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The Transnational Dimension of Innovation in China

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Background Papers-Reihe des Kompetenznetzes „Regieren in China: Voraussetzungen, Beschränkungen und Potenziale politischer Anpassungs- und Innovationsfähigkeit im 21. Jahrhundert“

Das vom Bundesministerium für Bildung und Forschung geförderte Kompetenznetz „Regieren in China“ setzt sich zum Ziel, die Voraussetzungen, Erfolge und Grenzen der Anpassungs- und Innovationsfähigkeit von Institutionen, Verfahren und Inhalten des Regierens in China zu erforschen. Im Einzelnen geht es dabei um Fragen der Funktionsweise und Kapazität des Staates sowie der (Re-) Produktion von Regimelegitimität, die sich nicht nur auf der zentralstaatlichen, sondern auch auf der lokalen Ebene stellen.

Weitere Fragekomplexe sind die Beziehungen des Staates zur Wirtschaft (Aufbau eines Regulierungsstaates) und zur Gesellschaft (Entstehen einer Zivilgesellschaft, Integration neuer sozialer Gruppen und Schichten, Umgang mit Protestbewegungen) vor dem Hintergrund rasanter wirtschaftlicher und sozialer Modernisierung. Diese Fragen werden seit einigen Jahren in Bezug zueinander gesetzt und verdichten sich zu einem größeren Forschungszusammenhang hinsichtlich der Wirkungen ökonomischen, sozialen und institutionellen Wandels auf Verfahrens- und Organisationsmuster, die kennzeichnend für die Praxis des Regierens auf den verschiedenen Ebenen des politischen Systems der VR China sind.

Dieses Forschungsprogramm verlangt nach interdisziplinärer Kooperation, der Verwendung verschiedener Ansätze und Theorien sowie einer Verbindung von makro- und mikropolitischen Perspektiven.

In der vorliegenden *Background Papers*-Reihe werden zwischenzeitliche Bestandsaufnahmen und Forschungsergebnisse der Einzelprojekte in allgemeinverständlicher Form für eine breitere Öffentlichkeit sowie Interessierte aus Politik und Medien aufbereitet. Das Ziel ist es hierbei, die engen Grenzen der innerfachlichen Kommunikation zu überwinden und einen Beitrag zur gesamtgesellschaftlichen Debatte über Chinas wachsende Bedeutung in der Welt zu leisten.

Background Paper No.2/2013:

The Transnational Dimension of Innovation in China [Discussion Paper]

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The Transnational Dimension of Innovation in China

[Discussion Paper]

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The Transnational Dimension of Innovation in China

Abstract

Advances in Chinese innovative capacity are characterized by two major features: (1) Chinese high-tech industries remain highly dependent on transfers from foreign MNCs, while the majority of China's high-tech exports are still brought about by foreign firms. (2) The innovative capabilities of Chinese provinces are increasingly diverging, with some developing extremely fast and others not advancing at all. While the widely used national innovation system (NIS) approach is well-suited to analysing large-scale, national level policies and programmes, the Chinese case necessitates a complementary perspective that includes the transnational and the regional dimensions of technological innovativeness. Therefore, this paper reviews recent approaches in the study of technological development that focus on innovation in its regional *and* transnational *contexts. It addresses the intersections in the analysis of transnational R&D and regional innovation systems (RIS). And it stresses the role of public policy and regional context in promoting innovative capabilities.*

Contents

1. Introduction

China's innovation landscape is in motion. The tremendous growth of the Chinese economy over the last twenty years has been accompanied by great change in China's industrial set-up. Instead of merely serving as the low-wage assembly line for products innovated elsewhere, more and more Chinese firms have moved into high-tech sectors, engaging in high-tech and knowledge-intensive activities. In 2012, China's global share of high-tech commodities by production value was nearly one fifth. China has increased its investment in science and technology by about 10% a year, even during the global recession (Ernst 2011: 5). For over ten years, China has ranked second in its total number of researchers, ahead of Japan, and second only to the United States (OECD 2007: 23). The Chinese government's innovation policy initiatives, most prominently the "Medium and Long-term National Plan for Science and Technology Development", demonstrate the government's determination to turn China into a world leader in the field of high-tech innovation. Due to its increasing capacities in knowledge-intensive services, China has become an attractive destination for innovation off-shoring. In 2012, there were as many off-shore R&D operations of U.S. firms being conducted in China as there were across the whole of Europe (Atkinson 2012:7). In product development especially, no other country receives as many off-shore contracts assignments as China, with a share of 44% of the global total (Lewin, Massini Peeters 2009: 910).

These generally positive developments are contrasted by two deficiencies: Firstly, China's dependency on foreign technology and knowledge inputs remains strong. Although Chinese high-tech exports are increasing, 88% of high-tech exports are brought about by foreign firms operating in China, including joint ventures (OECD 2007: 15). Chinese high-tech industries are significantly less involved in R&D activities than those in advanced OECD countries (Yang, Hui 2012: 1). Consequently, foreign-invested R&D is an important factor in China's innovation landscape and interaction with foreign high-tech MNEs is a primary source of knowledge for many Chinese firms. Secondly, the innovative capabilities of China's provinces are increasingly diverging. While industrial clusters in some regions are developing at breakneck speed, others are lagging behind and do not seem to draw any profit from national level innovation strategies or foreign R&D spillovers. Furthermore, even those coastal provinces that are on the track to becoming innovative hotspots seem to be pursuing their own innovation strategies beyond the central government's planning. Although the national innovation system (NIS) framework has contributed a great deal to the understanding of innovation activities, it has analytical limitations. While it is well-suited to analysing large-scale, national-level innovation

policy initiatives and programmes, it is precisely the transnational and the regional dimension of innovation that are beyond the scope of the national innovation system approach.

The purpose of this paper is to present and bring together recent research approaches in the study of technological innovation and innovativeness in China that depart from the well-established 'classical' NIS framework and that focus on innovation in its transnational and regional context. A common and well-tested framework for the analysis of innovativeness of regions is the regional innovation system (RIS) which applies NIS instruments to individual regions and provinces, in careful consideration of its local authorities, institutions and its geographic and demographic context. As for transnational R&D, several distinct concepts and frameworks have evolved. This paper will discuss transnational value chains (TVCs), transnational production and innovation networks (TPNs/TINs) and the research undertaken on the recent phenomena of innovation and R&D off-shoring.

The paper will first recapitulate the origins of innovation research in China and shortly discuss the NIS framework. The main part of the paper will focus on those frameworks that deal with the transnational and regional dimension of innovation. The third part of the paper will discuss the points of contact that exist between these two views. Furthermore, the role of regional, political and institutional conditions in these transnational frameworks will be discussed.

2. Early Approaches in Innovation Studies

The dynamics behind technological innovation have been the object of academic research for more than a century. In Schumpeterian thought, the driving force behind innovation was the firm, led by entrepreneurs who initiate and import new technologies, which superseded the technology that had previously been in place. In the following decades, the views held by politicians and researchers on innovation processes changed several times. For a long time, technological innovation was believed to be the result of a linear process. This process starts with basic research not directly connected with commercial interests or industrial applicability and thus often conducted at universities and public research institutions. Building on the insights gained in this basic research, firms would employ their in-house R&D facilities to develop new technological products. The implication for governments and researchers was that innovation processes could be supported and perhaps accelerated through the increase of basic research (Martin 2010; Godin 2005).

In 1961, Burns and Stalker's "The Management of Innovation" challenged this understanding of innovation, arguing that innovativeness is dependent on the organizational

structure of the firm, which can be either mechanistic, building on rigid hierarchies, or organic, allowing employees to exchange knowledge and experience (Burns and Stalkers 1961: 104-108). Other authors disagreed with the notion of a dichotomy of research activities and asserted that innovations result from interactions and knowledge flows between economic sectors, performers and users of innovation (Godin 2005: 35). This discourse on the very nature of innovation had two fundamental effects on innovation policy and practice. Firstly, Burns and Stalker's book established "innovation management" as a sub-discipline of business administration. Innovation management pursued the routinization of innovation and an increase in the efficiency of R&D activities by optimising a firm's organisational structures and by closely attuning research and development to market trends. Secondly, from the 1960s onwards, additional variables were included in the theory of innovation. Recognising the influence of market demand on specific products in the innovation activities of firms, the "demand-pull" was accepted as a decisive factor equivalent to the "science-push" of the 1950s and '60s.

After the economic crises of the 1970s, the understanding of innovation changed radically. The incipient fierce competition between many countries that had recently opened up to market-capitalism, the emergence of the first so-called knowledge economies and the heavily constrained government support on research led to a new way in which firms approached innovation, involving interactive engagement with final users and the implementation of new forms of innovation management, such as customer surveys, technology foresight and targeted concentration of funding (Martin 2010: 29-31). In contrast to earlier opinions, the notion that technological innovation is the result of complex interaction between research performers and users implied that innovation cannot be simply 'performed' by any single actor or 'decreed' by a government.

3. An Established Concept: The National Innovation System

3.1. An Outline of the NIS framework

The development of the national innovation system (NIS) approach in the early 1980s heralded the definite end of linear, monocausal frameworks. It does not focus on single variables; instead it seeks to bring together all actors and institutions involved in innovation processes – including a country's government and authorities, legal and social conditions, educational systems as well as universities, research institutes and firms – into one system of many interdependent and interacting variables (Lundvall 2009: 2-5). There have been many

definitions of NIS, although there is little variation between them. Dieter Ernst defines the NIS as "…the institutions (the rules of the game) and the organisations that systematically interact with and have an effect on the creation and diffusion of innovations in any economic system." (Ernst 2002: 499). Apart from their complex nature, national innovation systems are characterised by their openness. Innovation systems do not function independently from other NIS and inter- and transnational economic activities (Welsch 2005: 68-69).

