Keeley, 2007). Already in 2006, it took over Japan to become the world's largest investor in R&D (Gereffi, Wadha & Rising, 2006).

A key concept to analyse 'qualitative development' is upgrading. Upgrading was first introduced in business literature, where upgrading is analysed within individual firms (Porter, 1990; Kaplinskey, 2001), and the technological upgrading and the technological capabilities approach (e.g. Lall, 1992; Bell and Pavitt, 1992) which pays attention how local suppliers in developing countries increase technological skills in order to supply to global markets. Nowadays, it is a common concept in regional economics as well, where it is used to analyse upgrading of industrial clusters inserted within global value chains and production networks (e.g. Gereffi, 1999; Humphrey & Schmitz; 2002; Giuliani et *al.*, 2005; Coe et al, 2004 Schmitz, 2004).

Upgrading has been discussed in many empirical en theoretical studies. Major findings include that in many cases the degree of upgrading is limited to process and product upgrading (e.g. Coe et al, 2004). Widely discussed has been the governance in Global Value Chains (GVC) and Global Production Networks (GPN) as an explanation for the degree of upgrading (e.g. Gereffi, 1999). It is also acknowledge that the degree of upgrading differs per industry (Guiliani et al, 2005). However, less widely insights have been given *how* the process of upgrading differs per industry. We aim to fill this gap by

[1] Alessandro Costa and Rachel Feng assisted with the fieldwork in Beijing and Shanghai.

linking the concepts of upgrading with knowledge bases. Therefore, we address the following main question: *How does upgrading take place regarding to different knowledge bases?* In other words, we will show how upgrading mechanism differ per knowledge base. In addition, we will give some new insights in the major upgrading drivers and barriers as well as the spatial scale on which upgrading takes place for different knowledge bases.

The concept of knowledge bases has been used to analyse differences in the geography of innovation for different industries. There are three types of knowledge bases: analytical (science based), synthetic (engineering based) and symbolic (aesthetic based) knowledge base (Asheim and Gertler, 2005; Asheim and Coenen, 2005; Asheim et al, 2006). The dominant knowledge base differs per industry as well as per project stage in product development processes, and can thus be used as a suitable tool to analyse how upgrading differs per industry and within product development projects. We argue that differences in knowledge bases are dependent for the way of upgrading.

We have tried to analyse the upgrading process of the symbolic and synthetic knowledge bases in two industries in China: the automotive industry in Shanghai and the architecture, engineering and construction (AEC) industry in Beijing and Shanghai. China is an extremely interesting case, not only for its upgrading ambitions in both manufacturing industries (like automotive) as well as in creative industries (e.g. architecture), but also because of a powerful state that can influence global-local interaction and thus it might stimulate upgrading of Chinese firms by western firms. In addition, the concept of knowledge bases has been constructed with evidence from developed countries, and there is a need to see if the arguments also hold in industries and cities in developing economies (Chaminade, 2011).

The paper has been structured as follows. Section 2 discusses the complex relationships between different knowledge bases and upgrading and tries to link the s. In section 3 the case studies will be introduced and the research method explained. In the empirical part of the paper (sections 4 and 5), we describe the two cases and the principal results regarding the process of updating, while in the last section (section 6) we draw some final conclusions and give policy implications and directions for further research

2 Upgrading and knowledge bases

2.1 What is upgrading?

The concept of upgrading stems from business literature (Porter, 1990; Kaplinsky, 2001) and the technological upgrading and the technological capabilities approach (e.g. Lall, 1992; Bell and Pavitt, 1992). The first approach analyses upgrading within individual firms, while the latter focuses on how local suppliers in developing countries increase technological skills in order to supply to global markets. Upgrading can be defined as "making better products, making them more efficient, or moving into more skilled activities" (Schmitz, 2004, p1). Gereffi and Than (1998) mention that industrial upgrading includes organizational learning needed to improve the position of firms or nations in international trade networks. Similarly, Humphrey and Schmitz (2002) speak about activities which enable firms in developing countries to compete on the global level. These activities, including the increase of skill content of these firms and the move towards niche markets with entry barriers, are similar to the previous definitions. Four types of upgrading are distinguished: process upgrading (using more efficient production processes), product upgrading (making higher valued products), functional upgrading (doing higher added functions, like R&D and design instead of production) and inter-sectoral upgrading (firms move into new product activities) (Humphrey and Schmitz, 2002). However, this typology can be criticised as the different types are related with each other, and therefore, in many cases it is difficult to distinguish them separately (Ponte and Ewart, 2009). For instance, the use of LEED certification in the AEC industry, which forces constructors to use sustainable building materials and to build energy efficient buildings, includes both product as well process upgrading at the same time. Moreover, empirical results are mixed. In many cases the degree of upgrading is limited to process en and product upgrading (e.g. Coe et al., 2004) and upgrading in practice is often more difficult to realise than in theory (Lorentzen and Barnes, 2004).

In conceptual terms, upgrading has been linked with various other concepts that deal with the geography of innovation, including clusters (e.g. Giuliani et al, 2005), regional innovation systems (e.g. Vang and Ashiem, 2006), GVC (e.g. Humphrey and Schmitz, 2002; Gereffi et *al*., 2005; Giuliani, 2005) and GPN (Ernst and Kim, 2002; Coe et *al*., 2004). However, it is not linked with the concept of knowledge bases yet. We argue there is a need to do so, in order to give insights

in differences in the upgrading process of different industries and within product development projects. Before doing this, we first explain the different knowledge bases in more detail.

2.2 Knowledge bases

The concept of knowledge bases (Asheim and Gertler, 2005; Asheim and Coenen,2005; Asheim et al, 2007; Moodysson et al, 2008; Gertler, 2008; Asheim and Hansen, 2009) presumes that there are variations in the geography of innovation for different firms and industries. Thus, it is possible to analyse the role of proximity for innovation. The dominant knowledge base differs per industry. There are three types of knowledge bases: analytical (science based), synthetic (engineering based) and symbolic (creativity based) knowledge. The knowledge bases differ in the way of learning; the mix of tacit and codified knowledge; codification possibilities; innovation barriers, required qualifications and skills; innovation challenges and pressures; and communication modes used and the relevant spatial scale of interaction.

