Industrial organisation in China: Review of issues and conceptual framework

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Abstract

This document provides an overview of the literature review of approaches to industrial organisation, including an analysis of the global value chain approach. It was conducted by John Humphrey while visiting the Institute of Developing Economies (IDE-JETRO).

Keywords: industrial organisation, global value chains, transaction cost economics, innovation

1 Introduction

The objectives of the research project "Industrial organization in China: Theory building and analysis of new dimensions", which is being conducted by a team of researchers at the Institute of Developing Economies, are threefold. The first is to develop an improved understanding of the patterns of industrial organisation that lay behind the remarkable growth of Chinese manufacturing industries in the 1990s and in the first decade of the 21st century. The second is to understand the extent to which the industrial model underlying this growth is changing as a result of the rapid transformations of China's labour market and consumption patterns. The third is to consider the impact of possible changes in this industrial model in China on industrial development in countries in the south-east Asian region that have close trade and investment ties with China. A large part of the literature on Chinese development is focused on the country's role in the East Asian division of labour and its incorporation into global value chains. Nevertheless, the transformations of the domestic economy in China also deserve attention, and this paper provides an overview of the literature that feeds into the empirical analysis that is being conducted by the project.

Parts of the Chinese economy have shown distinctive characteristics over the past quarter century, with low barriers to entry, low levels of industrial concentration and considerable vertical dis-integration. These organisational features helped Chinese firms to be highly competitive in producing large quantities of undifferentiated products at low cost, responding to the needs of Chinese consumers and overcoming the limited technological capabilities of Chinese businesses. However, in some sectors, at least, there are indications that industrial structure and competitive strategies are changing. The research project will explore these changes and their implications for both China and its neighbours. The core issues for this research project concern the determinants of industry structure: the degree of concentration exhibited in different sectors of the economy, the extent of vertical integration (or dis-integration) in these sectors and the patterns of relationships that are established between the businesses operating in these sectors. There is a rich literature in this area. Significant contributions have been made by contractual theories, including Williamson's analysis of transaction costs and their implications for contractual arrangements. These contributions focus on the decision whether to produce a product in-house (make-in) or buy it from a separate business (buy-out). The same question is raised by knowledge-based and resource-based theories of the firm, and by the literature on modularity, which links the analysis of product modularity and modular design architectures to industry structure and the points at which transactions are best managed. Finally, global value chain analysis also addresses these issues, but from an emphasis on how businesses manage the buy-out option in different ways.

The following section outlines the distinctive characteristics of the "Chinese model" and then outlines the research questions that have been developed out of a consideration of this model. Sections 3-6 review the literature, starting with transaction costs theory, moving on to knowledge-based and resource-based theories of the firm, followed by modularity approaches and concluding with GVC theory. Section 7 examines challenges for GVC theory arising from the discussion of changes in Chinese industrial organisation.

2 Industrial organisation in China: characteristics and research questions

The research project starts from the existing literature on the Chinese model of industrial organisation and then raises questions for further study about how this model

might be changing. The first part of this section presents the distinctive characteristics of this model, as discussed by various authors, and the second sets out the research questions for the current project.

2.1 Characteristics of the Chinese model of industrial organisation

Industrial structure in China shows some notable differences to that seen in other countries, including Japan, the United States and India. These differences have been noted by various authors, and the results from a number of (mostly Japanese) researchers on these issues were collected in a volume edited by Watanabe (2014c). The research that led to these papers was carried out in the period up to approximately 2010 and presents a description of industrial structure at that time. In the introduction to this collection of papers, Watanabe summarises the salient features of this industrial structure.

Low levels of concentration across a range of sectors. While the Chinese economy does possess large companies, often former state-owned enterprises, there are a range of sectors in which levels of industrial concentration are substantially lower in China than in other countries. The differences in three firm concentration levels in China as compared to India and Japan (see Table 1) are substantial.