With regard to their components, the units of an NIS, researchers conceptualised a 'narrower' and a 'broader' perspective on the NIS. In the narrow perspective, innovation systems only include those organisations that are directly involved in the generation of knowledge, such as R&D departments, universities, research labs and national innovation policy-making organisations. In the broader sense, innovation systems include any and all those organizations and institutions that have an impact on the production of innovations, such as social institutions, macroeconomic regulation, the financial, educational systems, as well as physical and communication infrastructure (Lundvall 2010: 2-3).

3.2. Applicability to China – Strengths and Weaknesses

It should be considered an achievement that the first scholars to analyse innovation processes from a systemic perspective moved away from monocausal models. The NIS approach was the first to boast a complex understanding of innovation and to apply a broader perspective on the independent variables. Innovativeness is explained through a holistic approach taking into account both institutional and organisational factors that may affect technological upgrading. The framework ascribes organisations and firms the ability to foster technological and innovative capabilities through cross-organisational interaction, and recognises that the state may steer and support innovation processes by creating favourable framework conditions, allocating resources and directly coordinating research activities (Ernst 2002: 499). In a study on the Chinese national innovation system, Liu Xiaolin (2009) demonstrates the extent to which NIS is useful in analysing large-scale change in a country's innovation landscape. Working from national figures of the country's GERD, FDIs, university funding, LME numbers, and the budgets for China's large national-level science and technology programmes, he measures the rise in China's national innovative capabilities. Other NIS studies have focused on the role of institutions (i.e. Eun 2009; Suttmeier, Cao, Simon 2006) or analysed the Chinese NIS in comparison to those of other countries (Conlé, Wogart 2008).

The NIS does have some analytical weaknesses. One of them is directly linked to its strength of being highly inclusive about its variables: By embracing the totality of all factors that might

possibly or impossibly, directly or indirectly, in some way or another, have a greater or lesser influence on a national economy's innovative capability, the NIS concept runs the risk of losing its analytical sharpness. Of course it would bear no valuable results to move back to pre-NIS models and focus on single variables, but it is fair to recognise that some variables of an NIS are simply of greater importance than others.

Another weak point lies in the NIS's scale. National figures and statistics can be misleading, especially in context of a country of equivalent size and twice the population of Europe. China's provinces and regions show great variation between one another in terms of innovative capabilities and output, and also regarding their innovation strategies and S&T policies (Kroll, Conlé, Schüller 2008: 177-178; OECD 2007: 25-26), which is not at all atypical for emerging economies.

NIS research on developing countries and emerging economies has shown that their innovation systems share a number of features. Innovation processes in developing countries follow different patterns from in industrialised countries. The majority of firms do not have the capacities or facilities to conduct their own R&D. Hence, much of the innovation taking place in Chinese firms is of incremental nature; technological development often involves the absorption of foreign technologies (Pietrobelli, Rabellotti 2009: 217). As a result, knowledge inflows from industrialised countries and cross-national inter-firm connections are very important factors for China's industrial upgrading. The relevance of foreign technology inputs and transnational inter-firm linkages, not just for single firms but in fact for entire regions (cf. Fu 2008; Yang, Hui 2012) is not given sufficient attention to as part of the national innovation system (Pietrobelli, Rabellotti 2009: 214; Ernst 2002: 499-500).

4. The Transnational Dimension of Innovation in China

Since the 1990s, the study of innovation has been approached from a different angle. Economists, sociologists, geographers and political scientists began to focus on the performers of innovation themselves instead of their systemic framework conditions. Several approaches were developed around the analysis of foreign-invested firms, multinational corporations and, most importantly, the transnational dimension of innovation.

This chapter will deal with the series of analytical concepts that do not follow the systemic approach but instead focus on transnational R&D in China, discussing the following three main concepts. In the following pages, three main concepts will be discussed:

(1) transnational value chains (TVCs)
(2) transnational production and innovation networks (TPNs and TINs)
(3) innovation offshoring

These approaches share the view that performers of innovation should be treated less as the units of a nationally or regionally confined system, but as parts of networks and chains that reach beyond national and regional borders. Innovation is regarded as a stage in the value chain, inseparable from the production processes they initiate. Whether a firm needs or aspires to be innovative or not depends on its position in its respective value-added chain or transnational network.

This emphasis on the transnational dimension of innovation responds to (a) the importance that many sources, even in IS literature, ascribe to the role of foreign-invested R&D and multinational corporations in China, (OECD 2008; Breznitz, Murphree 2011:106f) which is not sufficiently covered by NIS literature and (b) overcomes the analytical shortcomings of the systemic approaches, which often lapse into description of China's entire socio-economic and political institutional set-up.

These transnational approaches build on the fact that of innovation is mainly performed by trans- and multinational corporations (TNCs, MNCs), along with a few highly innovative small and medium enterprises (SMEs) and so-called "born-global" enterprises (Boutellier, Gassmann, von Zedtwitz 2009:3). Foreign-invested enterprises and multinational corporations, most sources agree, are the main performers and the crucial driving force behind economically relevant R&D (OECD 2007; Breznitz, Murphree 2011:106f).

Many papers discussing these transnationally-oriented approaches continue to use the original terminology, referring to 'global value chains' and 'global production networks', although the term 'transnational' is analytically more appropriate. There may have been several reasons for using the term 'global', such as enhanced comprehensibility, or the attempt to avoid a word with too strong socio-scientific connotations. In the case of 'global' production networks, the terms 'international' and 'transnational' were deliberately avoided at the expense of analytical sharpness because they derive from state-centric discourses. Considering that few processes are truly 'global' and that the conventional terminology creates analytical surplus, this paper will refer to these concepts as 'transnational' value chains and production networks.

4.1 Transnational Value Chains

The basic argument of the transnational value chain approach is that international trade and transnational interaction of firms can be understood in terms of value-added chains that span across regional and national boundaries. In many ways, these transnational value chains work just as Porter's value added chains – they include all processes and activities that contribute to the conception, making, marketing and distribution of products. Relevant to innovation studies, however, is that value chains serve as channels of communication through which knowledge, technology, ideas and capital – in short, everything that is technically needed for an enterprise to bring forth innovations – is transferred from one firm to another and possibly from an industrialised to a developing economy. Thus, a value-added chain that spans across national borders can serve as a transnational trajectory of knowledge.

The transnational value chain approach, more commonly referred to as 'global' value chains (GVC), was developed by an interdisciplinary group of predominantly American scientists in the 1990s. The initial framework of "global commodity chains" (GCC), developed by the sociologist Gary Gereffi, focussed on the global organization patterns of firms and did not take knowledge exchange into consideration at this stage. The primary objective was to analyse the social implications of value-added chains on a transnational level. The assessment of power asymmetries and hierarchic constellations between firms showed that some firms are in a position to exercise control over the activities of other firms in the same chain. This control can run in both directions: large retailers and branded manufacturers tend to control the production processes of their supply chain ("buyer-driven value chains"), whereas large transnational manufacturers, especially in technology-intensive industries such as electronics, have the potential to 'govern' the chain from the producer's side ("producer-driven value chain") (Kaplinsky, Morris 2000: 36).

By the late 1990s and early 2000s the commodity chain concept had been continuously improved and augmented into the transnational or 'global' value chains (TVC) approach. The TVC framework aims to unravel the forms of the integration into transnational value chains, their nature and content and the ways in which firms integrated into TVCs can improve their position in global markets (Kaplinsky, Morris 2000; Gereffi, Humphrey, Sturgeon 2006).

4.1.1 Governance of Transnational Value Chains and Knowledge Transfer

The most central component of the TVC framework is the 'governance' of transnational value chains, and not just with regard to innovativeness and knowledge. Gereffi's first findings on commodity chains had already established that governance in value chains is directional.

Humphrey and Schmitz (2001) acknowledged that inter-firm governance does not just set parameters such as production processes, quality standards, time frames, quantity and price but also about upgrading and knowledge. They conceptualised the important role of lead firms – large, influential firms, often from developed economies, that actively exert influence on other firms upstream and downstream in value chains. Lead firms put their local producers under constant pressure by incessantly demanding high production rates and steady quality while also striving for cost reductions at all ends. At the same time, suppliers can profit from joining value chains involving lead firms because they provide knowledge, technical advice and sometimes even equipment and thus contribute to local innovativeness. To local suppliers, engagement in a value chain with a lead firm is both challenging and rewarding, as it can help them increase their production capacities quickly (Humphrey, Schmitz 2001).

Gereffi et al. (2005) laid out a fivefold typology of forms of value chain governance that ranged from market-based inter-firm relations in which all parties meet on an equal footing to vertically integrated hierarchies, in which the dominant firms exerts direct control over other units in the value chain. Searching for an operational theory capable of predicting the most likely type of value chain governance to arise under given circumstances, the researchers identified three dichotomous key variables, each combination of which corresponds to a distinct governance type. These key variables were (1) the complexity of transactions taking place in the chain, (2) the codifiability of these transactions and (3) the technological capabilities of the supply-base. Fig. 1 shows the possible configurations of these variables and the corresponding types of chain governance. Since 2003, when the first working paper for the 2005 article by Gereffi, Humphrey and Sturgeon was published, this typology has been used in numerous studies in various regional contexts (e.g. UNIDO 2004; Humphrey und Schmitz 2004; Sturgeon 2008; Pietrobelli, Rabellotti 2009, 2011).

