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From foreign technology dependence towards greater innovation autonomy: China's integration into the information and communications technology (ICT) global value chain (GVC)

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Abstract

China's integration into the information and communications technology global value chain has taken place as global technology corporations outsourced and offshored an increasing range of functions, including manufacturing and assembly, and to some extent innovation to more competitive regions within China. This paper reviews the literature conceptualising this process of China's integration from an initial period of technology dependency on foreign companies to more recent attempts by China to achieve greater levels of technology autonomy. From initial disappointment with low levels of technology transfer from foreign companies to more aggressive efforts in recent years to push for indigenous innovation by leveraging market access, China has achieved limited success in establishing domestic brands but continues to lack significant core technology in critical areas such as semiconductors.

Keywords

China, information and communications technology, global value chain, integration

INTRODUCTION

Emerging countries such as China, being latecomers to technology development, are often referred to as 'late developers', since face major challenges in catching up with more developed regions which tend to dominate the trajectory of technology development. Since much of this catching up and technology upgrading has been taking place in an era of increasing globalisation, researchers have developed a range of conceptual frameworks including Global Production Networks (GPN), Global Value Chains (GVC) and Global Innovation Networks (GIN) to better explain the implications for emerging regions of becoming more fully integrated into the value chains of global corporations, who in turn outsource and offshore an increasing range of

production, assembly and in some cases innovation functions to more competitive regions in less developed parts of the world. This paper reviews literature mainly from the past decade examining these issues in relation to China's integration into the global value chain of the information and communications technology sector.

Together with increased flows of foreign investment across the globe, the information and communication technology sector more than others have facilitated significant internationalisation and even globalisation of economic activity in recent decades. New regions, particularly the so-called BRIC countries (including China) have emerged as major locations for mobile investment as transnational corporations (TNCs) exploited the expanded opportunities offered by new business organisational models facilitated by information and communication technologies (ICTs). This changing geography of competitiveness has presented opportunities for emerging regions to compete for mobile investment and develop specific specialisations particularly in production and assembly. Over time, however, as more value chain functions and tasks have been outsourced and offshored, an increasingly complex and extensive range of components of the ICT value chain has been relocated to China. Decentralisation of production globally has also been associated with centralisation of production in key locations within emerging regions such as urban technology parks, which facilitate a more coordinated approach to final assembly. In the case of China the most favoured locations initially were along the eastern seaboard, in the Pearl River Delta (PRD) at first and later in the Yangtze River Delta (YRD) and more recently with some production being relocated inland.

With increased globalisation of economic activity and particularly of electronics manufacturing, technology TNCs have experimented with the most effective and profitable forms of production organisation, seeking the most cost-effective locations for particular functions. Hence within the ICT sector we have seen the growing decentralisation of production, with the centre of gravity of the ICT global value chain (GVC) shifting from major centres of innovation such as the US eastwards towards Japan, South Korea, Taiwan and later to mainland China. Part of the explanation for China's rapid growth in ICT production is the historical coincidence between China's post WTO opening up to FDI after 2001 and the significant international flows of technology company investment resulting from the growing trends of outsourcing and offshoring to lower cost regions. The complementarity of China's need to attract technology investment to build up its own technology infrastructure in areas like telecommunications and the need of major technology companies to improve their competitiveness through outsourcing and expanding into new markets resulted in major flows of FDI into China (Zhang and Peck, 2014).

This paper focuses on conceptual attempts to explain China's increasing integration into the ICT GVC from the initial attraction of technology TNCs by means of foreign investment (FDI) to the more recent attempts by China to promote its own technology sector. We first explore the literature conceptualising the ICT GVC in a globalising economy. Next we look more specifically at the evolving ICT sector in China, which initially has been dominated by foreign investment. The following section examines the more recent shift in China towards indigenous innovation, with China developing a variety of policy measures to promote its own ICT sector. The following section examines studies which have analysed the role of supplier networks within the ICT GVC in China and finally we make a number of conclusions based on this review of literature.

CONCEPTUALISING THE ICT GVC

Some scholars and indeed policymakers have sought to understand the catching up and upgrading challenges facing late comers to technology through economic theory (Gao and Liu, 2012; Ernst, 2014). Some researchers have developed conceptual frameworks such as global production networks (GPNs), global value chains (GVCs) and global innovation networks to both explain how transnational corporations (TNCs) have evolved their internationalised business models and how the emerging regions involved have been affected by increased integration into value chains (Coe and Yeung, 2015). These varying frameworks have given rise to extensive and fruitful debates about the most effective ways to explain these dramatic changes in the economic geography of economic activity, with some scholars emphasising the role of firms within value chains of production, and particularly how value is generated and captured in different regions (Gereffi, 2014). Others have focused more on the role played by particular locations in these developments as regions have competed for investment and sought to integrate their economies within the value chains of TNCs, seeking at the same time to promote upgrading of their own technology sectors while avoiding the negative effects of becoming entrapped in low value added functions (Chen, 2014; Liu, 2016). Others have placed an emphasis on the growing role of innovation as a major component of competitiveness and have tracked the increasingly dispersed geography of innovation networks internationally as TNCs extended their production to new regions (Ernst, 2009). While there is considerable overlap between these various approaches, this paper will focus primarily on the GVC perspective .