The knowledge bases have been dealt in various conceptual and empirical studies. In a conceptual way, the knowledge bases have been linked with regional innovation systems (Coenen et *al.*, 2004; Asheim and Coenen, 2005; 2006; Coenen et *al.*, 2006), the communication modes face-to-face and buzz (Asheim et al, 2007; Van Tuijl and Carvalho, 2009) and the creative class (Asheim and Hansen, 2009). Empirically, the knowledge bases have been tested in different industries biotechnology, food and ICT realms (e.g. Asheim et *al.*, 2007; Moodysson et *al.*, 2008; Moodysson, 2008; Gertler, 2008), electronics, furniture (Asheim and Coenen, 2006), car design (Van Tuijl and Carvalho, 2009) and the media industry (Martin and Moodysson, 2010). With exception of the latter two, most of the analysed industries rely on the synthetic and analytical knowledge bases and not on the symbolic one. Similarly, in their study that links knowledge bases with the creative class, Asheim and Hansen (2009) analyse several job functions, but only one of these (‘writers and creative or performing artists’) relies on the symbolic knowledge base. Moreover, this is the only study that compares the symbolic knowledge base with the other types. Symbolic, just like synthetic, knowledge plays also a crucial role in the automotive industry and the architecture, engineering and construction industry. Analytical knowledge –that is especially relevant in science based industries (such as bio-technology)- plays a major role in early stages of innovation processes, which are often done in ‘the West’ and Japan, but is assumed less relevant in our case

studies. Therefore, we focus on the symbolic and synthetic knowledge bases and link these knowledge bases with the concept with upgrading. In order to do so, we first discuss these two knowledge bases in more detail.

Synthetic knowledge base

The synthetic knowledge base is dominant in engineering based industries, such as the automotive industry, shipbuilding and machinery industries. It includes economic activities where innovation takes place by application or new combinations of existing knowledge. Knowledge development takes place in an inductive process in order to solve problems and aims to answer the 'know how question'. Typical activities include trail-and-error production, experiments, custom production and computer-based simulation, and the outcome of the knowledge development process is highly concrete and visible, for instance in the form of prototypes. Examples are the development of new ships, adaptation of cars for specific markets and changing machines for other applications. Although the knowledge is partly codified, the dominant knowledge type is tacit and is based on know-how, craft and practical skills. Cooperation for the synthetic knowledge base takes often place between different departments of a firm (for instance between the marketing department and production) and with suppliers and customers. University cooperation takes also place, but concerns mainly collaboration in the field of development and applied research.

Symbolic knowledge base

The symbolic knowledge base has been developed for the cultural industries, such as media, advertising, design and fashion, which gain importance and where competition is increasingly based on the 'sign value' of (intangible) brands instead of the user-value of tangible products. Its activities are innovative and design intensive and are related to aesthetic attributes of products, creation of designs and images and the economic use of various forms of cultural artefacts. Innovation takes place through the recombination of existing knowledge in new ways and knowledge development is a creative process which implies reusing or challenging existing conventions. Instead of answering the know-how question, knowing who is relevant in the symbolic knowledge base. Knowledge development is based on learning-by doing, and takes often place in project teams in studios. Learning takes also place via interaction with the professional community (for instance during fairs and events) and 'border' professional communities. 'Underground' (street and youth) culture plays also a major role in learning, just like 'fine' culture. Similar to

the synthetic knowledge base and because its strong cultural embeddedness, knowledge has a strong tacit component and is based on craft, practical skill and searching skills. The knowledge involved is incorporated and transmitted in aesthetic symbols, images, designs, artefacts, sounds, signs and narratives with strong semiotic knowledge content.

Table 1 provides a summary of these two knowledge bases. It should be noted that the knowledge bases are stereotypes and that industries in reality are dependent on combinations of all three knowledge bases. Therefore, there is room for debate and it is dependent on the purpose of the individual studies in which knowledge base industries are categorised. For instance, Asheim and Hansen (2009) classify architecture as synthetic knowledge, but confess that architects rely on a combination of synthetic and symbolic knowledge. The dominant knowledge base also differs per type of architecture and per stage in the architecture design process. In the beginning, the conceptual design stage, concept designers play a major role and rely mostly on artist based knowledge, while in later stages engineering designers and consultants gain importance with the focus on engineering based knowledge. Similarly, the automotive industry is mainly an engineering based industry (Moodysson et al, 2008), but symbolic knowledge gains importance, and therefore Van Tuijl and Carvalho (2009) unpack the car design process in order to analyse the interplay between symbolic and synthetic knowledge bases. In this article, we pay attention to processes of upgrading in firms as well as in projects that deal with the development of cars and buildings. We analyse how upgrading of the synthetic and symbolic knowledge bases actually takes place, and pay attention to possible barriers that may hinder upgrading of these two knowledge bases.

Table 1 Differentiated knowledge bases

	Synthetic	**Symbolic**
Rationale of knowledge creation	Applying or combining existing knowledge in new ways; *know how*	Creating meaning, desire, aesthetic qualities, affect, intangibles, symbols, images: *know who*
Way of knowledge development	Problem solving by experimentation and	Advanced design based on virtual

	trial-and-error; custom production	experience and artistic skills (creative process)
Way of learning and actors involved	Interactive learning with customers and suppliers	Learning-by-doing in studio, project teams
Knowledge characteristics	Experience based practical/technical knowledge; strong tacit component; context specific	Knowledge adapted to cognitive institutes (e.g. perception); importance of interpretation, creativity, cultural knowledge, sign value; strong context specificity
Meaning	Various substantially between places	Highly variable between places, class and gender
Main communication mode	Face-to-face interaction	Buzz and face-to-face interaction
Spatial configuration of interaction	Mainly local, although global relations are also relevant	Local and temporary local

Based on: Asheim and Hansen (2009), Asheim et al (2007), Gertler (2008), Martin and Moodysson (2010); Van Tuijl and Carvalho (2009)

2.3 Linking knowledge bases with upgrading

The concepts of knowledge bases and upgrading have various things in common, making it possible to link them. Both deal with major issues in the economic geography literature, such as innovation, learning, knowledge creation, transfer and absorption. The knowledge bases deal with knowledge creation, development and use, and criteria for successful outcomes, and the strategies to turn knowledge into innovation to promote competitiveness (Asheim, Boschma and Cooke, 2007). This is exactly the core of upgrading, which refers to

'innovating to increase value added' (Giuliani et al, 2005, p522). Upgrading includes activities of firms in developing countries to improve their position in international networks and includes the increase of skill content of these firms and the move to niche markets with entry barriers (Humphrey and Schmitz, 2002). Furthermore, major conditions to realise upgrading of firms in developing countries are besides connection to global networks, that firms have sufficient absorptive capacity and receive political support to exploit the benefits of network participation (Ernst and Kim, 2002). This requires the interplay between different actors in the process of creating, transmitting and absorbing knowledge, which is one of the major aspects in the concept of knowledge bases (Asheim, Boschma and Cooke, 2007).