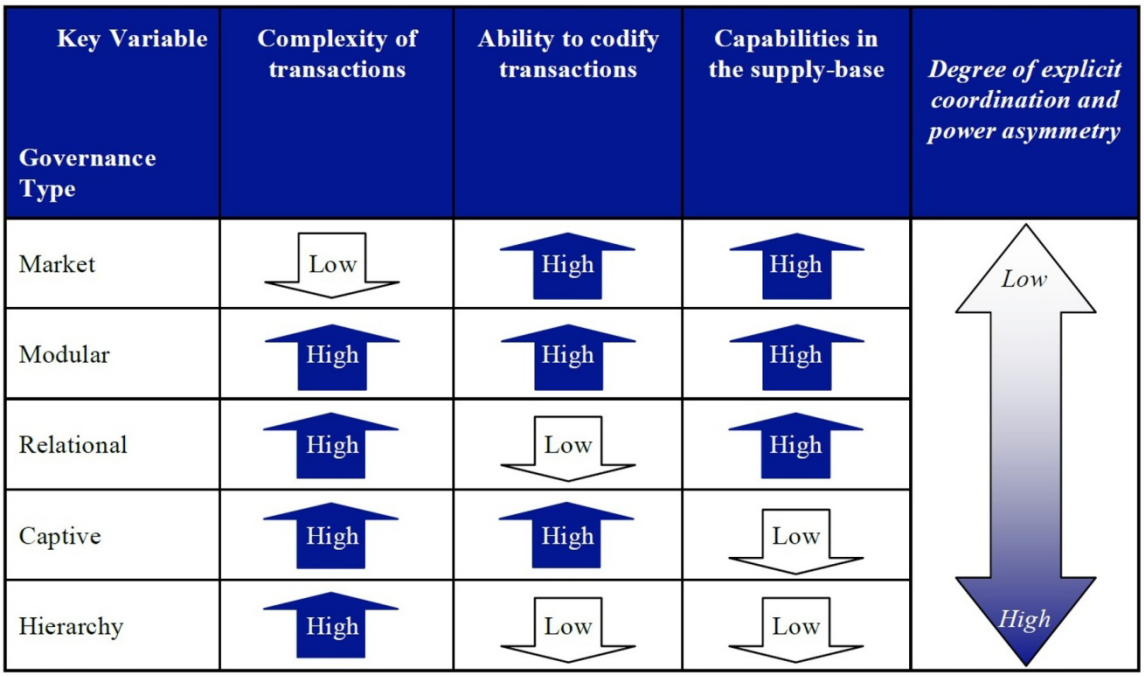

Figure 1: Types of governance in transnational value chains (Gereffi, Humphrey, Sturgeon 2005, as adapted by Dicken 2007)

It is through the achievements of Italian researchers Carlo Pietrobelli and Roberta Rabellotti that this TVC governance theory could be operationalized in innovation studies (Pietrobelli, Rabellotti 2009; 2011). The researchers argue that each governance type corresponds to specific patterns of knowledge transfer, as summarized in the following paragraph (ibid ad 223-223).

(1) Market-based value chains emerge when the transactions are not very complex and easily codifiable and when suppliers are highly competent. Given that the trading of finished goods in market-based chains takes place without much need for monitoring or control, the most likely form of knowledge spill-over is the simple imitation of products. Additionally, small suppliers acquire knowledge through adaption to consumer preferences and international standards.

(2) Modular chains are marked by highly complex transactions that are codified through codifications and standards. They emerge when highly competent and well-equipped suppliers produce custom components or modules for their buyers. In these first two types of value chain governance, the power asymmetry and the degree of explicit coordination between the interacting firms are at their lowest. In modular chains, knowledge is transferred through the standards and technical codes used to codify, and thus reduce the complexity of, transactions.

(3) In relational chains, competent suppliers and buyers exchange complex information that requires significant communication and ongoing adjustment. In these value chains, interacting partners profit from long-term engagement, which facilitates mutual upgrading and learning. The longer two firms are engaged in a relational chain, the more cost-efficient the cooperation becomes; switching to a new partner may be cost-intensive and time-consuming. The extent of hierarchic coordination in relational value chains depends very much on the specific case.

(4) In captive value chains, low-capability suppliers engage in complex transactions with large, dominant buyers. Since the suppliers in these chains depend on their buyers, there is a high degree of control and coordination on the part of the buyer. In captive value chains, dominant buyers deliberately provide their suppliers with the technological knowledge required for their specific, narrowly confined tasks. In these value chains, the importance of a foreign lead firm in the building of local technological capabilities is at its most pronounced. Altogether, relational and captive value chains perhaps offer the most opportunities for knowledge transfer.

(5) In hierarchic governance patterns, where the lead firm exerts direct control over activities in the chain, learning mechanisms resemble those of intra-firm trade between a TNC and its associated companies. In these chains, transactions are complex and difficult to codify and the suppliers' capabilities are low. Knowledge may be transferred through deliberate training, but also through unintended spillovers and imitation.

As indicated in the above, innovation in developing and newly industrialising countries has a different connotation than in fully-industrialised economies. The transnational value chain approach, strengthened by Pietrobelli's and Rabellotti's concepts of knowledge transfer can be helpful in the analysis of knowledge exchange and diffusion. In the TVC scope of analysis, great importance is attached to the role of lead firms. For SMEs, participation in value chains can be highly rewarding, since they acquire technological know-how on production processes and standards that are needed to enter global markets (Pietrobelli, Rabellotti 2011: 2). Drawing on the advance of knowledge of higher developed firms, lower-end firms build their capabilities and augment their knowledge base.

4.1.2 Inter-chain Innovation

Research on industrial organisation in its transnational chain context has shown the classical pathways in which firms profiting from intra-chain knowledge exchange have put their newly gained capabilities to use in order to move out of their existing value chains into more

profitable chains and to improve their position relative to large, Western buyers. Inter-chain innovation actually constitutes its own pattern of innovation beyond the classical radical-incremental typology. The rise of various Chinese firms to global brands may be a good example of successful inter-chain innovation (UNIDO 2004), the empirical basis for research on this development still seems underdeveloped. It is important to note that patterns of transnational value chain governance are neither static nor homogeneous in themselves, but fluid and changeable (Gereffi, Humphrey, Sturgeon 2005, 96).

In 2004 the UN Industrial Development Organisation (UNIDO) published a comprehensive paper on transnational value chain economics. Featuring Raphael Kaplinsky, Hubert Schmitz, John Humphrey and Gary Gereffi, the list of contributors included researchers that are influential in the TVC and innovation discourse. The authors described the various patterns of innovation from a value chains perspective. The distinction between the first two of the four types, process innovation and product innovation, basically resembles the better-known distinction between incremental and radical innovation. There are, however, patterns of innovation beyond this established typology - patterns that become visible when innovation is not simply seen to fall under the activity of a single firm, but rather as part of the activities of a constellation of firms. The UNIDO study presents a third and fourth type that are in line with the TVC approach: functional innovation and inter-chain innovation. Functional innovation occurs when firms are innovative in the organisation of their own activities and the workload they accomplish within a transnational division of labour. Firms may increase profits simply by changing the distribution of their activities. Inter-chain innovation takes place when firms are innovative with regard to their value chain arrangements, moving out of one value chain into a more profitable one.

Innovation literature on transnational value chains has identified two pathways along which inter-chain innovation may develop. A firm can either switch to a value chain that allows business with new buyers who may have been inaccessible previously (market expansion) or it can switch to a value chain that enables enhancement of technological capabilities and functional expansion (ibid ad 10). Combined into one matrix, these pathways provide two possible trajectories of inter-chain innovation (see figure 2):

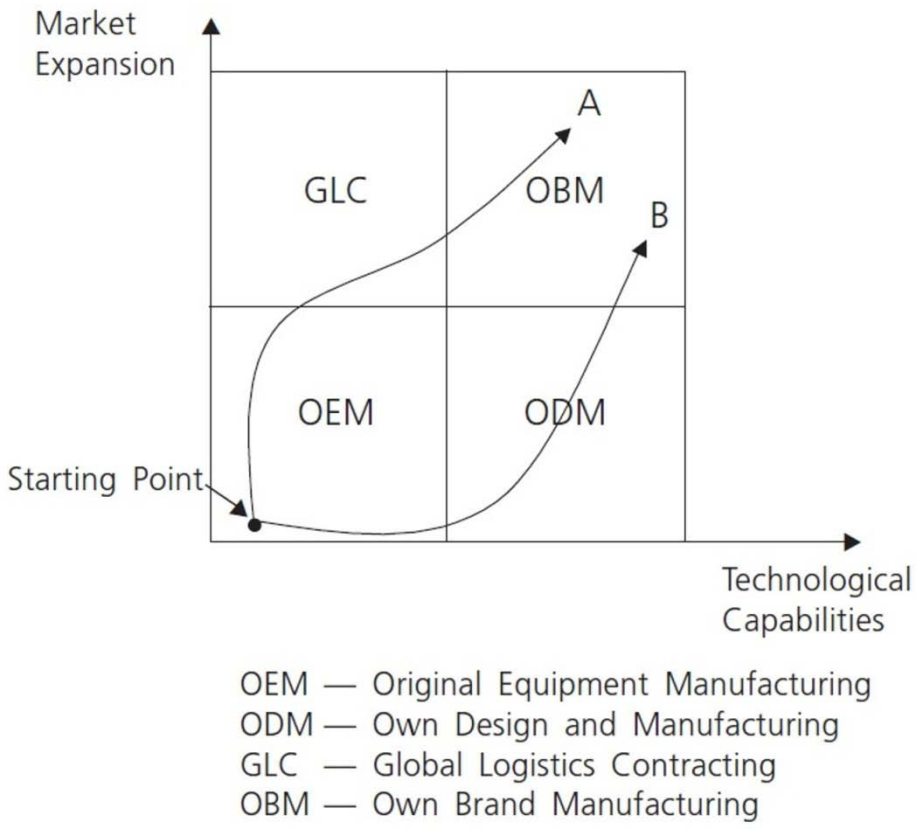

Figure 2: Leverage strategies in inter-chain innovation (Matthews, Cho 2011)