A common objective of these frameworks is to overcome the theoretical and methodological limitations of focusing on domestic economy models in an era in which globalised economy activity has become more significant (Sturgeon, 2008). Despite widespread globalisation, traditional orthodox economic theory, methodology and data collection remains firmly centred on the nation-state, and while the state continues to play a significant economic development role, an increasing proportion of economic flows are of intermediate goods or components of final products which are traded between the subsidiaries of TNCs located in different regions of the world (UNCTAD, 2013). Much of the added value generated and captured by this activity can no longer be explained by traditional trade theory based on import and export data, which assumes that value accrues to the different states in which these goods are traded. Hence the need for frameworks like global value chains, which more effectively track the network connections between key actors in economic activity and provide a more accurate insight into the beneficiaries of this activity (OECD, 2012). In an insightful paper on the growth of high tech exports from China, Xing (2016) explains why traditional explanations in trade theory such as comparative advantage, which mainly emphasise production costs and barriers to cross-country flows of goods, fail to take account of the critical roles performed by organisational structures in modern trade. He points out that the proliferation of global value chains (GVCs) has transformed trade in goods into trade in tasks and by successfully plugging into GVCs, China is able to bundle low-skilled services with the global brands and advanced technologies of multinational companies.

Sturgeon (2003) provides theoretical insights into the processes underlying the fragmentation of the electronics value chain, particularly in relation to the modularization of production associated

with the codification of complex knowledge over time, which helps to explain what can and what can't be outsourced. The modularization thesis has been subject to some criticism more recently as being overly deterministic and underplaying the evolving role of original design manufacturers (ODMs) in the value chain (Yang and Chen, 2013). Over time as the ICT GVC has evolved, there have been processes of re-integration of more functions particularly by large ODMs (and in some cases lead companies) as they seek to extend their capabilities and improve their revenue streams beyond basic assembly tasks (Sturgeon and Kawakami, 2011; Lee and Gereffi, 2015). One of the world's largest ODMs, Foxconn, is a very good example of this recent evolution. An important related issue is the extent to which the locus of innovation within the ICT GVC has shifted eastwards to Asia and associated with this re-integration of functions by ODMs, the extent to which innovation has shifted from the dominant control of lead companies with potential upgrading consequences for supplier companies in the GVC (Jiang et al., 2016).

Although the GPN/GVC/GIN frameworks have gone some way towards accounting for the integration of emerging regions in the ICT GVC, these approaches present many methodological challenges, since they often depend on a detailed examination of the supplier networks of case study firms and necessarily include extensive interviewing (Coe and Yeung, 2015). These different frameworks focus on particular aspects of the integration process. While the GVC approach provides considerable depth towards understanding the processes underlying the evolution of the ICT global value chain, some questions can be raised about the representativeness of case studies. This may partly explain why some researchers, while adopting these conceptual approaches, continue to rely on large surveys containing aggregate data on firm characteristics (Sun et al, 2013).

An important aspect of China's evolving ICT GVC has been that it has not only attracted a significant volume of mobile FDI in the ICT sector in recent years but it has also attracted a large complex network of both lead companies and their many component suppliers and contract manufacturers, resulting in one of the most significant integrated and comprehensive ICT production ecosystems globally. The presence of such a large and sophisticated ecosystem has major implications for the supply chain decisions of many global technology companies and their suppliers. With such a major shift in the centre of gravity of ICT production to China, such companies have few options but to be significantly involved in benefiting from this ecosystem, particularly since it is also located in a rapidly growing market for ICT products and services (Grimes and Sun, 2016).

Distinctive regional trajectories

Despite the obvious shift by researchers from localistic and region-based frameworks to models which take account of China's integration into global value chains, some researchers continue to focus on regional development issues associated with the specific impacts of integration on particular regions in China. In a historically situated analysis of China's leading science park, Beijing's Zhongguancun, Zhou (2008) challenges the prevailing view that foreign multinational corporations and exports are the driving forces for technological progress by arguing that in China it is the conjunction of domestic and export markets that has provided the main impetus to technological learning and industry competitiveness. A growing literature has compared the distinctive innovation dynamisms in three mega-city regions of Beijing, Shanghai-Suzhou and

Shenzhen-Dongguan (Lin et al, 2011; Su and Du, 2010; Wei et al, 2012; Zhou et al, 2011). Shenzhen is recognised as an innovation centre for domestic rather than foreign firms (Zhou et al, 2011). It has nurtured some of China's most innovative firms such as Huawei, ZTE and Tencent (Fan, 2011; Yeung and Liu, 2008). Although Beijing, Shanghai and Shenzhen are all regarded as high tech cities, unlike Beijing and Shanghai, which both have prestigious universities and research institutes, Shenzhen's innovation system has limited involvement with such institutes (Chen and Kenney, 2007; Schiller, 2011; Yang, 2016).