Moreover, both concepts have been used to link global with local developments. Knowledge bases explore the geography of innovation and the role of proximity, while upgrading investigates the role of local suppliers in developing countries in Global Value Chains (e.g. Gereffi, 1999) and and/or global production networks (e.g. Ernst and Kim, 2002; Coe et *al*., 2004). Finally, the degree of upgrading depends on the type of chain governance (e.g. Humphrey and Schmitz, 2002; Giuliani et *al*., 2005) and the type of industry (Giuliani et al., 2005 and Pietrobelli and Rabellotti, 2005). The knowledge bases focus on the differences between industries, and therefore, we argue that the concept can function as a useful tool to analyse the way of upgrading per industry in more detail.

To summarise, both concepts deal with the geography of innovation. Upgrading is narrowly related with innovation. Morrison et al (2008) question whether upgrading is a synonym of innovation or the result of it. Confusion may also become clear from Guiliani et al's definition (2005, p552): 'Innovation to increase value added'. Kaplinsky et al (2005) show that innovation does not necessary lead to upgrading as competitors can be more innovative, and thus, upgrading can be seen as relatively innovative performance. So, upgrading is equal to innovation as long as it generates higher value added. Crucial for innovation (and thus for upgrading) is the acquisition of new knowledge and skills. An important question is new for whom: a single firm, a region or country, the world or a sector (Dahlman, 2008; Althenburg et al, 2008)? In other words, upgrading can occur on different spatial scales: within firms, within enterprise networks, within local or national economies and within regions (Gereffi, 1999), and more recently within value chains and between clusters (Oliver et al, 2008). New to a sector is equal to inter-sectoral upgrading in which case

current skills and knowledge have been applied in other sectors (Humphrey and Schmitz, 2002). Regarding the newness to a region (or country) or the world, it is useful to distinguish three different sources of innovation. The first is the acquisition of technology and skills which already exist abroad. A second is domestic creation of new knowledge. The third is the effective use and dissemination of new knowledge throughout the local economy, whether it has been imported from abroad or created locally (Dahlman, 2008).

Upgrading is not easy (Lorentzen and Barness, 2004) and various conditions need to be met to realise upgrading. First, local firms need to be connected with networks of global operating firms. However, this is not a sufficient condition, as local firms also need to have sufficient absorptive capacity to have access to new knowledge and capabilities (Ernst and Kim, 2001). In addition, the degree of upgrading depends on how firms organise learning and innovation activities in their organizations and how they employ specific regional and national assets. (Isaksen and Kalsaas, 2009). For the latter, it is important that assets of local suppliers and global operating firms are complementary (Coe et al, 2004). Moreover, governments are able to set development and upgrading criteria in case they have control over unique local assets, which is also known as obligated embeddedness (Liu and Dicken, 2006). Second, policies and local institutes are required to support local firms in exploiting benefits that stem from interaction with global operating firms (Ernst and Kim, 2001). Finally, other factors that influence upgrading are the type of chain governance (Humphrey and Schmitz, 2002) and the type of industry (Guiliani et al, 2005).

Moreover, and as an explanation for differences in upgrading between industries, we argue that the way of upgrading is dependent on the knowledge base used. Knowledge bases differ in the way of learning; the mix of tacit and codified knowledge; codification possibilities; barriers, qualifications and skills; innovation challenges and pressures; and communication modes used and the relevant spatial scale of interaction (see table 1). Differences in these elements explain how (and why) upgrading differs per knowledge base. Especially, differences in the way of learning and the process of knowledge development are important for analysis of upgrading.

Synthetic knowledge develops via a process of problem solving, trial-and-error production and experimentation, and learning takes place via interactive communication with

suppliers and customers, while symbolic knowledge has been constructed via a creative brainstorm process and learning takes place via learning-by-doing in studio project teams. On the job training and face-to-face contacts are crucial for learning in architecture firms due to the high tacit component of knowledge as it is empirically shown by a recent study of Kloosterman (2010).

In last three sections, after detailing our research method in section 3, we show empirical evidence that support our argument; i.e. we show how the upgrading process of the synthetic knowledge base differs from the symbolic one. The empirical evidence consists of two case studies in which we analyse the process of upgrading in two industries in China: the AEC industry (in Beijing and Shanghai) and the automotive industry (in Shanghai).

3 Selection of the Cases (Automotive and AEC in Beijing and Shanghai) and theResearch Method

The data for this paper have been gathered through interviews that were conducted in Beijing and Shanghai during two international comparative research projects and a return visit to China for this article specific. The first project concerns a study towards the development of manufacturing in a global-local perspective with a case study of the automotive industry in Shanghai (Van Winden et al, 2010; Van Tuijl et al, 2011) The second project is a study towards the role of design in cities with a case study of the development of (architecture) design in Beijing (Van der Borg and Van Tuijl, 2010; Van Tuijl and Van der Borg, 2011).

After these studies, Shanghai was visited again in order to gather data for both the automotive as well as the AEC industry. In addition, more data for the AEC industry was gathered in Holland by visits of two congresses as well as five additional interviews with internationally operating architects. Modern Dutch design is world famous and many of them are clustered in the Rotterdam and Amsterdam regions where there are also various specialised institutes (see Kloosterman 2010). Many architects operate on an international scale and are also involved in projects in China.

In total, sixty three interviews were conducted of which twenty seven in the automotive industry, twenty eight in the AEC industry and eight in other creative firms. The interviews each took between one and two hours and we followed a semi-

structured interview schedule focussing on the development process of cars respectively buildings or neighbourhoods (stages of the process; actors involved and their tasks; locations of activities; type of workers used); drivers and barriers for development; HR policy and training; linkages with universities, other firms and local and higher governments. We did not audiotape the interviews for confidentiality reasons, but notes were taken during and after the interviews. Additionally, all quotations have been made anonymous to protect the privacy of the interviewees.

The open character of the interviews gave rise to unexpected information and yielded important new insights. We cross-checked our results with the interviewees by sending them by e-mail a preliminary 'findings report' and analysing their comments on the understanding of the rationales and mechanisms involved in the analysed upgrading processes. Moreover, we triangulated and complemented the interview data with other secondary sources, like scientific publications, press releases, corporate reports, policy documents and information from multiple companies' websites.