Both pathways display a firm's development from original equipment manufacturing (OEM), as is common in captive and hierarchic value chains, in which Chinese firm produces components for a dominant foreign buyer, to the desired state of own brand manufacturing (OBM). Following Path A, a firm might try to diversify its clientele and gain access to new markets. This expansion to new clientele and markets can be achieved through global logistics contracting (GLC). After the expanding firm has become a global provider in its sector, incremental technological upgrading can lead to OBM. Although the most typical examples for this strategy that come to mind might be certain industries in Taiwan, Hong Kong, Indonesia and Malaysia, Chinese firms also started to apply GLC in the 1970s and 1980s. In all of these cases, the first move towards market expansion consisted in the switching of value chains so that goods were shipped to Western buyers directly without going through the hands of an intermediary (ibid 10-11). With the expansion to new markets, technological upgrading led to the establishment of their own brands.

While Path A of inter-chain innovation was more typical in earlier decades, the trajectory of inter-chain innovation more typical of the 1990s and 2000s follows Path B: through learning

and enhancement of technological capabilities, a firm moves from the production of simple products and custom components in hierarchic and captive value chains to the development of own designs (ODM) in relational and modular chains. As a second step, market expansion and clientele diversification lead to OBM.

4.1.3 Applicability to China – Strengths and Limitations

The transnational value chains framework has brought a great deal of clarification into the field of value chains research. TVC research focuses on the actual performers of innovation and which external influences their innovativeness draws upon. The approach is sector independent and analytical, providing a solid basis for making careful prognoses and predictions.

In some ways Gereffi's GCC framework already acted as a counter-model to earlier approaches that focused on state institutions, making a point for liberalisation and the Washington consensus in development studies (Pietrobelli, Rabellotti 2009; Sturgeon 2008). As a consequence, however, institutions remain the framework's weak spot. In the original TVC framework laid down by Gereffi, Humphrey and Sturgeon, the institutional, political and social contexts are neglected for the sake of the framework's simplicity (Gereffi, Humphrey, Sturgeon 2005: 82). The authors acknowledge that "national-level rules and institutions (e.g., in finance corporate governance, and education and training) profoundly affect the character of industries", but do not see them as decisive for TVC governance (ibid ad 99). Early TVC literature in particular focuses on inter-firm governance rather than on state-over-firm governance. The vast majority of governance over TVCs is exerted by higher-end firms "regardless of the institutional context in which they are situated" (ibid). This ignorance towards institutions and organisations and over-emphasises the role of the single firm pose a severe limitation and proves especially inadequate in the context of a newly industrialized country where governments at all levels are eager to intervene in economic developments such as China. This is why

Though useful in grasping the role of firms in relatively simple, labour intensive but low-tech manufacturing, as per the examples used in the first chain models, the linear chain metaphor may turn out to inadequately reflect structures of governance and knowledge transfer of high-tech production, as individual segments of production processes are turned into self-contained and easily relocatable modules.

The TVC model depicts both production and learning processes in an unrealistically linear form. Firms can operate in multiple value chains at the same time, each of a different governance type. Philip Cooke adds to the criticism of TVCs, pointing out that the TVC model was originally designed to account for simple production processes such as those in the textile and apparel sector, and might fail to capture and explain the complex developments in more complex high-tech clusters (Cooke 2012, 2).

4.1.4 Examples of TVC research

TVC research has brought much insight on the role of foreign firms in industrial upgrading. UNIDO (2004) demonstrates that many Chinese firms have managed to work their way out of captive and hierarchical value chains and engage in relational and market-based chains. A good example of this is China's textile sector which used to be bound in captive value chains and subsequently developed into relational TVC patterns through technological upgrading of Chinese suppliers (Gereffi, Humphrey, Schmitz 2005: 91). In their research on Ikea's Chinese and Southeast Asian supply chains, Ivarsson and Alvstram (2010) argue that the Ikea case might be the precedent for a sixth type of value chain governance pattern: the developmental value chain, which is distinctively buyer-driven and dominated by a large transnational retailer with a global sourcing model, aiming at close, long-term business relations with constant, stringent monitoring – but also, substantial upgrading prospects for the suppliers. On the power asymmetry scale, this pattern would most likely be located between the relational and the captive patterns, or count as a sub-type of captive chain.

4.2 Transnational Production and Innovation Networks

During the first half of the 2000s, while the TVC framework was surfing the wave of its greatest analytical achievements, it gave birth to another transnational framework of analysis. Building on the insights gained from transnational value chains combined with varieties of capitalism literature and actor-network theory, researchers from the University of Manchester such as Jeffrey Henderson, Peter Dicken, Martin Hess, and Neil Coe developed the concept of global production networks (GPN) (Henderson et a. 2002; Coe et al. 2008) which then became the basis for global innovation networks (GIN). The concepts of GPNs and GINs came in response to the degree of disintegration and modularisation of production processes in transnational value chains (Ernst 2002: 504-506; Ernst 2008a: 560; 2009, 504). All economic processes, including R&D, are fragmented to an increasing extent into modules and dispersed

across firm, country and sector boundaries. These processes have led to what Ernst refers to as "vertical specialization" (ibid) at all stages of the chain. Modules of production processes are easily outsourced and relocated, which then constitutes the process of "concentrated dispersion". This observation challenged the TVC framework and posed the question of whether transnational production processes should perhaps instead be modelled as networks rather than linear chains.

4.2.1 The Emergence of Transnational Production Networks

Building on the phenomenon that firms in industrialised country outsource production – and with them, knowledge, equipment, standards and personnel – in order to gain access to cheaper labour and to shape local networks in which several firms interact, researchers designed a research approach that takes the network itself as level of analysis. This approach combines a regional dimension of network interaction with a transnational perspective on knowledge exchange. In his 2002 paper "Global Production Networks and the Changing Geography of Innovation Systems, Implications for Developing Countries", Dieter Ernst draws a conclusion from the geographic dispersion of industrial production from Europe to Asia and argues that, contrary to the assumption made about globalisation in the 1990s, production is not evenly spreading across a borderless globe, instead it dispersed to new industrial locations, where it crystallises in concentrated networks around dominant "flagship" firms. Hence, global production networks are in themselves an organizational innovation of firms, combining concentrated dispersion with a process of integration of hierarchical layers of network units (Ernst 2002: 504-506).

Ernst describes the emergence of a 'global' production network as a form of progress in the organisation of economic and industrial activities in which geographic dispersion of economic activities is brought about in a concentrated way, alongside a process of integration into a multi-layer, multi-actor network with possibly hierarchic patterns of interaction that include multiple suppliers, buyers, sub-companies, joint-ventures, business and R&D cooperation formats in multiple locations. Knowledge and technical know-how move within these networks. According to Ernst, the resulting networks consist of both inter- and intra-firm linkages centred around a dominant "flagship" firm, which may exert direct influence over lower-end participants, contractors and suppliers in terms of their strategic direction, prospects of growth, resources and capabilities (Ernst 2002: 508-510).

4.2.2 Innovation in TPNs – The Emergence of Transnational Innovation Networks

Whereas Jeffrey Henderson viewed the TPN framework more as an analytical means of assessing hierarchies and industrial organisation, Dieter Ernst was the first researcher to conceptualise GPNs as carriers of knowledge diffusion and thus of relevance to the technological and innovative capabilities of firms (2002; 2003). His line of argumentation on innovation in transnational production networks begins with his diagnosis of the "spatial stickiness of knowledge":

> *"... [I]nnovation, in contrast to most other stages of the value chain, is highly immobile: It remains tied to specific locations, despite a rapid geographic dispersion of the markets, finance and production. [...] Knowledge and innovation [...] do not automatically follow, once production moves [...], industries tend to agglomerate and cluster in particular geographic locations, giving rise to persistent patterns of national and regional specializations."* (Ernst 2002: 501-502)

According to his account, knowledge and know-how are not automatically transferred whenever production is outsourced or goods are transported. On the contrary, while the last few decades have seen an unprecedented rise in the off-shoring of manufacturing and assembling, for a long time the knowledge-intensive sections of value-added chains seemed to remain in those countries where large labour-outsourcing firms were based. The process of globalisation has reduced this "spatial stickiness of knowledge" as it enabled the emergence of transnational production networks.

Industrial upgrading, firm capabilities and knowledge diffusion have already been discussed in the earliest writings of the network approach (Henderson et al. 2002, 446). Similarly to the discoveries on TVCs, one feature ascribed to transnational production networks is their ability to transfer knowledge and technology. TPN research understands innovation as more than just R&D; instead it is a complex ability growing from a constant interplay of knowledge acquisition and application. Based on this comprehensive understanding of learning and innovation, transnational production networks, once established, are translated into networks of innovation. Along with manufacturing and assembling, flagship firms outsource and coordinate increasing amounts of more knowledge-intensive services and support-services, creating a "virtuous circle" of knowledge transfer (Ernst 2002: 511-512).