Table 1: Market shares of three largest firms in selected industrial sectors in China, India, and Japan (%)

Country / Sector	China (2005)	India (2004)	Japan (2003)
Air conditioners	26.5	48.2	45.9
TVs	28.4	55.5	49.6
Automobiles	27.2	79.0	55.6
Motorcycles	25.2	86.0	96.9

Source: Watanabe (2014a, p. 10).

The distinctive characteristics of industrial organisation in China are shown clearly in the automotive industry. This is an industry where a relatively small number of businesses tend to dominate. Outside of China, the countries with the largest number of automotive firms producing both the body and chassis in 2010 were the United Kingdom (26 companies) and Malaysia (21 companies). In 2009, there were 145 such

companies in China (Marukawa, 2009, pp. 173-174). In the same year, there were 54 different firms in China assembling at least 50,000 vehicles a year (Marukawa, 2014, p. 60). This low level of industry concentration was not the result of distortions in the Chinese economy. First, Marukawa (2014) argues that this level of fragmentation is not the result of government interference. In fact, he shows that the government regarded such low levels of concentration as undesirable and likely to create inefficiency. Low concentration occurred despite government policy, not because of it. Second, Marukawa shows that the large number of firms in the industry was not because there were many loss-making state-owned enterprises that were failing to exit the sector. Only eight of the 54 firms were loss-making in 2009. Third, there were few signs that this level of concentration was changing rapidly. Five years after Marukawa's data, in 2014, there were still 48 different automotive brands selling at least 50,000 vehicles, although some of these brands would have been owned, or part-owned, by the same companies.[1]

Vertical disintegration. In some sectors, there is also a high degree of vertical disintegration along the chain. This is particularly noticeable in mobile phones, where specialist businesses provide design services, moulds, procurement of parts, customised printed circuit boards and even assembly services to companies selling mobile phone handsets.

Technology platforms. Technology platforms are central to this pattern of industrial organisation in China. The proliferation of entrants was facilitated by the role of suppliers in providing key technologies in the form of technology platforms that lower barriers to entry. In the mobile phone sector, the literature emphasises the role of the Taiwanese chipset provider MTK in facilitating market access by providing easy-to-use chipsets that incorporated both hardware and software (see, for example, Yasumoto & Shiu, 2007). Similarly, Marukawa (2009, p. 177) points to the role of engine suppliers in reducing the cost of entry into the automotive sector, while Watanabe (2014b) discusses the role of technology providers in the air conditioning and TV sectors.

[1] Source: https://en.wikipedia.org/wiki/Automotive_industry_in_China. Marukawa's own data on new entrants shows that they were predominantly joint ventures or spin-offs from existing companies.

Limited technological capability. The product platforms used by Chinese companies in these sectors reduced the level of technological capability required to enter the market. For the case of LCD televisions, manufacturers relied on their suppliers for platforms (the 'system on a chip" that integrated many of the key functions of the television) that could be used without necessarily acquiring broad technological capabilities, and this allowed them to avoid heavy investments in R&D. In the case of mobile phones, the use of platforms combining software and hardware and the emergence of specialist design houses for the design of printed circuit board assemblies resulted in a similar economy of technological capability. The competitive advantage of these companies lay in controlling costs and their familiarity with particular segments of a heterogeneous Chinese market, not in the domination of relevant technologies. Kimura (2015) argues that this is a rational strategy to overcome the problem of limited technological capability. Businesses redraw the boundaries of the firm to buy in technology platforms.

Market platforms. The literature also notes the importance of market platforms in reducing the costs of both national and international distribution. Ding and Pan argued that "market platforms can resolve the issues related to the marketing capability shortages faced by firms in developing countries" (Ding & Pan, 2014, p. 15). Ding and Pan point to the role of specialised markets in providing low-cost access to a broad range of customers and the role of specialist service providers further in reducing transactions costs and simplifying buying processes.

Arm's-length market relationships. Despite the substantial amount of vertical dis-integration seen across a number of sectors, the literature characterises interfirm relationships as predominantly consisting of arm's-length market relationships. To the extent that business between companies involves exchanges of standardised products, this is the expected outcome.