Recent attention has been paid to industrial upgrading of coastal regions, e.g. the Pearl River Delta and Yangtze River Delta through spatial relocation of labour-intensive production activities and some other activities such as financial settlement centres from the coastal regions to inland China (Yang and He, 2016) and Southeast Asia as the emerging destinations of China's outward foreign direct investment (Zhu and Pickles, 2015). The landscape of China as a "world factory" has undergone dramatic transformation, the effects of which on the progress of technological innovation and regional division of labour warrants further observation and investigation.

Since particular regions in China have been especially impacted by China's integration into the ICT GVC, this focus on regional development is understandable. Nevertheless an effective investigation of these regional issues requires a broader regional analysis of China's evolving role within East Asia's ICT GVC. Zhang and Peck (2014) explain the role of overseas Chinese capital, mainly through Hong Kong and Taiwanese entrepreneurs and companies in integrating major locations such as Guangdong and Suzhou into the ICT value chain. In emphasising the role of external capital as opposed to the Chinese state in shaping this integration, they tend to downplay the significance of China's gradual integration into East Asia's ICT value chain and the role of companies from East Asian neighbouring countries in how this integration evolved (Lee and Gereffi, 2015). Over time, some functions and tasks which were previously carried out in Taiwan, Japan and South Korea have been gradually transferred to mainland China as the regional value chain has evolved (Lee et al., 2016).

Part of the challenge, therefore, in seeking to develop more effective explanatory models in recent times has been that of achieving a better balance between focusing on local factors and conditions as opposed to emphasising the global (Sturgeon, 2003). The other important challenge in applying economic geography explanatory theories to the specificities of China is to sufficiently take account of the political economy dimension of China's development (Wang and Lin, 2013). For example, Jiang et al (2016, 662) seek to bridge what they see as a gap between Western and what they refer to as 'China-centric scholarship' in explaining the contribution which international transactions can make to indigenous innovation in China. Also, while Chen (2014) has noted how Suzhou's local government has had a specific policy of attracting not only lead companies to the region, but also the supplier networks of these companies, in an attempt to embed the investment locally, the potential for value capture by particular locations is also related to ownership of intellectual property (Grimes and Sun, 2016).

CHINA'S EVOLVING ROLE IN THE ICT GVC

Policy tensions between integration and autonomy

Because of these major challenges facing a late developer country like China, there is considerable overlap between attempts to conceptualise such challenges in a more interconnected world economy and efforts by policymakers to develop effective programmes to achieve the necessary balance between global integration and local autonomy (Liu and Cheng, 2011). In an era of globalised economic activity, however, policymakers, whose remit restricts them in many cases to their own domestic economy, tend to rely particularly on traditional conceptual models such as endogenous growth or trade theory to devise such programmes. Liu and Cheng (2011), in noting China's on-going dependence on foreign technology and its weak local innovation, wonder whether a transition economy in the context of globalisation can be successful in adopting an indigenous innovation strategy, and whether its domestic market can be sufficient to support such an inward looking strategy, while Jiang et al., (2016) suggest that international transactions by Chinese firms can make an important contribution to indigenous innovation.

A potential area of conflict, both theoretically and practically can emerge between the transnational nature of global corporations which exercise considerable power and control within global value chains, and the objectives and domestic-oriented policies of individual states (Wang et al., 2014). This can be particularly the case in technology areas such as telecommunications which are closely associated with national security and defence issues. In addition to this, being a late developer nation that has experienced rapid growth in the past 30 years has resulted in considerable tensions regarding international trade agreements, technology standards and the rights of nations to pursue their own development strategies (Ezell and Atkinson, 2014). Obviously global institutions such as the World Trade Organisation play an important arbitrating role when conflicting objectives in relation to trade agreements and regulations about foreign investment arise.

While one hesitates to over-emphasise any particular uniqueness in relation to its specificities, China has in many ways followed a similar development path to its Asian neighbours of Japan, South Korea, Taiwan and Hong Kong (Chen and De Lombaerde, 2013). Yet China's hybrid political economy of aggressive capitalism within a socialist framework creates particular challenges both for theoreticians and policymakers in getting the balance right between uniqueness and shared paths of development (Zhang and Peck, 2016). From a historical perspective, the rapid rise of such a huge country, accounting for one fifth of humanity occurring in a period dominated by expansion of the digital economy globally, presents some unique elements, including those of scale, speed of change and digitalisation. The rapid growth of its economic power in such a short period also presents challenges for the developed world and its dominant corporations for successfully integrating with China's economic system (Hout and Ghemawat, 2010). The ongoing debate about trade deficits between China and more developed regions such as the US is an example of the tensions associated with this adjustment.

With its late 'opening up' to the rest of the world, and its accession to the World Trade Organisation (WTO) in 2001, China presents a particularly important case study of ICT GVC integration partly because in a relatively short period of time it has become one of the most significant global locations for ICT production and assembly and increasingly for internet-related activity. Technology development generally and ICT activity in particular was prioritised early on as a major sector for economic development of the country. Much of the research has focused

on key policy issues facing China as a late developer in ICT which has been dominated for many years by a relatively small number of global technology TNCs, who, for the most part have controlled the trajectory of the technology. Initially, because of China's weak capabilities in this sector, there was a heavy reliance on attracting these global technology companies to invest in building up the sector in China, with the hope of bringing about a transfer of this technology to local companies (Grimes and Sun, 2014). China's sensitivity to its heavy dependence on foreign technology, particularly in the ICT sector which impacts on national security issues, has strongly influenced policy perspectives. The long term objective has always been to reduce this level of dependence on foreign IP and to enhance China's own technological capabilities (Liu and Cheng, 2011).