Thus, global innovation networks "emerge as a natural extension of GPNs and hence share most of their characteristics" (Ernst 2009: 6). Transnational innovation networks (TINs) seem to mirror the organisational structures of TPNs: research and development are modularised and dispersed in concentrated form just like other stages of the value chain, and controlled by flagship firms. Knowledge sharing is a constituent feature of innovation networks. While production networks are established when flagships try to gain quick access to supplies and services at low cost, innovation networks emerge when these goods and services become more knowledge-intensive and flagships complement their core competencies with skills and capabilities of suppliers (ibid ad 16). Hence, transnational innovation networks feature asymmetric power constellations with large, multinational corporations at the centre, controlling resources and exerting influence over the position and strategies of subcontractors and suppliers further down. The options for upgrading of lower-end units in innovation networks are manifold: the concentration dispersion of knowledge-intensive activities as well as manufacturing and assembling extends the value-added chains of products, which leads to an increase in the number of firms that can capture value along the production process and to opportunities for technological upgrading, which then results in the upgrading of units further down (Ernst 2002: 512).

From his analysis of Asian TINs in the electronics sector, Dieter Ernst identifies four different types of GINs (Ernst 2009: passim). The learning prospects attributed to the single types are reminiscent of Gereffi's TVC governance. (1) Intra-firm TINs are dominated by large flagships based in Silicon Valley that offshore (but do not outsource!) R&D. These TINs remain strongly hierarchical as the Asian labs integrated within them are directly dependent on the flagship's resources and planning. (2) Intra-firm TINs with foreign flagships are considerably more common in China. They emerge when global brand firms outsource certain stages of R&D to own design manufacturers (ODM). (3) Some large Asian firms establish their own, mostly intra-firm, innovation networks. The role of Asian-led networks is special because often they cannot compete with Western firms in the field of cutting edge innovation. Building their knowledge base and developing their technological capabilities takes time and requires long-term participation at the lower ends of production and innovation networks in order to acquire the required know-how. (4) International public-corporate R&D consortia have become common fare since the global financial crisis as many firms cannot afford to invest many resources into risky R&D. They are often accompanied by (5) informal social networks between the co-workers of the firms involved that facilitate the transfer of know-how.

4.2.3 Applicability to China – Strengths and Limitations

The TPN/TIN approaches build on transnational value chains, but dealt with two shortcomings of the value chain approach. The first shortcoming is that the chain approach is actually very theoretical and was inspired by Porter's value-added chains theory, confining its scope of analysis to a single product and the firms involved in its production.

The GPN framework aims at understanding how production is organised regionally and globally between firms and organisations, including R&D, manufacturing, marketing and distribution. The focus of analysis in the network approach is not confined to the single firm – not even to the flagship – but to the network as a whole. It accepts governments, firms, and other organisations as actors within the network, each with their own priorities and interests, that have an impact on the economic and social outcomes of a given network. As in the TVC approach, attention is not only paid to processes that lead to the creation of a product, but also to the social components and implications of these processes, such as the creation and transfer of value and the distribution and change of power within the network (Henderson et al. 2002: 445-447), the latter of which is seen in a more fluid, less rigid and linear way than in Gereffi's "buyer and supplier driven" taxonomy (Henderson et al. 2002: 447).

One achievement of Ernst's and Henderson's production networks is that they reveal the "multi-actor, multi-scale" characteristics of production and innovation processes (Coe et al. 2008: 267). In contrast to the value chain approach, the networks approach is capable of capturing more complex organisational patterns than the linear chain approach and includes concepts of the roles of geographic proximity and governmental influence. The network approach is compelling because of its interdisciplinary basis, combining economy, geography and politics.

4.2.4 Selected examples for TPN/TIN research

Although a number of papers make statements about learning and innovation in China (for examples, see Ernst 2009: 12; Cooke 2012: 4), the number of studies applying the network approach in specific Chinese contexts is, as in all transnational approaches, still limited.

In a very product-focused research paper, Greg Linden, Kenneth Kraemer and Jackson Dedrick examine production and value in the innovation network of Apple's iPod that spans between China and the U.S. Following through the iPod's production process and examining the network units involved in innovation and R&D, the researchers investigate the differing

extent to which different units respectively profit from the production of an iPod (Linden, Dedrick, Kraemer 2009).

Philip Cooke (2012) examines the Singaporean innovation policy regarding the HDD sector. He asserts that the government of Singapore strategically turned the city state into a regional innovation hub by deliberately settling GPNs in the area and extending them into its less-developed neighbouring countries. Although the paper is not directly about China, Cooke draws several comparisons to other Asian countries and their innovation policies. He argues that China is among the countries applying similar network-based strategies (ibid ad 12). The significance that Cooke ascribes to the role of the government in TPN/TIN coordination makes his findings especially interesting for further research with focus on China.

4.3 Innovation Offshoring

Innovation off-shoring and outsourcing are among the most striking phenomena in innovation dynamics, and have global implications. For decades, western firms had only moved abroad those stages of their value-added chains that involved low-skill low-wage labour, such as manufacture and assembly, while keeping high-skill and knowledge-intensive activities, like R&D and design in-house. It was considered common wisdom that, in order to retain their competitiveness against emerging firms in NIEs, firms needed to keep their innovative core competences under tight control (Lewin, Massini, Peters 2009: 903). In fact, the relocation of R&D and innovation activities was and still is seen as a risk of hollowing out one's own innovation system.

With the beginning of the twenty-first century, the global division of labour was challenged by two developments. Firstly, with rising capabilities in host countries, local firms engaged in ODM and OBM and assumed more knowledge-intensive activities of their own initiative. Secondly, MNEs from based in industrialised countries entrusted more and more Asian subsidiaries and Asian firms with knowledge-intensive stages of their value chain. In "Global Innovation Management" (2009), the economists Roman Boutellier, Oliver Gassmann and Maximilian von Zedtwitz describe trends in globalisation of R&D activities of companies. They argue that, although R&D is still the least internationalised function of MNCs, its degree of internationalisation is increasing dramatically, especially in Asia. This finding is supported by other researchers (Ernst 2006; 2008a; 2009; Lewin, Massini, Peeters 2009). They assert that outsourcing and relocation of R&D segments in MNCs and transnational value chains is

profitable to many firms, since it is often the best way to access foreign pools of research talents (Boutellier et al. 2009, 5-6) and top quality suppliers (ibid ad 21).

China, along with other Asian countries, has advanced to an important destination of R&D outsourcing (Atkinson 2012; Ernst 2006, 2008a, 2008b, Lewin, Massini, Peeters 2009, Economist Intelligence Unit 2007). Originally Chinese locations offered favourable conditions to offshore R&D because of potential proximity to existing manufacturing plans, but the country's investments in human capital and economic diversification have further improved China's position in research (Lewin, Massini, Peeters 2009: 918). By 2004, China had become the most important location for overseas R&D affiliates after the U.S. and the UK, followed by India and Singapore (Ernst 2009: 18), and in 2012, U.S. firms were conducting as many offshore R&D operations in China as they did in Europe (Atkinson 2012:7). In product development, China holds the highest share of the world's total off-shore implementations (Lewin, Massini Peeters 2009: 910).

While innovation off-shoring and outsourcing can be understood as phenotypes of transnational innovation networks, their dynamics exceed the notion of TINs. While the TIN framework implies that innovation networks primarily 'grow' out of production networks that undergo incremental upgrading, innovation off-shoring means that research is transferred to firms or institutions without building on pre-existing production networks. Given the increasing prevalence and importance assigned to modern day innovation offshoring, it has expanded beyond the constraints of the TIN framework and may require a new possibly economist approach of its own. The following section will discuss some approaches to analyse the mechanisms and reasons behind innovation off-shoring.

Arie Lewin, Silvia Massini and Carine Peeters (2009: 903-905) have introduced distinctions between different patterns of innovation off-shoring, based on the strategy it fulfils for the offshoring company. (1) Home base augmenting (HBA), also called asset-augmenting, describes the process of a firm directing research in order to increase its knowledge base at home. This strategy is typically applied by SMEs whose in-house research capacities at home are limited and seek to conduct research at reduced costs. (2) A home-base-replacing strategy may not necessarily aim at replacing in-house R&D completely, but it does redirect complete R&D segments. This strategy is typically pursued by large MNEs that wish to access culture- or nation-specific knowledge. A third basic pattern is the (3) home-base-exploiting strategy, which attempts to adapt a product to local requirements and is usually located in local manufacturing and marketing. Eventually, the knowledge sourcing models of MNEs often

combine to form a (4) flexible-globally-distributed pattern, which allows global talent recruitment and experimentation with different organisational configurations (ibid ad 919).

4.3.1 Why are Firms Off-Shoring R&D?

Much research has investigated which factors are responsible for stimulating innovation offshoring and determining the direction of global knowledge flows. This section will summarise lines of argumentation on the various factors that have led to the current development. Push factors put firms in industrialised countries under pressure to rearrange their knowledge sourcing pull factors create incentives that promise profits if R&D activities are internationalised.

One very important reason behind innovation off-shoring is of course the costs of R&D (Ernst 2008: 560). The cost and complexity of R&D have risen (Economist 2007: 4), and in places with shortages of well-trained and talented researchers, the cost of maintaining in-house R&D facilities is high. A Chinese chip designer for example costs a firm about 10-20% of an equivalent post in Silicon Valley (Ernst 2005: 55). R&D off-shoring allows a tremendous reduction of costs, though more through flexible-global-distributed than through home-base-replacing strategies (Lewin, Massini, Peeters 2009: 920). Political conditions, laws or regulations can increase costs in the research process in off-shoring countries which firms may want to circumvent (Ernst 2005: 48).