While this industrial structure led to the emergence of many small companies, collectively they could acquire a substantial market share. Ding estimates that 2010 shipments of mobile phones from the informal *shanzhai* sector[2] reached 360 million

[2] The *shanzhai* sector can be defined according to its industrial organisation characteristics. Ding and Pan (2014: 122) refer to it as "low-end market oriented and is formed by a large number of loosely

units, or approximately one third of total production in China (domestic and export sales combined).

2.2 Research questions

The distinctive characteristics of industrial organisation in China lead to a series of research questions that are largely related to the determinants of industrial organisation. These questions, and the thinking that led to them are set out below.

Question 1. Do the characteristics of low levels of concentration, vertical disintegration, reliance on technology platforms and arm's-length market relationships constitute a distinct 'Chinese' model of industrial organisation?

The logic of this question is based on Sturgeon's (2002) identification of a new model of industrial organisation in the United States — modular production networks. He argued that there was a new and novel form of industrial organisation, and one which is spread to other parts of the world. Without arguing that this was the only way of organising production, Sturgeon did argue it was a form of industrial organisation that was different to other forms. This question can be reformulated into two questions.

Question 1A. What are the key features of the model of industrial organisation presented above in Section 2.1?
The idea of a "model of industrial organisation" is about linking, on the one hand, product and consumer features with, on the other, industry structure characteristics (levels of vertical integration/disintegration, levels of concentration at particular points in the chain, degree of product modularity, governance structures). Therefore, it is necessary to specify the causal links between product technologies, product architectures and market characteristics, on the one hand, and industry structure characteristics on the other.

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connected SMEs and a small number of platform providers who bear huge fixed costs." A similar approach is taken by Hu et al. (2013). Other authors emphasise illegality, fake products, etc. and refer back to the term's original meaning relating to lawlessness and people and areas beyond the control of the Chinese state (for example, Zhu & Shi, 2010, p. 31).

The argument behind this question is that the Chinese industrial model can produce low-cost products with limited product differentiation and is, therefore, most suited to a market where consumers are predominantly motivated by price considerations. One of the competitive advantages of this industry in the period up to (approximately) 2010 was a high degree of fragmentation, with specialisation and multiple businesses in each sector. This structure is associated with low costs, rapid response to new opportunities, and the ability to identify and serve consumer needs, particularly those of low-income and rural consumers. However, the same structure makes simultaneous and coordinated change along the chain more difficult to achieve. The model might be less effective in sectors where innovation and product differentiation are important sources of competitive advantage and profitability.

In exploring these issues, it will be important to establish whether these are characteristic specific to China, or of a particular type of industrial model more generally. It should be noted that Yasumoto and Shiu (2007) describe the characteristics outlined above — platforms, high levels of specialisation and vertical dis-integration — as features of standardised platforms rather than a distinctive feature of China. Similarly, Kawakami's description of the use of the 'system on chip' for the optical disk drive and TV sectors also described features that were not necessarily limited to China — even if they were more likely to be found in countries with less competent manufacturers. Therefore, it will be necessary to be careful about describing what are "Chinese" characteristics and what characteristics that are typical of standardised platforms in general.

Question 1B. Is the model observed circa 2010 a temporary phenomenon that occurs at a specific stage of development, or does it identify enduring and distinct characteristics of a range of Chinese industries?

While the evidence from mobile phone industry is that there have been substantial changes in the industry structure since 2010, the (limited) evidence from the automotive industry is that levels of concentration have remain unchanged and that many businesses continue to operate with a lower level of vertical integration than seen commonly in the auto industry. Establishing whether changes in industry structure are taking place across sectors will require investigation of the sectors associated in the literature with the 'Chinese' model. These are air conditioning/refrigeration, vehicle production, motorcycles, and televisions. This will involve finding data on trends in levels of concentration in these other sectors.