Many of the earlier studies focused on the role of foreign technology companies in China and on their impact on particular regions and on local technology capabilities. The earlier stages of policy, during the 1980s and 1990s, required joint ventures (JVs) between foreign and local companies, with the expectation that technology would be transferred to Chinese partners by means of spillovers (Zhou et al., 2016). While a greater level of scepticism might have been expected from Chinese policymakers based on the experience of foreign investment in other regions of the world, government authorities were limited in their bargaining power seeking to demand technology transfer in exchange for market access. During this early stage of development technology companies in the US and elsewhere were beginning to outsource and offshore their production and assembly functions to lower cost regions in Asia (Sturgeon, 2003). Partly because of the emergence of fabless semiconductor manufacturing in Taiwan and because of the significant capabilities of Taiwanese contract manufacturers of electronic products, much of this outsourcing focused on Taiwan initially, but over time began to be relocated to mainland China (Saxenian, 2007).

Because of the late-developer status of China some of the literature on China's integration into the ICT GVC has focused on the double-edged nature of this integration, the dangers of being locked into lower value added functions, and the challenges facing late developing nations in developing their own technology sector, particularly in the context of what is seen by some as an on-going hegemonic and oligopolistic control of the technology trajectory by mainly western countries and major global technology companies (Ernst et al., 2014). This historical hegemonic control relates to the major key nodes of technological innovation particularly in the west and the dominant role played by western countries and their large corporations in technology standard setting, accruing key intellectual property through patents and to some extent seeking to prevent potential competitor nations and companies from upending their market dominance. Late developer nations like China face enormous challenges in establishing their own domestic technology standards that are capable of winning wide acceptance internationally (Breznitz and Murphree, 2011). Because of the global nature of the technology sector, interoperability between electronic devices and their components is essential for success in internationalised markets. There is, therefore, from the outset, a fundamental tension between the need for late developing nations to be integrated in global technology development and the need and ambition of such nations to achieve some level of technology autonomy (Ernst, 2011). From a theoretical perspective this tension is reflected in the inability of endogenous growth theory, which sees knowledge as a highly localised public good and traditional trade theory, which emphasised domestic economies, to fully explain the interconnectedness of economic activity in the global economy (Wang and Lin, 2013).

The significant gap in technology development between China and more developed regions gives rise to a major topic of debate in the literature which seeks to specify the extent to which the locus of innovation in the ICT GVC has shifted to China in association with the major shift in ICT production and assembly operations. Although there continues to be widespread scepticism about the overall level of innovation in China's ICT sector, some have suggested that the locus of innovation has to some extent followed the shift of ICT production to Asia and particularly to China (Cooke, 2013). Other scholars, however, provide a more qualified evaluation of China's innovative ability in the ICT sector (Ernst, 2009; Breznitz and Murphree, 2011). There is little doubt that as the centre of gravity of ICT production has shifted to particular regions of China, over time local capabilities in technology development have increased, but major questions remain about the extent to which Chinese companies as opposed to Taiwanese and other foreign components suppliers continue to dominate the ICT GVC within China. Thus while the reconfiguration of the ICT GVC away from the US and Europe has not diminished technological inputs from these regions, particularly in high value added software components, China's significant role as a major global centre for ICT production needs to be contextualised within the broader East Asian production network, with Japanese, South Korean and Taiwanese companies playing major roles in added value activities through being major component suppliers for assembly activity in China (Lee et al., 2016).

Despite the many similarities in terms of development paths between China and its Asian neighbours, its own very specific ideological political economic system has strongly influenced its policy development in its search for greater technology autonomy (Lee et al., 2016). Having had little choice but to attract foreign technology companies as major investors to China initially, and having sought every opportunity to absorb technology learning from these investors, it appears that China is growing in confidence in its ability to replace many of these leading brand companies by developing its own brands. In relation to companies in emerging markets, Santos and Williamson (2015) argue that they can access brands, production modules, technologies and talent from global markets and use these assets to improve their competitiveness in home markets. Referring to Huawei's early success in the telecom's equipment market Lee et al (2016) argued that China's ability to leap to and Own Brand Manufacturing (OBM) without going through the Original Design Manufacturing (ODM) stage, resulted from its unique mode of learning from foreign bases.

While there is little doubt that China has achieved considerable success in recent years in replacing foreign brands with its own brands, a more fundamental issue is the extent to which asymmetrical relationships continue to characterise China's integration within the ICT GVC. At the macro-level, asymmetry of power relations continues since much of the intellectual property underlying the key components of electronic products assembled in China is derived from outside the country and continues to be controlled by a relatively small number of very successful global companies in key technologies such as semiconductors and operating systems, areas in which China continues to lag.