A comparative case study based on interviews was chosen to investigate way of upgrading and drivers of various knowledge bases. Comparative studies make it possible to include many different entities, and thus could give insights in these entities via comparative analysis (Jensen and Rodgers, 2001). This article deals with different entities (e.g. regional vs. global; different actors; different stages in the development processes of new products; different industries) and thus a comparative analysis is suited to serve our goals. Case study research is a research method that deals with 'how' and 'why' questions about contemporary events over which the researcher has no control. Via case studies a researcher is able to cover contextual conditions (Yin, 1994) and to understand cause and effect relationships (Jensen and Rodgers, 2003) in real-life interventions that are too complex for a survey or experimental studies (Van Winden, 2003). There are many different variables and actors with own strategies which influence each other and can have different influences on regional upgrading. Comparative case study research is suited to give insights into this complex web of several actors, relations and variables and thus to serve our goal to get insights in the way of upgrading of different knowledge bases.

The automotive and AEC industries have been selected as case studies both are project based industries dealing with complex products which cannot be developed by one single actor alone.

Cars and buildings (or neighbourhoods) cannot be fully standardised and global concepts need to be adapted to local circumstances (such as regulations, market requirements, climate, etc) and thus require a global-local interaction between various stakeholders as well as between various knowledge bases. In order to give insights in the way of upgrading of different knowledge bases in both industries we interviewed engineers as well as designers and spoke with different project partners including lead architects, policy makers, university professors, CEOs and local managers of car assemblers, car suppliers and engineering firms and other industrial experts. Additionally, eight interviews were conducted with fashion designers and artists in order to increase our understanding of the development of the symbolic knowledge base in China. The automotive industry has been analysed in Shanghai as it is the largest automotive cluster in Shanghai with a rapid development that has had attention in a large number of other studies dealing with governance, policy, upgrading, learning and development in a global-local perspective (e.g.Liu and Dicken, 2006; Thun, 2006; Van Tuijl et al, 2011). In general, Shanghai is a modern fast growing and open city with many international linkages making it interesting to analyse urban development in a global-local perspective, especially in key projects like Pudong (e.g. Chen, 2007). This makes the city also suitable to analyse upgrading of different knowledge bases in the AEC industry. This industry is also analysed in Beijing, as the capital is considered as one of the global cities with the most architects (Knox and Taylor, 2005) and the proximity to the state government has some advantages for the development of architecture due to fast decision making, implementation of plans, access to financial resources and development of key projects for which foreign ‘starchitects’ have been invited (Van Tuijl and Van der Borg, 2011). This makes it interesting to study upgrading of different knowledge bases in a global-local perspective. In the next two sections, we analyse the upgrading mechanism and drivers and the spatial scale on which upgrading takes place for different knowledge bases in our case studies of the AEC respectively and automotive industry.

4 Upgrading knowledge bases in the architecture, engineering, and construction (AEC) industry

The architecture, engineering and construction (AEC) industry depends strongly on symbolic and synthetic knowledge bases. Especially for architecture symbolic knowledge is crucial in

competition which is largely based on high concept innovation (Kloosterman, 2008)[2]. As put forward by a Chinese director of a leading Dutch engineering and design company: "Design is decisive; we win competitions always on design." However, for the realisation of the final product, the synthetic knowledge base is at least as important: 'The architecture's concept must be made possible by a structural engineer' (McNeill, 2005a, p503).

The AEC industry is a project based industry which uses different firms in a temporary multidisciplinary project organisation in order to deliver custom built and unique products (Kamara et al, 2002). Architecture, the creative part of the industry, differs in several ways from other creative industries. First, the product is famous instead of the artists in a field where self publicity is not socially accepted. Second, unlike paintings and sculptures, the product is incredibly complex due to many actors involved in the design process (e.g. architects, engineers, clients and policy makers), customer requirements, and a long construction period (McNeil, 2005a). This is also dubbed by Larson (1993) as the 'heteronomy of the architecture profession' meaning that architects work on behalf of clients instead of being free artists. Clients are very diverse and dispersed, and as consequence, unlike other global operation service industries, like advertising, architecture firms do not follow clients by opening offices everywhere, but travel around. This is known as the phenomenon of the 'mobile architect who is constantly travelling to visit project sites and clients' (Faulconbridge, 2009, p2540)[3]. This is needed in order to communicate with clients and to put embedded global architecture in the local context (Faulconbridge, 2009). Even globally operating '*star*chitects' such as Foster or Koolhaas are restricted by local issues (McNeill, 2005a). Concepts, like skyscrapers, can be exported to other locations, but the design process is heavily influenced by contextual factors, like policy, climate, client requirements, culture and available resources (McNeill, 2005b): "Architecture is a skill which you can apply everywhere. There are houses in Greenland, the North Pole, Holland and Belgium. The difference is in laws and the

[2] It should be noted that only a part of the companies focus on innovation. Many other firms tend to compete on service or on price while innovation is low (Kloosterman, 2010).

[3] Note that is only true for specialised architecture firms. Architecture and engineering consultancy firms in contrast are highly globalised with offices all over the world. For instance, DHV Group has 73 offices in 21 countries and Arup has even over 90 offices across Europe, North America, Australia and Asia (company websites).

bureaucratic process. Also understanding of the local context is important; you have to know where the sun is and which is the shadow side" (Dutch architect). Another Dutch architect stated: "Take for instance the use of bricks. In Holland the use of bricks for indoor as well as outdoor walls is quite common; while the use of bricks in England is not done as it is associated with houses for the poor working class". Similarly, as noted by a Chinese architect about the concept of eco-cities: "All our projects are tailor-made products. There is a high dependency of local resources and the wishes of clients differ per case. Eco-cities can therefore not simply be copied from other places."

The complexity of the product, the need to put global concepts in local context and the interaction between local and global operating actors as well as the multidisciplinary and project based character of the AEC industry have impact on where innovation takes place, which actors are involved, and on upgrading as we show in this case.

Key requirements for upgrading are learning and knowledge management and transfer between different actors. Knowledge management in the AEC industry takes place on two levels, within individual firms (or firms networks) and between firms (Kamara et al, 2002) especially between firms in project organisations which is important for inter-organisational collaboration and learning (Love et al, 2004). As we have seen in section 2, upgrading can take place at different levels (e.g. Gereffi, 1999). We use these two levels - within firms and between firm - to analyse how upgrading differs for the synthetic and symbolic knowledge base. In addition, we discuss contextual factors that influence the way of upgrading in the AEC industry in China.

Upgrading within firms

There are two important ways on which upgrading can occur on firm level. First, both foreign based architecture companies in China as well as Chinese companies make use of multi cultural design teams in which Chinese architects learn to work in teams and to express their creativity. The Chinese cultural and educational system differs from western education systems and there is less attention to express creativity. As noted by a German principal architect: "The problem is the lack of own ideas. Chinese students are not trained to express own ideas. … We give them the opportunity to do this via brainstorming in project teams, although sometimes it remains difficult". Similarly, an Italian principal architect put forward: "In our office it is crucial to work together and to learn from each

other. This happens mainly via brainstorming in project teams aiming to get ideas. We try to increase creativity via various competing project teams".