Question 2. How much does the 'Chinese' model depend upon large-scale domestic demand for undifferentiated and low-priced products?

Question 1A is concerned with the characteristics of a model of industrial organisation that appears to be very effective in producing low-cost, undifferentiated products. But how might this model be affected by changing consumer demand in China? The issue here is not to why consumer demand is changing, but rather to determine whether these changes lead to changes in industry structure. An alternative way of presenting this question would be to ask whether the 'Chinese' industrial model can meet the changing demands of consumers while maintaining its core characteristics of low concentration, fragmentation, vertical dis-disintegration and arm's-length market relationships.

Question 3. If changes in industry structure are observed, to what extent can they be attributed to changes in technology rather than changes in demand?

This is a corollary of the previous question. Changes in technology could have substantial consequences for industry structure. It might be argued above that all changes in technology must have some benefits for product purchasers, whether directly in the form of functionality and user experience, or indirectly in the form of cost reductions (and lower prices). However, in a globalised world this is not necessarily the case. Products produced on a global scale and whose degree of product differentiation across different markets is limited might experience technological changes that apply across the world irrespective of the drivers in particular markets.

Question 4. Can the 'Chinese model' of industrial organisation be transferred abroad as Chinese firms internationalise via exports or direct investment?

Fujita (2013a, 2013b) has analysed how Chinese motorcycle makers created a high degree of turbulence in the Vietnamese market — first by competing successfully against Japanese incumbent businesses, and subsequently by changing the product range and competitive strategies of these incumbents. But how much will these impacts change business structures, products and consumer demand in China change? One possibility is that the domestic and export markets would differentiate. Products no longer in demand in the domestic Chinese market might still be exported to low-income countries where such products remain attractive. As long as the level of demand in export markets is to sustain the industry without any complementary domestic demand, Chinese exporters could continue to prosper. The alternative is that the loss of the

domestic market undermines the capacity to compete in export markets. This may differ by sector.

Question 5. What does the Chinese model mean for our conceptions of industrial development and value chain linkages?

Much industrial development thinking, particularly in East Asia, has focused on 'catch up' and the acquisition of technological capability. The theory of 'latecomer firms' to the global economy (for example, Mike Hobday, 1995; Michael Hobday, 1995) suggests that developing country *exporting* firms encounter two penalties for their late entry into global markets: a technology gap (they do not possess the innovation skills, hard technology or capacity to absorb technologies that developed country competitors possess) and a marketing gap (they do not understand the characteristics of developed country markets). Examples of East Asian businesses starting with little knowledge of how to produce products and then becoming world leaders include South Korean firms in microwave ovens (Magaziner & Patinkin, 1989) and in the steel industry (Amsden, 1989), and more recently Taiwanese companies in flat panel displays (Zhang, Shi, & Wu, 2010).[3] Businesses, with varying degrees of state support, go about systematically acquiring technological capabilities through learning-by-doing (particularly through acting as assemblers or OEM manufacturers for multinational companies), licensing technology, investing in research and development of human capital formation, and taking advantage of support from publicly-funded innovation systems. The 'Chinese' model does not appear to have these characteristics. Businesses that have flourished in the early part of the 21st century did not appear to seek to acquire core technologies. If this model is sustainable and competitive, at least in some sectors, what does this imply for our conceptions of industrial development?

This paper focuses on the third and fifth questions — the determinants of industry structure and the implications for theory of recent trends in industrial organisation in China. The literature review focuses on two big questions for industrial organisation — the determinants of the boundaries of the firm and the management of inter-firm relationships. It covers four strands of literature: hold-up models, resource-based and

[3] A later analysis of this sector in Taiwan suggest that it was not able to maintain its competitive advantage (Ito, 2016).

knowledge-based theories of the firm, modularity theory and global value chain (GVC) theory.