The shift towards indigenous innovation

The debate about asymmetry of power relations between lead companies and suppliers within the evolving ICT GVC has also been important, with the general assumption that lead companies have exercised significant control over suppliers in terms of contract conditions such as pricing and conditions relating to speed to market (Yang, 2014). With the growing extension of ICT GVC activity within China, the composition of supply chains and the exercise of power within them are important to understanding the nature of Chinese input and the benefits arising from participation. Although China's ICT sector had become increasingly integrated into the ICT GVC with a major shift in ICT production and assembly to China over a relatively short period, policymakers in China were beginning to rethink the cost-benefits of this integration and were determined to use their significant market bargaining power and a number of specific policy measures designed to restrict market access for foreign companies while boosting the efforts of Chinese companies to improve their technological capabilities (Zhou et al., 2016).

In the post-crisis economic environment, China faces many urgent developmental challenges, including the need to reconfigure its development away from the unsustainable world factory model to a profile of higher value added activities. This transition presents enormous challenges and is likely to take decades to realise definite progress (Chen and De Lombaerde, 2013). Although China continues to depend significantly on foreign technology, its political establishment tends to adopt a highly aggressive and techno-nationalist approach to these challenges, which are closely associated with state security and defence (Zeng and Fang, 2014).

Thus, China's emphatic policy shift in 2006 to 'indigenous innovation' revealed a particular disenchantment with its perceived lack of technology transfer by means of FDI (Grimes and Du, 2013). In some sense this might be seen as China's initial steps towards a form of 'decoupling' or at least an attempt to ameliorate potentially negative effects of being locked into low value added functions in the value chain (MacKinnon, 2012; Horner, 2014). China's policy environment has rightly been characterised as one in which structured uncertainty rules, being highly pragmatic and responsive to achieving the best possible returns for China's needs (Tang et al., 2016). However, despite its dissatisfaction with the pace of progress, China continued to depend on deep involvement with global technology companies since the complexity of the technology itself makes it difficult for emerging countries like China to develop a home-grown technology platform (Yu et al., 2014). Some scholars, however, question whether the goal of indigenous innovation is achievable, since few domestic technology standards have made an impact internationally and often don't meet the needs of local governments in China whose policies are focused on export-oriented businesses (Wang et al., 2014).

Despite this questioning, very specific rules were introduced after 2006 whereby only products and services with a certain level of 'indigenous innovation' would be eligible for sale in China's very large public procurement market. In addition to fears about protectionism, foreign companies were concerned about restrictions to selling products only in market in which the IP had been developed, which was contrary to the global model of such companies. While never clearly stated, it was generally accepted that this policy was to prevent foreign companies from dominating the local market by using instruments such as domestic technology standards, government procurement, and regulations about patenting locally. An example of domestic standards was China's development of the Time Division Synchronous Code Division Multiple Access Standard (TD-SCDMA) for 3G mobile telecommunications. While delaying the

introduction of 3G into China, its development provided experience for both Chinese engineers and telecommunications companies, which could in turn be used for developing the 4th generation wireless technology, allowing China to play a bigger role than heretofore in the development of global standards. However, Chinese scholars such as Liu and Cheng (2011) express some scepticism about the relative success of TD-SCDMA, arguing that even major State Owned Enterprises (SOEs) like China Mobile were reluctant to commit themselves fully to the project, while Breznitz and Murphree (2011) present a more negative evaluation of this experiment as an example of continuing interference of the Chinese state in the market.

After ten years of pursuing this policy, however, it is questionable whether such a highly integrated country in global technology developments can actually benefit by seeking to control developments within its own borders. Ernst et al., 2014 in particular have highlighted this dilemma facing China, arguing that whatever about China's techno-nationalistic ambitions, even its own private sector companies require easy access to global technology (Liu and Cheng, 2011). As often happens in China, policymakers can fall back on emphasising national political goals more than the fundamental requirements for technological advancement, seeking to benefit from globalisation on its own terms and achieving its technological goals by whatever aggressive means it sees fit, such as the acquisition of technology capacity from foreign companies (Hudson, 2016).

As China faces a growing number of challenges, including a decline in its labour force, the most recent policy shift, introduced in 2013, was the new manufacturing and technology drive "Made in China 2025" strategy, which seeks to deal with technical change arising from increased automation and use of robots and increased integration in global value chains. While the major technology challenges such as developing greater autonomy in areas like semiconductors and software architecture, which the indigenous innovation strategy sought to address continue to affect China's ability to determine its own future, it is clearly too early to speculate on possible outcomes of this new strategy which is likely to shape the future development of China's labour force.