Chinese firms also work with multicultural teams and hire foreign architects to bring new creativity and working methods. As expressed by a Chinese director of a construction company: "Many Chinese firms hire foreign architects to do joint projects. They are also using foreigners as teachers. Chinese project partners learn from foreign architects by continuously raising questions and by observation". It should be noted that foreign designers are also used by Chinese firms in order to win projects as many clients still prefer foreign architecture. According to an Italian principal architect: "It is so easy to get projects; only my face sells". An architect from another Italian studio noted: "We always visit clients with a team of foreigners and Chinese people. This is not because the Chinese cannot do the job, but because the client expects foreigners". The use of foreign architects in Chinese offices might also have a downside as the dependency of foreigners is often large. As an Austrian architect working for a leading Chinese architecture firm noted: "I do not want to be arrogant, but the fact that we won a major international competition in Canada is largely due to my work and some other foreign architects".

On the job training seems to be less relevant for architecture firms than for engineering firms. As expressed by a Chinese architect: "Training of architects is not so important. It is not a matter of good or bad architects, but they simply need to fit in your style". In a similar way a manager of a Chinese architecture engineering firm put forward: "The best moment to hire architects is when they leave university. In this stage, they are still fresh and have fresh ideas." He continued that this is a large contrast with engineers: "They <engineers> are, I would nearly say, useless when they have finished their study and are learning on the job. This is a long and expensive learning process, and therefore we want to keep the best engineers".

A second way in which upgrading in firms may occur is via the organisation of study trips abroad. Study trips are crucial to get inspiration from different places, to observe other styles and to meet future clients. As expressed by the vice director of a Chinese establishment of a Dutch architecture and engineering consultancy firm: "We always invite Chinese colleagues and clients to visit best practices in Holland. We show what is possible and explain how project planning

works". Similarly, an architect of a leading Chinese architecture firm expressed: "We want to do more projects in Europe. We want to learn from others and therefore we organise study trips to Berlin and places in Denmark".

Another major upgrading mechanism is labour mobility. Architecture, just like other creative industries is strongly project based and has a high job rotation (Vinodrai, 2006). This labour mobility is important for learning and as provider of new sources of inspiration (Kloosterman, 2010), and is thus crucial to gain symbolic knowledge. This labour mobility has a strong international character. Both foreign as well Chinese architecture studios work with international design teams to mix ideas. For instance, a major Chinese architect mentioned that nearly half of the employees is foreign which helps to get new inspiration and to win competitions abroad. Similarly, many foreign offices have Chinese architects in order to understand the local context: "We have one Chinese designer who is project leader of all our projects in China. She speaks the language and knows how to deal with Chinese clients" (Dutch architect). Many Chinese architects study and work or study abroad as "New Argonauts" (Saxenian, 2007) and return to their home country to work for Chinese offices or start their own business. Many successful Chinese architecture firms have principals who studied abroad.

Upgrading within specific projects

The dominant knowledge base, the actors involved and the way of upgrading differs per project stage. The first stage[4] concerns client orientation, in which architects meet clients and observe the building plot in order to get knowledge of the local context. These meetings need to be at the spot and the actors meet face-to-face to prevent miscommunication and for cultural reasons: "The largest risk of doing business in China is losing your face. Therefore, we meet clients and partners physically" (Italian principal architect).

The second stage is concept design, which can be done everywhere and 'designing at a distance' increasingly takes place (Faulconbridge, 2009; Munck, 2009). The knowledge

[4] The stages of the product development process in the AEC industry emerged out of our research data and inductive reasoning and are aligned with on the stages of the car design process (Van Tuijl and Carvalho, 2009).

base is mainly symbolic and observation is the crucial tool to get inspiration. Creativity stems from watching movies, browsing the internet, books and magazines, travelling around and observation of competitors, clients and other creative industries. As expressed by a Dutch architect: “We have antennas everywhere … It is a ‘profession madness’; we do not work from 9.00 hrs to 17.00 hrs”. Another Dutch architect noted: “Science fiction has become the heart of architecture. It combines science with fiction. I love it”. Similarly, as a representative of a Chinese architecture firm noted about the roof of a large museum: “The idea of architect X comes from a movie in which he saw a dome that protects against viruses”. According to an Italian principal architect: “Designers need to travel around to get inspiration and to see other cultures and trends.” Due to a relatively low level of creativity of Chinese architects and the high image of western architects, concept design has been mainly done by western architects while in further stages Chinese designers and architects play a main role as well: “Foreign designers are responsible for the brilliant idea; they make sure how the building looks like” (Director Chinese construction firm). Moreover, cost reasons do matter in the selection of the actors involved in different stages: “Foreign architects are often mainly selected in the concept stage. The fee of foreigners is too high for other stages” (architect Chinese institute). The only way upgrading may take place in this stage is via joint brainstorming in international project teams within firms as we have described earlier.

In further stages -schematic design, design development and city documentation- there is a continuously interplay between symbolic and synthetic knowledge bases. In the words of a Dutch architect: “We are real designers, but we also have enough technological knowledge; this is needed to communicate with consultants”. All actors, clients, policy makers, consultants, architects, engineers, meet each other in order to brainstorm and work out plans resulting in concrete construction drawings that are used as a manual in the construction stage. Foreign actors are obliged to work with local institutes by law: “We are forced to cooperate with Chinese partners to get licences. There are many different licences for different construction works, like buildings in the chemical industries, headquarters, bridges, etc. Therefore we have many local partners” (Chinese director of Dutch engineering consultancy firm).

Global ideas and local knowledge are brought together in projects. Mutual learning takes place via joint brainstorming

and via the exchange of documents and proposals by local institutes. Creative design and planning of large complex projects are often done by foreign companies, while engineering work and detail design are the work of Chinese experts. Chinese engineers and consultants have a large understanding of the local context and strong engineering facilities: “Local institutes, like Tongji University, have modern test labs with the newest technologies. I wish we had such facilities in Italy” (Italian principal architect). However, depending the characteristics of a project and requirements of the client, engineering work can also be done abroad. As put forward by a Dutch architect about a project dealing with a new hydraulic concept: “In this project we used a Dutch knowledge institute as it is widely accepted to have a Dutch water certificate. In other cases, we use local specialists to obtain the right certificates”

The final stage, the construction stage has nearly always be done by Chinese construction firms, although western firms still stay involved in the project until the final product is finished. During all stages, from concept design until construction, various foreign firms cooperate with local firms as it is obligated by law. Chinese policy makers use interaction between foreign and local firms as upgrading mode to learn new concepts and working methods. Moreover, local institutes that check proposals act as ‘gatekeepers’ between local and foreign firms by passing documents between the actors. Normally speaking, there are no intellectual property rights (IPRs) on architecture designs, this often leads to duplication of original works. Although many interview partners agree about tensions around duplications, some have a milder view:
“It is part of the game; it happens everywhere. It also happens at home <in Holland>.” (director of a Dutch architecture and engineering consultant). Many agree about the need of a duplication strategy to catch up quickly. However, a duplication strategy may lead to lower product upgrading as desired as often it is not possible to copy original works due to the lack of the same construction materials or financial restrictions. Moreover, a duplication strategy hinders development of creativity as it implies using standard solutions instead of creating new ones.