The second important factor behind R&D off-shoring is “the global race for talent” (Lewin, Massini, Peeters 2009), meaning that firms compete with one another for the most skilled and talented knowledge workers. The processes of bringing forth innovations have grown increasingly complex (Economist Intelligence Unit 2007: 5-6), and thus require sufficiently large teams of researchers, which can be hard to find in their home countries. Instead of falling back on the second-best at home, firms relocate parts of their research to China and other countries. The seemingly unlimited supply of well-trained knowledge workers seems to be limited only by their low level of English language competency, which is a recognised barrier to R&D off-shoring (Lewin, Massini, Peeters 2009: 922).

Another important factor is that R&D off-shoring facilitates access to high-growth markets – this argument is especially true for China, with its vast, rising middle-class and its very genuinely Chinese consumer culture. Firms might pursue an HBE strategy and open up research facilities in proximity to their manufacturing in order to customise their products to local requirements and accelerate the reaction rate in their research, especially in sectors with

short product life cycles (Ernst 2008: 560). A factor closely related to this is the so-called "not-invented-here syndrome" (ibid ad 557) that makes customers avoid technologies or products that have not been developed within their own country and which can cause firms to offshore R&D in order to improve their reputation in target markets into which they wish to enter.

4.3.2 A "Global Hierarchy" of Innovation Hubs

According to Dieter Ernst (2009) R&D off-shoring has not dissolved the global division of labour, it has, however, altered it significantly. He argues that the internationalisation of innovation has led to the emergence of new innovation hubs, which are catching up quickly in terms of their technological capabilities and stand in fierce competition with one another. In an overall global comparison, they create a global hierarchy of innovation hubs consisting of four classes (ibid ad 35-36): At the top of the pyramid, there are the (1) "global centres of excellence", situated in the U.S., Japan and the EU. (2) "Advanced locations" can be found in Israel, Ireland, Taiwan and Korea. The group of (3) "catching-up" locations includes Beijing, the Yangtze River Delta, the Pearl River Delta and locations in other Asian countries such as Hyderabad, Bangalore and Delhi. (4) New frontier locations can be found in some lower-tier cities in China such as Chengdu, Chongqing and Xi'an, but also in various other newly industrialising countries.

The position of Chinese cities and regions in Ernst's hierarchy of innovation may be at the lower end, but they are unmistakably moving upwards. Ernst argues that the rise of both the group of advanced and the group of catching-up locations began with a wave of off-shoring of manufacturing and services, one in the 1960s, the other in the 1980s. Comparing the two, it seems the catching-up locations undergo the same transformation as the location now classed as advanced, but require a shorter timeframe (ibid ad 37).

5. The Regional Dimension in Transnational R&D

Among China's provinces and regions, there is great variation in terms of their innovative capabilities and output, their ability to mobilise resources and put them to use (OECD 2007: 25-26), as well as in terms of their historic development (OECD 2007) and their strategies and S&T policies (Kroll, Conlé, Schüller 2008: 177-178). In a Fraunhofer ISI study, the authors call it "a peculiarity of the Chinese innovation system" that, as early as the 1980s, many government functions in economic coordination were transferred local governments which

have since developed and pursued their own strategies (Ibid.). In "The Run of the Red Queen", Breznitz and Murphree challenge the idea of a Chinese national innovation system, arguing that China's NIS actually consists of and is shaped by regional subsystems with very different set-ups, that are constantly struggling not to fall behind (Breznitz, Murphree 2011). Some R&D policies, such as the establishment of special economic and technology zones, had originally been developed by provinces in order to stay ahead of one another (Kroll, Conlé, Schüller 2008: 178). Just how misleading national averages in statistics can be is perfectly exemplified by the data on R&D expenditure: The top seven provinces taken alone account for nearly two thirds of China's gross expenditure on research and development (GERD) (ibid ad 179).

5.1 Regional Innovation Systems

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5.2 Differences Between the NIS and the RIS Perspective

The sheer size and heterogeneity of China's innovation landscape, the rapid technological development of some coastal industrial hotspots and the fierce competition between the

technologically most innovative agglomerations have caused researchers to direct their attention toward the Chinese regions and to apply the IS approach, taking provinces and sometimes even municipalities as the primary unit of analysis. Although the RIS framework was originally designed to explain the success of the technological powerhouses in advanced Western economies (Asheim, Vang 2006: 29), Chinese regions and provinces such as Guangdong, Beijing and Shanghai have in fact proved to be particularly useful objects of research, allowing for the further development of RIS theory into an increasingly independent perspective on industrial development.

The analytical advantage of the RIS compared to the national perspective lies in its ability to establish ties between the large-scale institutions that play a role in the innovation system and the dynamics of local industrial clusters and specific industries. Corresponding to NIS research, the main focus of analysis is on (1) key actors such as the performers of innovation, firms and organisations, (2) framework conditions that encourage or discourage specific behaviour, (3) governance and administrative organs that frame research areas through funding and deliberate coordination and (4) specific policies and programmes which direct the innovation process (OECD 2009: 347). However, exploring Chinese RIS implies more than regarding them as national innovation systems of smaller scale. Chinese provinces are characterised are subject to social, economic and demographic conditions that are beyond provincial-level control and are embedded in structures of national governance and central-local relations that need to be taken into account. Until the economic reforms, most SOEs were controlled by provincial authorities, many of which maintained their close connection to local industries. Consequently, provincial technology policies can be more down-to-earth and involve closer relations between policy-makers and the performers of innovation (Kroll, Conlé, Schüller 2009: 201), which directs the attention of RIS researchers to personal and organisational connections within regional systems.

Building on the work of Philip Cooke, Bjorn Asheim and Jan Vang (2006) define a regional innovation system as a “system in which firms and other organizations are systematically engaged in interactive learning through an institutional milieu characterized by local embeddedness” and “regional clusters surrounded by 'supporting' knowledge organizations” (2006: 29). By this definition, it is the notion of “embeddedness”, conceptualized as personal relations and networks integral to local social and cultural institutions, which distinguishes this system from the NIS (ibid).

SOE: State-Owned Enterprises; SME: Small and Medium Enterprises; PRO: Public Research Organisations; MNE: Multinational Enterprises.
1. "Past Cold War" R&D intensive regions.
→ Direction of structural change.

Figure 3: A typology of Chinese RIS (OECD 2009)

Another analytical advantage of the regional perspective is that it allows intra-national comparison of regional units with similar cultural, social and historical characteristics. The similarity that the Chinese provinces share in terms of their historical development and culture allows an even sharper comparative focus on their innovation policies. Thus many studies on Chinese RIS compare provinces and regional innovation systems, their S&T programmes, their strategies to achieve urban and regional agglomeration effects, their efforts in universities and in science and technology parks and their different ways of interacting with the central government. Henning Kroll, Marcus Conlé and Margot Schüller point out that Chinese provincial governments not only differ significantly in the resources they spend on R&D support but also in their success in convincing the central government to make even more funds available (2008: 179). Jon Sigurdsson (2004) compares regional development in three technologically advanced regions that have profited tremendously from strong central government support and from favourable cluster-building. In another study Henning Kroll (2009) focuses on provincial-level science and technology programmes. He asserts that, while many provincial governments put their efforts into supporting those industrial sectors that have already reached an advanced technological standard. One study issued by the OECD (2009) compares China's RISs in terms of their historic development and identifies lock-in effects in the regional development of some provinces. The authors track the advantageous RIS set-ups of some provinces and the inefficiency of others by the trajectories of development since the 1970s. A visualization of this argument is shown in, Fig. 3.

5.3 Strengths and Weaknesses of the RIS Perspective

Of course, the RIS perspective has its limitations. Just as the NIS framework, the regional innovation systems approach was originally designed for and applied to developed, industrialised economies. It sought to explain the success and the innovative output of regions such as Silicon Valley and Baden-Württemberg (Asheim, Vang 2006: 29). Applied to a newly industrialising country such as China, the original RIS framework had two major limitations.

Firstly, China has been undergoing constant rapid transition for decades. One could argue that the enormous regional discrepancies in growth and innovativeness we now see were in fact inevitable in a continent-sized economy undergoing its industrial revolution at warp-speed. It is possible that some of these discrepancies are not tied to regional systemic socio-economic and political-institutional specificities, but to geographical factors, such as some regions' proximity to the coast or some lucky, early provinces 'catching the worm' and building on their head start, that is, the cumulative effects of economic growth. In short, some regional dynamics of growth and industrial development may be in part over-interpreted by the RIS framework.

Secondly, as in NIS literature, many works on China's regional innovation systems focus on how systems promote industrial upgrading, technological advancement and gains in technical know-how as though they were solely supported by their own firms, universities and research institutions. However, like all other emerging economies, China's regional systems heavily rely on knowledge, technology, capital, ideas and impulses from abroad (Asheim, Vang 2006: 29). Consequently, the original RIS framework must be further customised to the Chinese case to grant the role of multinational corporations in industrial upgrading and the transnational dimension of innovation processes greater importance in the framework.