The ICT GVC and supplier networks

Having considered the wider policy challenges facing China in seeking to pursue greater levels of national autonomy in key technologies, attention will now be turned to more specific empirical studies of China's evolving role in the ICT GVC, and the extent to which upgrading by local companies has been accomplished. There has been considerable interest in inter-firm and intra-firm networks with GVC studies paying particular attention to issues of governance and the exercise of power between lead firms and their suppliers. Initially, many studies tended to suggest an idealized top-down hierarchical model with lead firms dictating conditions to supplier companies. More recently a more complex model has evolved with shifts in asymmetrical relationships between lead firms and suppliers, with changing economic conditions in the post-crisis period, and with relocation to new locations of production, partly influenced by pro-active local government incentives (Yang, 2014). GVC studies have also examined shifts in the locus of innovation over time as supplier companies, particularly ODMs have acquired a greater range of capabilities and lead firms have been more willing to outsource a wide range of functions to

ODMs. Some have argued in favour of an ‘ODM model’ with ODMs becoming more involved in the innovative aspects of ICT production (Yang and Chen, 2013).

Global value chains can be conceptualized in terms of their evolution globally and regionally, or may be analysed in terms of how local regions within countries are impacted by their integration within these chains. Few studies succeed in examining the dialectical process both from inside a country like China and from without. The evolution of GVCs is closely related to the key role of global corporations in FDI, establishing subsidiaries in different global regions or extending their supply chains to these regions. In some cases as lead companies or even their key component suppliers or contract manufacturers relocate to a new location, they are often accompanied by a large number of suppliers, thus resulting in the transplantation of a supplier network from one location to another. The relocation of Taiwanese ICT supplier companies to the Chinese mainland, particularly after 2000, is a good example of this (Wei et al., 2012; Wei, 2015). They go on to explain that supplier networks in Suzhou, Shenzhen and Dongguan were dominated by Taiwanese companies who shared a similar culture and that gaps in technology with local companies were an obstacle to networking. The involvement of key technology companies such as Apple in China is associated with the existence of many of their major components suppliers and assembly contractors (Grimes and Sun, 2016).

In attracting and facilitating ICT investment, through providing incentives, technology park infrastructure, and plentiful technical skills, China obviously had its own national objectives and aspirations in terms of building up its own technology sector through technology transfer from foreign companies. But the nature of regional integration into the ICT GVC may hinder local embeddedness into the supplier networks of global lead companies. This lack of integration, for a variety of reasons including the low absorptive capacity of Chinese firms, has been a major subject of interest in many studies. The contrasting fortunes of Suzhou and Shenzhen, with Shenzhen being more successful in developing linkages between foreign and local companies than Suzhou, where local government policy favoured foreign companies at the top of the value chain, which created barriers to involvement by local companies because of their weak technological capabilities (Chen, 2014). In Shenzhen there was a strong bias in favour of foreign invested enterprises (FIEs) with the result that the complete supply chain was dominated by foreign companies and domestic suppliers were left at the bottom of the chain involved in low cost component supplies. In Shenzhen, on the other hand Chen argues that smaller FIEs at the lower end of the value chain were attracted, allowing local companies to upgrade their capabilities over time. Chen’s interpretation of these contrasting developments, however, may reflect earlier stages of development up until 2010/2011, with a more varied pattern of development evolving since then. In concluding that China’s earlier experience in benefiting from this integration was more favorable to foreign companies and not very beneficial to local companies, while being reasonably based on the empirical evidence, the major policy shift towards indigenous innovation from 2006 may reflect a flawed analysis of how to achieve the optimum advantage from such integration (Brandt and Thun, 2016).

A number of studies have been carried out on China’s ICT sector, looking both at the effects of FDI on the sector and also the potential for technology transfer and local firm upgrading (Yang, 2013, 2014a; Breznitz and Murphree, 2011; Sun et al, 2013). The prolific work of Yang (2013, 2014) on Taiwanese involvement in the evolution of the ICT GVC, particularly in the PRD

region, has been based on extensive company interviewing and has highlighted the challenges facing Chinese companies from gaining access to Taiwanese-dominated supplier networks (Yang and Liao, 2010). The low level of involvement of Chinese suppliers in Apple's supply chain in China also points to a more general failure by local companies to become significant suppliers (Grimes and Sun, 2016).

Although many studies have commented on the major shift or relocation of production from the earlier concentration of mainly Taiwanese companies and their suppliers in Guangdong in the PRD to Jiangsu in the YRD, apparently seeking a more sophisticated production environment, few studies have analysed more recent shifts to the interior regions of China. Yang and He (2016), however, have presented more recent data, supported by company interviews, which reveal a reduction in the contribution of Hong Kong/Macao/ Taiwanese companies in total electronics production in Guangdong from 72.7 per cent in 1998 to 40.9 per cent in 2009 with their contribution to exports dropping in the same period from 82.5 per cent to 40.9 per cent. The share by domestic firms in Guangdong during this period increased from 23.1 per cent to 43.9 per cent and their share of exports from 32.7 per cent to 68.8 per cent, revealing a significant shift in the overall profile of electronics production in Guangdong province, particularly the PRD region during this period.