Contextual factors that influence upgrading
In addition to the issue of duplication, there are several other factors that may limit the extent of upgrading. There are especially many barriers that hinder the development of creativity and thus on upgrading symbolic knowledge. A major barrier is the development stage of the country. Economic

development has priority and design has been considered as a luxury product. Many clients have limited budgets, and need to focus on cost saving and choose for simple solutions instead of innovative architecture. For instance, as expressed by a Chinese architect: “For project X, we wanted to use the Gaudi style, but after several studies the client decided that the materials were too expensive. So, in the end other materials were chosen, and the plan changed from a unique to a regular building.” The focus on commercial values also influences the educational system as in many art studies, like architecture, the most attention has been paid to art business, instead of development of creativity. Remarkably, the focus on cost saving leads in some cases to downgrading of western firms, as many foreign designers are attracted to China, especially Shanghai, for market reasons. They need to adapt their behaviour to the wishes of the clients and need to focus more on business and commercial values instead of aesthetical values: “When we make concepts in Shanghai, the wishes of the user are central. Therefore, the first drawings are already in an advanced stage. This is a major difference from the start of our company in Venice, when we started with very abstract drawings” (Italian principal architect). Or to use the typology of Coxe et al, (1986; in Sklair, 2005), many firms change from ‘strong idea firms’ to ‘strong service firms’ and focus on business in the first place instead of delivering innovative architecture. Furthermore, time pressure hinders development of creativity: “We have a lack of time, although we need to travel around to see other cultures and trends. We need to change this. Maybe we can go to Japan as this is not so far” (Italian principal architect).

Besides cost saving, time pressure and client requirements in general are crucial in development of the product, not only in the early stages of the project, but also in later stages: “The investor can take all decisions and can revise concepts completely This is a major difference with Europe, where design is design. This is something where you keep your hands off” (director Chinese construction firm), and “Asia and Europe are two extreme worlds. In Europe, the client provides an extensive a thick package of papers with requirements in the client orientation stage. In China, the initial input from the client is limited, say one page. Other requirements in China are given in further stages. They change everything; in the end your idea is completely gone” (Austrian architect). Finally, local regulations may hinder upgrading. As expressed by an Italian principal architect: “See for instance the use of bamboo. In Italy it is allowed to use bamboo as construction materials and it has been tested intensively. In China, the use of bamboo

is still forbidden. Instead they use common steel constructions and add fake bamboo afterwards." Thus, regulations, budget restrictions and also risk averse behaviour of clients hinders upgrading in terms of the use of new methods and materials.

Upgrading knowledge bases in the AEC industry

From this case study, some major conclusions can be drawn regarding upgrading. First, due to the development stage of the country, upgrading is often limited to catch up to basic levels. So, innovation is often restricted to 'new to China', while 'new to the world' innovation has been done elsewhere. Second, due to project based character of the industry, a key mechanism for upgrading is joint brainstorming. This is true for both the firm level as well as for project level, and includes foreign actors as well as locals. Moreover, interaction between foreigners and Chinese has been stimulated by the government in the form of obliged cooperation between foreign architects and domestic institutes, of which the latter transfers codified knowledge among various Chinese players. The joint brainstorming includes a continuous interplay between the symbolic and the synthetic knowledge base. Only, the first stage of a project, the concept stage, mainly symbolic knowledge plays a role. This stage has largely done by foreign architects, while in China there are several barriers to develop symbolic knowledge. Chinese architects learn from their foreign colleagues via the mentioned brainstorming in project teams. Many architectural firms have both foreign as well as Chinese architects and labour mobility is a key mechanism for the development of symbolic knowledge. Synthetic knowledge development has for a large part been done by local actors, although for specific projects also foreign specialist can be used. *Upgrading knowledge bases in the automotive industry*

The development and upgrading process of the Chinese automotive industry, especially in the Shanghai region, has been widely discussed in literature. Many studies show the importance of the government structure that steers the development of the local automotive industry (e.g Thun, 2006); joint-ventures as vehicles for technological transfer and for technical and process learning (e.g. Depner and Bathelt, 2005; Dicken 2007); development of innovation systems (e.g. Gu et al, 2009; Van Tuijl et al, 2011), power relations between foreign multinationals and the Chinese government (Liu and Dicken, 2006). These and many other studies show strong product, process, and sometimes chain and functional upgrading as well, although often key investments and basic research is still concentrated in the home bases of foreign multinationals due to the fear of knowledge leakage. Many studies focus on technological upgrading, which is often very

much related with the synthetic knowledge base. Crucial for upgrading of the synthetic knowledge base is on the job training of Chinese engineers, which takes place in China as well as abroad. This is beneficial for the foreign firms- which provide the training- as well as for Chinese joint venture firms. On the long run, this effect is even larger due to labour mobility as many Chinese workers return to Chinese firms (Van Tuijl et al, 2011): “Especially state firms are popular employers nowadays. They can offer more than western firms: a higher salary and more job security. Backed by the state, these firms can simply offer more …” (Manager joint-venture firm).

In the automotive industry, learning in projects is crucial for both development of symbolic as well as for synthetic knowledge. This happens via interaction between foreign and Chinese actors and can be done in China or abroad, although more and more R&D activities have been done in China. In addition, regarding development of synthetic knowledge and technical upgrading, we have seen the importance of on-the-job training, while observation is a major mechanism to develop symbolic knowledge. Finally, regarding the symbolic knowledge the case also shows that the location of activities differs per type of design. Conceptual design, which has been done in an early stage of the development process of a new product, can be done on distance; it can be done by everybody at all places. In contrast, styling (or interior) design is strongly dependent on the Chinese context and is mainly done by Chinese designers. However, it should be noted that this is especially the case for car makers that use a regional adaptation strategy, such as GM and VW do. For car makers that follow a global car strategy, adaptation to the local context is only minimal and styling design has been done by global design centre (Van Tuijl and Carvalho, 2009).