6. Approaches Combined

As we have shown in the last chapter, researchers have developed very different concepts in order to analyse technological innovation processes, most of which originate in the West and were originally applied to Western contexts and need be customised to be applicable to the Chinese case. The NIS framework may be well fit for the analysis of large-scale programmes and the interactions of national-level authorities and organisations, but fails to measure or explain innovation where it actually happens, especially in a continent-sized country like China. The firm-level value chains approach focuses on the kinds of innovation that are most

relevant to the Chinese case – incremental and procedural innovations – and captures the vital role of foreign MNCs in the industrial upgrading of Chinese firms, but underestimates the importance of institutions and governance. The network approach captures sets of interconnected firms and value chains, connecting the regional and the transnational dimensions of innovation. The following section of the paper will discuss where the transnational R&D frameworks intersect with the advantages of the RIS perspective and what role politics exactly plays in them.

6.1 The Role of the Region in Transnational Approaches

A common theme running through all innovation studies literature, and especially the discourses on transnational R&D, is the on-going debate on the role of geography in innovation. While some authors emphasise the importance of agglomeration effects and geographic proximity in the building of innovative clusters, others argue that globalisation processes have nullified physical proximity as a decisive factor for economic development, as they have enabled exchange of knowledge, services and goods across regions, countries and continents.

The approaches of transnational research and development discussed in this paper disagree on this matter. Pietrobelli and Rabellotti, representing the value chains account, argue that similarity of organisational patterns is of greater importance than physical proximity (2011: 7); they do, however, acknowledge that spatial proximity may play an important role in relational value chains, along with social proximity, reputation and ethnic ties (ibid ad 3). Much TPN/TIN literature emphasises the relevance of geographic proximity to fruitful innovation, although there is a lack of consensus as to the reason for this. Some authors emphasise the importance of proximity for the very emergence of a network (Glückler 2007: 621-622), or the communication and the building of trust in inter-firm relations (Wang, Lin 2013: 399), while others see a need for a certain local critical mass of knowledge as a prerequisite for the emergence of innovative clusters (Sigurdson 2004: 6).

Dieter Ernst recognises the gravitational effect of geography but also points out that intra- and inter-firm linkages span across regions and nations into increasingly global networks, which renders geographic proximity less important (Ernst 2002: 502-503; 2008a: 557). In a globalized world marked by concentrated dispersion of production and innovation, three factors influence why some value-chain activities are being dispersed easily and fast and others lead to local agglomerations. Intense localized interaction occurs (1) in industries that

are highly volatile, i.e. in which short product-life cycles and high speed-to-market and constant design changes require constant exchange of information; (2) in networks with suppliers that do not just provide standard equipment and components, but that fabricate high-end customized products, and (3) when weak, lower-tier suppliers build their technological upgrading on close cooperation (Ernst 2002: 506-507).

The answer to the riddle as to how transnational R&D in all its shapes – as value chains, production networks and foreign-invested or offshored R&D – interacts with Chinese regional contexts seems to lie in the regional absorptive capacity (RAC) of Chinese regions and provinces. The term 'absorptive capability' was introduced by Wesley Cohen and Daniel Levinthal in 1990 and was confined to individuals and firms in its original meaning. The term described a firm's ability to "recognize the value of new, external information, assimilate it and apply it to commercial use" (cf. Cohen, Levinthal 1990: 128). Absorptive capacity is considered to be a function, an ability of entities that strongly depends on the knowledge it already commands. R&D activities thus have a double effect: They increase the entity's innovativeness directly and indirectly, first by adding to its knowledge base and then by contributing to its absorptive capacity, thus making it more receptive to spillovers from foreign knowledge impulses.

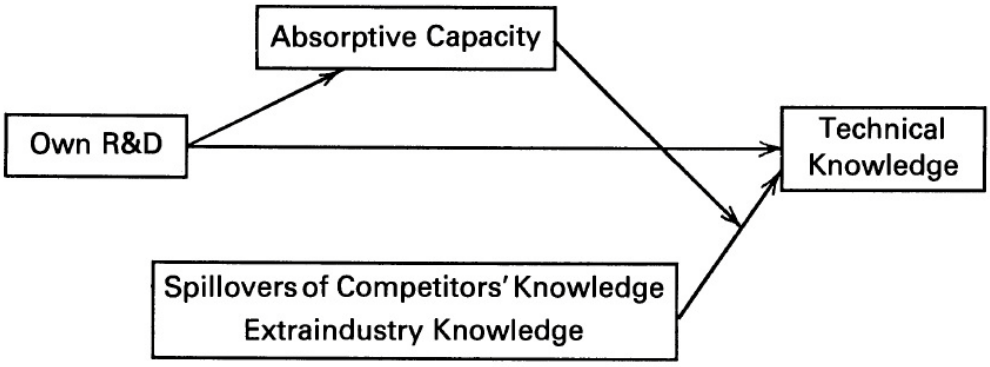

Figure 4: Absorptive capacity and cumulative learning (Cohen, Levinthal 1990)

Examining Chinese provinces on the assumption that the absorptive capacity can be conferred to a regional level constitutes a rather new approach. Some researchers have tried to conceptualise this regional absorptive capacity and have generally come to surprisingly similar results. In a Taiwanese study comparing the RACs of all Chinese provinces from 1997 to 2007, researchers Chih-Hai Yang and Hui-Lin Lin pursued the question whether high-tech imports and high-tech FDI can make up for very low levels of domestic R&D (Yang, Hui 2012). Altogether, the study does find convincing evidence for knowledge spill-overs, suggesting that

local firms had been able to assimilate knowledge gained from foreign firms' innovations. Upon further investigation it became clear that the surplus in technological upgrading was achieved in coastal areas, whereas inland regions hardly profited from knowledge inputs (Yang, Hui 2012: 24). Another study, focussing on innovation generated by foreign firms and in MNE's R&D labs supported these findings. Fu Xiaolan affirms Cohen and Levinthal's notion about innovation and learning being cumulative and path-dependent (Fu 2008: 7; Cohen, Levinthal 1990: 135-138).

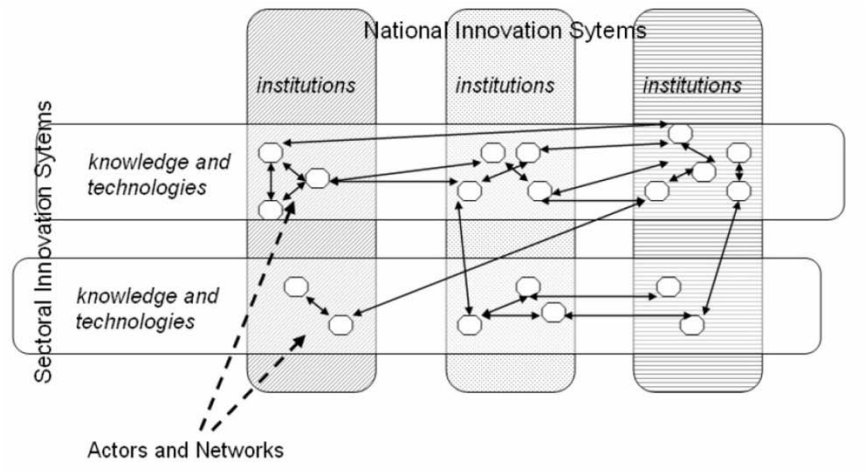

Figure 5: Internationally networked regional innovation systems (Kroll 2009).

A very interesting paper applying the RAC concept is provided by Björn Asheim and Jan Vang (2006), who operationalize the regional absorptive capacity in purely qualitative terms. To them, RAC is based on four requirements, namely a region's physical capital (hard infrastructure), soft infrastructure (institutions, relationships, norms that shape the density and quality of social interactions), human capital (education and training) and financial capital (Ibid ad 30-31).

Combining their concept of regional absorptive capacity with their findings from the RIS of Shanghai and Bangalore, Asheim and Vang put together a set of five determining factors for the role of MNC operating in a particular region, which consist of the (1) bargaining power of the host country to force an MNC to make contributions to the country's development, (2) distribution of decision-making powers between the central and the regional government, (3) the absorptive capacity of local firms, (4) the ability of the regional government to exploit local absorptive capabilities, (5) the quality of formal training and the quality of hard

infrastructure. They show the success of the municipal government of Shanghai in improving the region's absorptive capabilities in order to draw maximum profit from the presence of MNCs (Ibid ad 36-37). More on Asheim and Vang's paper will be said in the section on the role of politics in transnational R&D.

Another aspect to absorptive capacity is offered in the notion of "internationally networked regional innovation systems" presented by Henning Kroll (2009) working for Fraunhofer ISI. He emphasises the necessity of a sufficient knowledge base for the building of clusters in a particular region. However, it sees local firms as drivers of knowledge transfer, trying to source knowledge according to their needs if the local research landscape fails to provide the know-how needed for development. On the other hand, wherever knowledge produced by local research cannot be absorbed by the regional surrounding, it will be 'exported' and flow to locations where it can be applied. Kroll argues that regional innovation systems will thrive wherever interregional knowledge flows intersect and join local knowledge flows. (ibid ad 5-6).

6.2 The Role of Politics and Institutions in Transnational Approaches

A striking feature of innovation in China is the variety of government programmes concerned with technological advancement, industrial upgrading and the development of domestic innovative capabilities. Although it is debated whether state-directed programmes and plans will ever become the main driving force behind innovation, a great deal of NIS literature still emphasises the important role that the national and regional authorities play in China's innovation landscape (e.g. Liu, Cheng 2011; Schaaper 2010; OECD 2007; Ernst 2011; USCC 2011). The fact that, in addition to the national-level programmes that are well-covered in NIS literature, there are a number of decentralised, experimental programmes that still remain under-represented in innovation studies literature but that are actually characteristic for China's highly flexible policy-making (Heilmann, Shih, Hofem 2013), supports the notion that the role of science and technology policies must not be neglected.