Integration of regions within the ICT GVC can result in a complex landscape of both foreign and local companies playing a variety of roles either within or outside supply chains which tend to be strongly influenced or controlled by either lead or key supplier companies (Yang, 2007; 2013; Chen, 2014). The factors which influence the composition and profile of these supplier networks may depend on cultural affiliation, technology ability, quality of production and issues of trust such as in the area of intellectual property (Wei et al, 2012). In one study, Sun et al, (2013) focused on a 2006-2007 survey of 600 local Chinese companies within the supply chain networks of the ICT GVC in the three major mega-city regions of Beijing, Shanghai-Suzhou and Shenzhen-Dongguan. While noting that involvement in subcontracting with foreign or domestic lead firms should provide learning opportunities for local firms, they concluded that keeping the balance between autonomy and subcontracting is challenging with suppliers and lead firms having asymmetrical power relationships. By focusing only on Chinese supplier companies, however, in a sector in which many key suppliers are non-Chinese companies, and by seeing the transfer of technology only in terms of from lead firms to 'developing country' supplier firms may not do full justice to the more complex mixture of relationships within China's ICT GVC, which is relatively globalized. While it is reasonable to focus on the need for Chinese companies (as late developing nation companies) to upgrade their technological abilities and absorptive capacity, looking at this process in isolation from the complex networks of suppliers, composed of both foreign and local companies, provides only a partial insight into the evolving ICT GVC. In a study of strategies and tactics of Chinese contract manufacturers of western original equipment manufacturers (OEMs) in the apparel and electronics sectors in China, Sodhi and Tang (2013) portray a more complex relationship based around co-operation, competition and co-petition.

Using trade data for the period from 2001 to 2012, Sun and Grimes (2015) examined the changing trends in three categories of leading ICT companies in China, including own brand companies (OBMs), component companies and original design manufacturers (ODMs). ODM

activity expanded significantly during this period and is predominantly in the hands of Taiwanese ODMs, particularly Foxconn, which in turn have strongly asymmetrical relations with major client companies such as Apple, Dell and HP. Component suppliers, apart from the dominant role of Korean and Taiwanese companies in the TFT-LCD area, continue to be predominantly western companies with Samsung playing an exceptional role both as an own brand company and a major supplier. Thus while Chinese companies to date have performed poorly in both assembly and in supplying key components, a small number of Chinese ICT companies, while depending significantly on the capabilities of foreign companies, have developed highly successful brands. Their success raises interesting questions about the potential of native companies in an exceptionally rapidly growing market of enormous size of displacing global brands in a very different kind of marketplace.

A more detailed analysis of Apple's supply chain in China provides evidence of the dominant role played by foreign companies as suppliers of core and non-core components and in assembly functions, with limited participation by Chinese companies (Grimes and Sun, 2016). Thus, while there appears to be a tendency for core component suppliers to be located outside China for various reasons including IP protection, the fact that much of the final assembly of Apple products takes place in China creates a need for a range of both core and non-core component suppliers to locate some activities in China. The geography of intellectual property associated with Apple's supplier network reflects a company strategy designed to benefit from the comparative advantage of China as a location for more basic functions, while ensuring that the key intellectual property is developed in regions with higher levels of IP protection. An obvious consequence of the fact that much of the intellectual property for Apple's products originates in a small number of developed regions is that much of the value added arising from these products mainly benefits these countries of origin, while the direct benefits to China remain low despite having a significant part of Apple's value chain located in it (Dedrick et al., 2009).

Because of the increasing significance of China's domestic market both for local and global companies, China's policymakers seek to make maximum gains for local companies and the local economy by aggressively intervening in relation to market access for foreign investors. After an earlier period with greater dependence on foreign technology companies, with the emergence of local strong players in the market, China seeks to win whatever benefits it can in exchange for providing access to its market to foreign companies. There appears to be an on-going schizophrenic tension within China's policymakers and others between the acknowledged need to be connected and integrated with key global innovative milieu and the ideologically driven push for autonomous control of technology development within its own borders. Breznitz and Murphree (2011) convincingly argue that China's techno-nationalist approach is preventing an innovative technology sector from emerging in China. Ernst (2011), while appreciating the need China has to promote its own technology standards, argues because of the global nature of technology development in areas like semiconductors, China needs to get the balance right.

Thus while China's own weaknesses and challenges in developing technology independence, its large and growing market for ICT products does not afford it complete bargaining power with global corporations that exercise considerable power and influence in key technology development. Nevertheless, the Chinese state, perhaps in an unprecedented manner is not slow

about using many policy tools to demand advantages for its own companies, thus ameliorating the extensive power wielded heretofore by such global lead companies in the ICT GVC.

The China experience to date presents scholars with a challenge to reformulate their conceptualization of relations between the state and TNCs in the context of FDI. Although China's approach to attracting FDI has had many similarities to other countries, including some of its Asian neighbours, its strongly pro-active approach towards using its market as leverage for demanding technology transfer and other benefits from foreign technology companies has shifted the balance in this relationship. Whether the approach adopted by China will yield the results it seeks in the long term remains to be seen. Many scholars suggest that it may lose out on significant technology transfer because of the reluctance of global companies to risk their intellectual property in China.

CONCLUSION

This paper seeks to highlight the challenges faced by both theoreticians and policymakers in adequately conceptualising China's evolving role within the ICT GVC and the policy implications arising from it. As a late developing nation, that has experienced rapid and enormous growth since its opening up in 1978 and particularly since accession to the WTO in 2001, China faces considerable challenges in transitioning its development model from largely being the 'world's factory' to a more innovative economy. By focusing on China's role in the ICT GVC, some insights can be gained into the challenges facing such a late developer within a technology sector whose trajectory has been dominated by global corporations.