In general, literature also stresses a number of limits to the extent of upgrading. Despite high investments in R&D, strict government policies for technology transfer and a quick development of a pool of engineers, results of these efforts are still unclear (Altenburg et al, 2006). In addition, it might be questionable whether foreign companies invest in R&D and education to fulfil government regulations or as a strategic investment to improve the knowledge bases in China, as many companies still fear knowledge leakage (Depner and Bathelt, 2005; Van Tuijl et al, 2011). As an interviewee noted: “I remember that Chinese employees of VW were sent to Germany for training, but without result. They had the feeling that they went on holiday” (industrial expert). Moreover, tensions about

designs and IPR's between Chinese and western car (part) makers hinder upgrading: "A major problem for Chinese firms is the high costs of IPR's. Chinese firms are still very much dependent on western firms" (university professor). Tensions about design hinder especially development of the symbolic knowledge base, which can often not be protected by IPR's.

Less attention has been shown to upgrading of different types of knowledge. We analyse this via investigation of different project stages for the development of new product. In the stages, we analyse which knowledge base are relevant, where it has been done (China or abroad), which actors are involved, their tasks and the extend upgrading is possible. It is not possible to generalise our findings as it depends on the strategy of the individual car maker whether cars are completely designed for a specific market or a global car concept has been used in all markets with only limited adaptations to fulfil country specific regulations and conditions (such as roads and climate).

Upgrading within projects

The first stages of the car design process- pre-design stage and concept design- are dominated by the symbolic knowledge base (see also Van Tuijl and Carvalho, 2009), aiming to get inspiration for new car models and the development of the first drafts. Observation and joint brainstorming are the main mechanisms to get inspiration. As put forward by a manager from SAIC-GM: "We see what competitors do, we need to beat them." Similarly, the director of a SAIC research centre expressed: "We get inspiration from watching competitors and brainstorming in the team."

The location of these first stages, as well as the responsible actors and the way of upgrading differs per case. SAIC-GM organises internal competitions in which Chinese design teams compete with western teams. Based on government regulations and specifications given by the company, the teams deliver proposals in order to continue the project. In some cases, concept design has even been sourced out to specialised design firms. So, concept design by SAIC-GM can be done abroad or in China, and can be done by foreign, Chinese or by mixed design teams. Similarly, SAIC Motor Technical Centre has many foreign employees which jointly work on new concepts with Chinese colleagues. Also SMA, another Chinese car maker, hires western designers to increase the level of creativity of the firm and to learn how to design cars. Hence, working in mixed project team seems to be a major mode to learn new styles. In other cases, Chinese designers seem to

have a smaller role in the design: “The Chinese have no influence to adapt design; we need to keep the Ford DNA” (former engineer of Ford Trucks). Supplier Delphi works on rough concepts in its home base in the USA, while further development takes place in China. Spanish part supplier Ficosa has a similar strategy (Van Tuijl et al, 2011).

In later stages of the car design process, in which designers continuously interact with engineers, the synthetic knowledge base gains importance (Van Tuijl and Carvalho, 2009). Again, many of these stages can be done largely abroad (e.g. 95% of the engineering work of the SAIC-GM 18 model was done in Germany, see Van Tuijl et al, 2011) or in China. In both cases, the work has been done by mixed project teams in which foreigners come to China or Chinese engineers are sent abroad to work on projects and to do engineering and management courses. So, learning in project teams seems to be a major mode for upgrading the synthetic knowledge base as well. Notable is that although many activities can be done abroad as well as in China, China gains importance in R&D activities, due to pressure of the government, rising competition for the Chinese market and increasing variety in demand. This is witnessed by strategic investments of western car makers in R&D and design facilities. For instance, VW opened a design centre in Shanghai after the entrance of GM in China in 1997 (Liu and Dicken, 2006), and more recently, GM has opened a new basic research centre and invested in a strategic partnership with a local university (Van Tuijl et al, 2011). Finally, it is worth mentioning that styling design, mainly relying on symbolic knowledge, has as a strong domestic character due to dependency on Chinese consumer tastes: “All Chinese Buick models are styled by Chinese designers” (Manager SAIC). In this design work, western designers can also learn from their Chinese colleagues.

5. Upgrading and knowledge bases. A synthesis.

The principal results that were obtained in our empirical analysis are summarised in table 2 which shows the way of upgrading and the location (or geography) of activities of the two analysed knowledge bases. Despite large differences between the two industries in terms of among others the governance and organisational structure (e.g. hierarchical chain for automotive and project structure for AEC), the upgrading processes of the both knowledge industries and the location of activities show several similarities. Regarding upgrading of the symbolic knowledge base, in both cases we

have seen the importance of joint-brainstorming between Chinese and western designers in project teams in companies as well as between companies. This joint process is strengthened by government regulations which oblige foreign entrants to cooperate with domestic firms. Another similarity between cases is the importance of observation as a tool to develop new creativity.

Many different objects can function as source for inspiration, including competitors, clients, employees, other creative industries and surroundings and (multi) media. So, in this sense, especially concept design, in early project stages, may be seen as highly global and can be done everywhere and 'designing at a distance' increasingly takes place (Faulconbridge, 2009). However, it also favours the importance of large urban centres as location to catch 'buzz' (Storper and Venables, 2004) as downtown locations offer the right surrounding of a high concentration of activities and actors that can 'feed the creative input'. E.g. it is possible to observe life on the street and to follow competitors, clients/consumers and other creative people. Once the first idea (concept) has been developed, it can be developed further at other locations.

Table 2: Upgrading of the symbolic and synthetic knowledge bases

	Symbolic KB	Synthetic KB
Upgrading mechanism	Joint brainstorming in and between firms (AEC and Automotive) Labour mobility (AEC) Obligated cooperation (AEC and automotive) Observation crucial to learn new styles (AEC and automotive)	Inter-company training programmes (automotive and AEC) Labour mobility on long run (automotive) Technology transfer (automotive)
Geography of activities	Inspiration and concept design global, but importance of large	Engineering and testing work are mostly done in China, although

	urban centres to catch ‘buzz’ (AEC and automotive) Input local and need for face-to-face interaction with clients, other firms and authorities (AEC) Detail design (AEC) and styling design (Automotive) local	highly specific testing can also be done abroad (AEC) Engineering can be done abroad, but is increasingly done in China for market reasons and governmental pressure (automotive)
Upgrading barriers	Foreigners used as promotion tool (AEC) Design is a luxury product (AEC) Tensions between foreign and Chinese firms about duplication of designs (AEC and automotive) Educational system (AEC)	Risk knowledge leakage (automotive)

In later project stages, development of creative knowledge is strongly dependent on the ‘local’ (Chinese) context. Therefore, detail design in the AEC industry and styling design in the automotive industry is often done by Chinese actors who have more experience and understanding of local factors. Especially in the AEC industry, face-to-face interaction with clients, other firms and governments is important to gain insights in local factors. Thus it is important to put global (concept) architecture in the local context (Falcounbridge, 2009).