Hence, any attempt to examine the Chinese innovation system must take into account the role of institutions and government organisations. This is a challenge for some of the frameworks of analysis presented in this paper, since it is not obvious at first glance how the concepts of transnational R&D bring policy back into the game. This section will summarise the role transnational approaches in innovation studies ascribe to the state and how politics is brought back into the game by different researchers.

Transnational value chains theory, as mentioned above, does not place much emphasis on the political-institutional framework in which production and innovation take place. Several researchers have sought ways to include the influence of politics into the framework. Since transnational value chains span across national borders they allow firms to circumvent and undermine national-level institutions, rules and laws; and although TVCs may also offer new points of national policy leverage, the state is rather seen as a framework-builder than in the position to actively intervene in economic processes: Apart from the creation of transparent markets, the state may compete with firms higher up the value chain in the setting of production parameters either by adopting hygiene and quality requirements, putting up safety standards or banning child and slave labour (Humphrey, Schmitz 2004: 4; Gereffi, Humphrey, Sturgeon 2005: 85).

It is now known that state organisations can in fact take part in TVC governance and apply a wide range of instruments in order to exert influence over value chain activities, especially regarding innovative activities in value chains. The theoretical underpinning for the analysis of politics in TVC-driven learning and innovation processes is offered by Carlo Pietrobelli and Roberta Rabellotti, who combined the transnational value chains framework with insights from innovation systems literature (Pietrobelli, Rabellotti 2009; 2011). Whereas the originators of the TVC framework saw the state's role in setting some quality parameters, Pietrobelli and Rabellotti investigated the institutional and organisational means by which the state could affect the three basic variables upon which the TVC governance matrix is based: complexity of transactions, codifiability of transactions and supplier capabilities.

The higher the complexity of transactions in value chains, the greater the need for reliable and stable institutions. Strong institutions have the potential to reduce transaction complexity and to enable more transactions between firms as equal partners, since each party in a value chain is then able to count on stringent legal grounds and equal treatment. In countries with weak institutions, unreliable contract enforcement, rampant corruption and obstructive bureaucratic infrastructures, inter-firm coordination is costlier, riskier and more time-consuming, in turn complicating integration in less hierarchical government patterns, especially those based on markets (Pietrobelli, Rabellotti 2009: 228-229).

Regarding transaction codifiability, an innovation system can contribute to TVC-driven learning and innovation by strengthening metrology, standards, testing and quality (MSTQ) institutions and organisations in order to reduce the costs of learning-related transactions and support relational TVC governance, and to even transform hierarchic governance patterns into captive ones (Pietrobelli, Rabellotti 2011: 5-6).

Capabilities in the supply-base can be enhanced through various IS instruments, including all organisations that provide training and education and the institutions that encourage learning and professional development (Ibid ad 6). The NIS can support firms by equipping their workforces with new skills beyond production, such as design and marketing in order to help diversifying their clientele and improving their relative positions in value chains (UNIDO 2004: 8). Policies that promote the improvement of suppliers' capabilities may enable a transition of value chains away from hierarchical and captive governance patterns and help suppliers profit from joining transnational value chains (Pietrobelli, Rabellotti 2009: 230).

From the very beginning, the **transnational production networks** framework emphasized the role of politics and many studies that apply the TPN/TIN framework offer policy suggestions to support the emergence of innovation networks or to increase their innovative and technological capabilities. However, the role that politics can play is not cemented in a theorized causal framework.

Henderson conceptualised power in three forms: (1) Corporate power, exercised by firms over one another whenever they engage in asymmetric interactions, (2) collective power, exercised by collective actors such as the IMF, the WTO or international trade unions and (3) institutional power, exercised by governments, as well as international and economic organisations. Each of these forms of power is significant in terms of network development prospects (Henderson et al. 2002: 450).

The use of institutional power is not confined to national governments. A study on transnational production networks in regional contexts in Asia attributes the successful industrial upgrading in Shanghai to the municipal government's shrewd strategic coupling with transnational corporations in order to develop the region's absorptive capacities and attract investments in high-tech production networks (Asheim, Vang 2006: 36).

One striking study on the impact of politics on industrial upgrading through TPNs is Philip Cooke's analysis of the development of the Singaporean hard disk drive industry. Cooke asserts that the government of Singapore strategically allured foreign flagships such as Seagate and WD to extend their production networks to the city state. By outsourcing production to closer and less-developed countries, Singapore became an intermediate hub and was able to transform the newly developed TPN into an innovation network capable of entering into innovative competition with other Asian networks. Eventually, the above-mentioned regional absorptive capacity can be enhanced by strategic governance, such as by investment in infrastructure and by providing complementary support services or investments in a region's knowledge base (Ernst 2009: 37).

Research into **innovation offshoring** is still in its early stages and at this time lacks a solid framework on which to build. Scholars working in this field have recognised the effects of politics, especially in the development of frameworks. Lewin, Massini and Peeters see strict immigration laws as a push-factor behind R&D off-shoring, because they hamper the international mobility of knowledge workers and leave firms no choice but to relocate parts of their research abroad (2009: 920).

Dieter Ernst (2005) that R&D in some countries is more costly than in others, due to state regulations. By reducing these costs, governments can provide incentives to foreign firms by providing public goods such as functioning infrastructure and investing into training institutions. He also argues that by creating new standards, governments can attract high-skilled labour, as in the case of the third generation wireless standard TD-SCDMA in China, which created a strong motivation for foreign firms to expand their electronic product development to China (ibid ad 58).

7. Conclusion

This paper presents and juxtaposes a number of analytical perspectives on innovation in China. It recognises the achievement of the national innovation system, but also points out some limitations with regard to the Chinese case. The tremendous progress of the NIS lies in its holistic perspective, recognising the complex nature of innovation and including both the performers of innovation and the institutions and organisations that shape the innovation process as interacting units within one system. However, the Chinese case poses a number of challenges to the NIS. Firstly, the sheer size and heterogeneity of China's innovation landscape necessitate a complementary approach to the NIS through a down-to-earth perspective on how and where innovations are brought forth, and a closer look at discrepancies and developments at regional level. Secondly, innovation processes in China follow patterns different from those in fully industrialised countries. Incremental innovation and industrial upgrading through transnational inter-firm relations are much more common than radical innovation and completely new inventions produced by basic research in public laboratories and universities. Hence, the NIS underrates the significance of foreign knowledge inflows for the Chinese innovation landscape. Although the first of these two shortcomings is addressed in the regional innovation systems framework, neither the NIS nor the RIS integrate the role of transnational inter-firm interactions, MNCs and foreign-invested R&D sufficiently into their analysis. There has been a lot of research into the dynamics of industrial upgrading and knowledge flows and the transnational dimension of innovation. Two established strands of

research and one emerging strand have been presented, explained and examined, paying particular attention to their applicability to the Chinese case. The third part of the paper discussed the role of the political and regional dimensions of innovation and upgrading in these transnational approaches.

The concept best able to analyse and account for the regional impacts of transnational R&D seems to be the regional absorptive capacity (RAC). The RAC links the prospects of regional upgrading to the pre-existing knowledge base within firms and research institutions. According to this argument, regional upgrading is path dependent and cumulative. Attempts to measure the RAC of Chinese provinces have provided similar results (Fu 2008; Yang, Hui 2012). Interestingly, provincial governments can enhance their region's absorptive capacity, and Shanghai serves as a prime example for this (Asheim, Vang 2006).

The integration of the political dimension into transnational R&D frameworks is more challenging. The transnational value chains framework understands interactions of firms in terms of value chains that serve as trajectories for knowledge, capital and technical know-how, all of which are necessary for a firm to be innovative. How they are transferred from firm to firm depends on the mode of inter-firm value chain governance (Pietrobelli, Rabellotti 2011: 2). Although the original TVC framework deliberately excluded the dimensions of politics and institutions (Gereffi, Humphrey, Sturgeon 2005: 99), a number of studies make reference to the institutional framework in which TVCs operate. The most considerable contribution to the relationship between politics and innovation in TVCs has been made by Carlo Pietrobelli and Roberta Rabellotti (2007; 2011), who argue that governments have several instruments to influence the factors that determine the TVC governance patterns between firms, and increase the likelihood of the emergence of a TVC of a type that favours knowledge exchange.

The theory of transnational production and innovation networks is an inter-disciplinary framework that aims to link the regional and the transnational dimension of innovation. TPN/TIN researchers argue that production processes and value chains have become increasingly "fragmented" into modules that can easily be off-shored and outsourced, leading to the global dispersion of production processes but in concentrated form (Ernst 2002; 2006; 2009). This process of concentrated dispersion leads to the emergence of transnational networks dominated by "flagship" firms in which production, and eventually innovation, takes place. The framework emphasises the role of politics, but does not cement the political dimension within a theoretical framework of trajectories of influence. Governments and

institutions, and equally flagship firms, are recognised as potentially decisive factors in firms' activities (Henderson et al. 2002: 450).

This paper summarises the main arguments on the complex nature of innovation and innovativeness in its national, regional and transnational context. While the NIS and RIS have been applied to China numerous times and in different formats, there is still a lack of empirical research into innovation in a transnational context. Likewise, the relationship between transnational R&D and local clustering needs further clarification. Further research should address the political and institutional dimension of innovation in transnational value chains and innovation networks, and the concept of regional absorptive capacity, which may be a pertinent solution to capture transnational R&D in regional contexts and look for ways of integrating all three dimensions in the study of innovation.

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