In terms of conceptualising these recent developments, this paper focuses particularly on the global value chain framework, which seeks to overcome the limitations of more traditional theoretical approaches such as endogenous growth theory and trade theory, which fail to take sufficient account of where value is created and captured within a more globalised economy. As China opened its economy to the world and became more integrated into GVCs including the ICT GVC particularly after WTO accession, it began to attract record volumes of FDI, including many global technology companies that were beginning to outsource and offshore much of their manufacturing to emerging regions. The modularised and fragmented production networks of global ICT companies began to take shape as regions in China presented attractive factors of production, particularly low cost labour, which gradually turned China into the world's major centre of ICT production and assembly. The complementarity between these new global business models and the opportunities presented by emerging regions like China was essential in contributing to a more interconnected global economy.

China's rapid economic growth has been accompanied by major changes in China's economy and society, with many decades of its one-child policy resulting in a falling labour force and ageing of its population, with wide scale environmental degradation resulting from rapid development associated with poor regulatory standards, and with a significant shock to its export processing model arising from the 2008 global economic crisis. This is the global context in which China's role within the ICT GVC has taken shape. All of these changes have created huge pressure on policymakers to devise the means of transitioning the economy to a model based on

higher value added activities. However, this second stage in China's development presents much greater challenges than the earlier period of attracting foreign investment after opening up.

The initial policy focus was based on exchanging market access to foreign companies in exchange for technology transfer, with many foreign companies before WTO accession having to form joint ventures (JVs) with local companies. During this earlier period, China's high level of dependence on foreign sources of technology placed it in a relatively weak position, and while some sectors such as telecommunications did benefit from technology transfer the overall level of technology spillovers from foreign companies was disappointing. Over time, China's technology capabilities have developed and this is reflected in the emergence of a small number of national brands which have been highly successful in competing with foreign brands in the domestic market and in some cases internationally. The emergence of China's major internet companies, albeit in a strongly controlled but intensely competitive market has also been impressive (Liu et al., 2015). The research to date, however, examining the top importing and exporting ICT companies in China reveals ongoing weaknesses in China's involvement in supplying core components such as semiconductors for global technology companies and also in the area of contract manufacturing which has been a huge growth area in the ICT GVC in China but remains largely dominated by Taiwanese companies.

Detailed analysis of Apple's supply chain both globally and within China also highlights China's weaknesses technologically, with very low levels of direct Chinese involvement. Globally the geography of Apple's supplier subsidiaries reveals an asymmetrical relationship between IP rich regions in the developed market economies, where most of the companies supplying core components originate and China as an IP weak region in which most of the assembly of ICT products takes place. The analysis also reveals the foreign domination of supplier networks in China, reflecting the continued control of key intellectual property by non-Chinese companies, despite the fact that many have some operations in China. Over time, however, the growing concentration of ICT production within China's ecosystem of supplier companies almost certainly points to greater levels of upgrading taking place.

Within the policy environment, continued dependence on foreign technology in key areas like semiconductors, but also in terms of the potential effects on national security and internal political control in China, are major concerns and the Chinese state is adopting a very determined approach towards reducing this dependence. The major shift from 2006 towards 'indigenous innovation' resulted in very specific measures related to domestic standards and public procurement market access with negative effects for foreign technology companies in China. The most recent development of this policy is the 'Made in China 2025' strategy, which further specifies how Chinese companies will be helped over time to replace foreign companies in the domestic market. Within this more recent policy period, and particularly since the 2008 global crisis, China's enormous market presents both a major attraction for global companies that need further market expansion to remain globally competitive and also a significant leverage for the Chinese state in its bargaining with foreign companies. This complementarity, however, between the current needs of China and the global ambitions of technology corporations reflects a considerable shift from the earlier period of China's higher level of dependence. Thus, despite the considerable technology steps which remain to be taken before China gains greater

technology autonomy, it is likely to be in a better position than previously to extract greater collaboration from foreign companies to achieve its ambitious targets.

Drawing upon the review of literature on China's integration into the ICT GVCs, this paper elucidates the emerging transition of China's innovation path from technology dependence towards greater innovation autonomy. To become an innovation nation, Chinese indigenous enterprises should strategically work with GVCs while avoiding being captured by the lead firms and strengthen the strategic control over the paths of China's technology development. Echoing the recent discussion on China's status as "an innovation state" (Zhou et al, 2016) and the path of China's innovation (Fu, 2015), this paper sheds light on the emergence in China of indigenous companies that can compete globally even in the most sophisticated technological sectors, including ICT. Since China's indigenous innovation is diverse across industries and enterprises and fluid over time (Zhou et al, 2016), further studies are needed to explore the technological trajectories of other sectors and compare among different regions and with other developing countries. Some pertinent issues warrant investigations, including the roles and changing positions of Chinese indigenous firms in various GVCs, the institutions and policies that facilitate China's transition into an innovation nation, and more broadly the social implications of China's innovation and contribution to global well-being.

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