Another major upgrading mechanism is labour mobility. We have observed this mechanism in especially in the AEC industry, but it is very likely also relevant for car designers. Creative industries are strongly characterised by project work

and many professionals move from job to job and from project to project. This job circulation is a major source of transfer knowledge and creativity (Vinodrai, 2006). Many Chinese as well as foreign architecture firms work with international design teams in order to mix different styles and hire new architects in order to get new inspiration. So, labour mobility between architecture studios is crucial for learning as well as a new source of inspiration (Kloosterman, 2010) and is thus crucial for the development of symbolic knowledge.

In both cases, we have also seen the importance of foreign designers who bring new styles, although it might be questionable to what extent ideas have been created jointly or mainly by foreign designers. Moreover, tensions about duplication of original designs may hinder development of symbolic knowledge as a duplication strategy implies using standard concepts instead of creating new ones. Other possible upgrading barriers for development of symbolic knowledge, we which have especially seen in the AEC industry, include the development stage of country (design is a luxury good), the education system (often the focus is on commercial instead of aesthetical values) and the fact that in some cases foreign designers are used as a 'promotion tool' by Chinese architecture offices. They do this to win competitions, and in many cases it may be questionable whether Chinese architects learn new styles and/or other ways of working.

Regarding upgrading of the synthetic knowledge base, we have observed the importance of inter-company training programmes in both industries. Engineering consultants as well as car makers and their suppliers provide on the job training in order to learn new (western) engineering techniques and to use modern equipment. Training has been done in China as well as abroad. Besides, in the automotive industry we have seen technology transfer programmes (often part of government deals) and labour mobility on the long term as major upgrading mechanism. The latter case refers to Chinese engineers who worked for foreign (joint-venture) firms and return to Chinese firms and bring their obtained skills (Van Tuijl et al, 2011).

The geography of the synthetic knowledge base seems to differ in both cases, although this changes quickly as China gains importance as an engineering hub. In the AEC industry, most of the engineering and testing work has been done by Chinese experts who have a large understanding of the Chinese context and are seen as reliable partners for many clients. Only for specific projects clients request for foreign certification. In the automotive industry, many testing and engineering activities

can be done abroad, also because of the risk of knowledge leakage. However, due to rising competition, governmental regulations and increasing variety in demand, many car makers and suppliers invest in engineering centres in China in order to make specific cars for the Chinese market.

Finally, in both cases we have seen that in many project stages, project teams consists of different disciplines that jointly develop 'new' products. So, there is a continuous interaction between the synthetic and symbolic knowledge base. It should be noted that the character of the project teams differs between the two industries. Many car makers often work with internal project teams, sometimes supported with researchers from universities, suppliers or other car makers. The AEC industry, in contrast, works with many external project teams, including architecture firms, engineering consultants, construction firms and clients.

6. Some conclusions

The Chinese economy has grown very rapidly over the last decade. Moreover, the country has a strong ambition to change from made in China to designed and developed in China, i.e. to upgrade its economy. However, the way of upgrading differs per industry. This article gives insights in these differences by linking the concept of upgrading with knowledge bases. We argue that differences in knowledge bases are dependent for the way of upgrading, i.e. we analyse how upgrading takes place regarding different knowledge bases.
We have supported our argument empirically by analysing the process of upgrading in two industries in China: the AEC industry (in Beijing and Shanghai) and the automotive industry (in Shanghai). In both cases, we have focused on upgrading of two knowledge bases - symbolic and synthetic – on two levels: within firms and within projects. We have analysed how upgrading of these two knowledge bases takes place, and have paid attention to possible barriers that may hinder upgrading of these two knowledge bases. Moreover, we have given insights in the spatial scale on which upgrading takes place for these knowledge bases.

The cases show that joint brainstorming between western and foreign designers in internal and external project teams is a major mode to develop symbolic knowledge. In addition, both cases show the importance of observation as tool to develop new creativity. The results of the AEC case has also made clear the importance of labour mobility for upgrading the symbolic

knowledge base. The barriers which may limit upgrading of symbolic knowledge include: the development stage of China, the Chinese educational system and tensions about duplication of western designs. Regarding upgrading of synthetic knowledge we have seen that inter-company training programmes of foreign (joint-venture) firms, technology transfer and labour mobility on the long run are the major upgrading modes. A possible barrier for upgrading synthetic knowledge, especially in the automotive industry, is that foreign firms tend to keep certain engineering activities in their home base because of the risk of knowledge leakage. However, this changes quickly as many foreign car makers and their suppliers invest in engineering centres in China due to an increase in variety in demand, governmental regulations and increasing competition. In the AEC industry, most of the engineering work has been done by Chinese experts as they have a large understanding of the Chinese context; only for specific projects clients ask for certification by foreign experts. The geography of the symbolic knowledge base differs per project stage. Concept design, done in an early stage of projects, can be done 'everywhere', and is often done in large urban centres which often offer a good surrounding to 'feed the creative input' due to a high concentration of clients, competitors and other (creative) industries. Styling design and detail design, done in later project stages, are very much dependent on the 'local' context and is therefore often done by Chinese designers. Finally, in both cases we have seen that in many project stages there is a continuous interaction between symbolic and synthetic knowledge.

As this is only a first attempt to link knowledge bases with upgrading, further research and conceptualisation is desired. First, as we have focused on the symbolic and synthetic knowledge bases only, there is a need to give insights in the way of upgrading of the analytical knowledge base. This means to do more research in other, more science based, industries. Moreover, as China is a specific case with a powerful government that can set upgrading criteria (e.g. Liu and Dicken, 2006), it would be interesting to analyse the way of upgrading of different knowledge bases in countries with a less powerful state, such as in Eastern-Europe. Finally, our research has given quantitative evidence for the importance of international labour mobility and foreign education for upgrading. It would be interesting to collect quantitative evidence for role of these 'New Argonauts' (Saxenian, 2007) in upgrading. This could be done by tracing international career paths via a survey. Vinodrai (2006) has used a similar method for tracing career paths of designers in a cluster in Montreal.

How are these paths in an international perspective? To what extent are there differences in these career paths taking into account different knowledge bases?

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