These theories try to explain why firms exist at all, and also what determines the boundaries between firms. In a world of perfect competition, exchanges between economic actors are unproblematic. Actors possess perfect information about prices and production possibilities in the present and in the future. The resources (capital and labour) that would be used in production are perfectly fungible — in other words, they can be used to produce any product in the best possible way.

In this model of the economic world, life is lived in an eternal present. This is the world of the Walrasian auctioneer who matches supply and demand at a given point in time, with transactions carried out instantly and with no consequences for future rounds of bargaining (one of the consequences of assuming complete fungibility of capital). From another perspective, there is a future, but with perfect information about the future it is possible to account for all activities in this future through transactions that are made in the present. As Williamson argues, classical contracting tries to achieve this outcome through the idea of "presentiation" — dealing with future events by arrangements operating in the present (Williamson, 1979, pp. 236-237). One of the consequences of this approach is that there is no need for firms to exist. In a world of costless transactions and perfect information, individuals could contract individually with each other without ever having to create businesses. But, firms clearly do exist, and so explanations are required.

There are various overlapping literatures relating to the issue of the boundaries of the firm and how businesses manage inter-firm relationships. This literature review examines four of these: hold-up models, knowledge-based theories of the firm, modularity theory and value chains.

3 Hold-up models

Hold-up models are primarily concerned with why firms exist. As is noted by Holmström and Roberts, “the most influential work during the last two decades on why firms exist, and what determines their boundaries, has been centred on what has come to be known as the ‘hold-up problem’“ (Holmström & Roberts, 1998, p. 74). There are

two principal variants of these models: transaction cost economics, primarily derived from the work of Williamson, and property rights theories, developed by Hart and his collaborators. This literature review will focus predominantly on the former.

3.1 Transaction costs and governance, Williamson[4]

One approach to issues of industrial structure in the governance of interfirm relationships is transaction costs theory, as developed by Williamson. Williamson took up Coase's arguments about transaction costs and the reason why firms exist. His transaction costs theory jettisons two assumptions used in the perfect competition model. The first is the assumption of costless and complete knowledge, which is replaced by the idea of bounded rationality. In other words, there are constraints on the capacity of individuals and organisations to acquire and process information, and all information acquisition incurs costs. These limits on information acquisition and processing lead, among other things, to uncertainty about the future. The second assumption dropped by Williamson is fungibility of capital. He adopts the view that capital investment in the form of either productive assets or the development of organisational and personal skills creates specific capacities. For example, a machine embodies a specific technology and has a limited range of possible outputs. Investment in people and organisational structures creates abilities to do certain types of tasks better than others.

Even the combination of uncertainty about the future and non-fungibility of capital can be managed easily enough if the capacities can be used to make products that are bought by a wide range of purchasers (either the equipment itself is flexible enough to make a range of different products, or one type of product is demanded by a number of different purchasers). Problems arise when investments become increasingly transaction-specific. The specificity of an investment to a particular transaction is determined by the extent to which the asset created by the investment loses value if it employed for a different use. For example, if a group of people in an organisation have developed skills that are only needed to service one particular customer, the investment in developing the skills would be lost if no further sales are made to that customer. The combination of uncertainty and

[4] Clearly, Williamson's theorising evolved over a long period of time, but there is not scope in this paper to distinguish between different stages of his elaboration. On this point, see Gibbons (2010, p. 282).

asset specificity creates risks: businesses invest in the present in the expectation of returns in the future, but future returns could be lost.

Williamson's transaction costs theory explains how businesses use contractual relationships to manage these challenges. The argument is summarised in the following six points:

1. For any business, the cost of obtaining a product includes both production costs and the transaction costs incurred in managing the transaction.
2. Purchasing products from external suppliers has two key advantages over producing within the enterprise — economies of scale and risk pooling. In his early work, Williamson focused on the fundamental decision made by businesses whether to make a product in-house or purchase it from suppliers — the make-in or buy-out (MIBO) decision (Williamson, 1971). Suppliers can achieve the economies of scale associated with specialisation through pooling orders from several buyers. At the same time, they can pool the risk associated with demand fluctuations that affect particular businesses (but not the sector as a whole) by combining orders from multiple companies. These advantages depend upon supplier being able to use the same fixed and human capital assets to meet the needs of various buyers. In other words, the assets are not transaction-specific.
3. Despite these advantages, businesses may decide to adopt asset-specific technologies or employ asset-specific human resources if their use improves cost efficiency or product functionality. This reduces or eliminates the advantages of buying-out. The more specific the investment, the greater the loss of economies of scale. By definition, a specific asset is more or less specific to a particular transaction. In the extreme case, it would be specific to a particular customer and a particular transaction, with the result that the supplier would enjoy no greater economies of scale than if the buyer made the product in-house. Furthermore, asset-specificity will also lead to a loss of risk pooling.
4. Asset-specificity leads to a "small numbers" problem. The market changes from one in which the buyer has many potential suppliers and the supplier many potential buyers to one which tends towards bilateral monopoly — one buyer

and one supplier (Williamson, 1971, pp. 115-117).[5] The investments by the producer are specific to the buyer's purchases (no other buyers) and the supplier is the only business with any reason to make this particular investment (no other suppliers). If the relationship breaks down, the supplier is left with assets that will be devalued if they are used for other purposes (the definition of asset specificity) and if the buyer still wants to purchase this product it will have to make new arrangements for those assets to be available to a different supplier (or produce in-house).

5. This increases governance costs (the costs of arranging and managing the relationship between businesses). For Williamson, these governance costs are always related to the costs of dealing with opportunism (as discussed by Sturgeon, 2002). Williamson argues that "human agents are given to opportunism, which is a deep condition of self-interest seeking that contemplates guile" (1988, p. 68).[6] Scope for opportunism arises because of the combination of uncertainty and asset specificity.[7] Uncertainty means that contracts are necessarily incomplete because all future contingencies cannot be imagined. Asset-specificity opens up the possibility of one party gaining an advantage because of the possibility of the assets of the other being devalued if the relationship breaks down. Williamson argues that both asset specificity and uncertainty could still be managed if both parties could agree to deal with unexpected events in a fair manner (Williamson, 1981, p. 554), but he stresses that opportunism is always a risk. It is not necessary to assume that all businesses are opportunistic. As Williamson points out, "It suffices that those who are less opportunistic than others are difficult to ascertain ex ante and that, even among the less opportunistic, most have their price" (Williamson, 1979, p. 234).

[5] Williamson also discusses cases where asset specificity leads to bilateral oligopoly.

[6] "Guile" is defined by the Oxford English Dictionary as "sly or cunning intelligence", which means being willing to use deceit or take advantage of situations to benefit at the expense of others.

[7] According to Williamson, "Transactions conducted under certainty are relatively uninteresting" (Williamson, 1979, p. 253).

6. In the face of the risk of opportunism, businesses must find governance forms that lead to the lowest total of production and transaction costs.[8] Initially, this was presented as a choice between buying from suppliers (buying out, or market governance) or producing in-house (make-in or vertical integration/hierarchy). As asset specificity increases, the advantages of buying out (economies of scale and risk pooling) are reduced, and the costs of managing opportunism increase. As a result, vertical integration becomes more likely.

There are three notable features about this approach that are relevant for the development of a theory of industrial organisation. The first is that in this model vertical integration is always an option for firms to pursue when buying-out is no longer the low-cost option. As summarised by Marengo and Dosi (2005, p. 304), vertical integration will occur "whenever the workings of the market price mechanism incur costs that are higher than the corresponding costs of bureaucratic governance." This implies that the knowledge necessary for carrying out production tasks is freely available to businesses. More generally, various authors have pointed out that the transaction cost approach (in common with many economic approaches) assume that production knowledge is freely available and that businesses use the most efficient available technology in the most efficient way. The argument is expressed clearly by Langlois in the context of a specific discussion of Williamson on transaction costs:

> "In this literature, the world of transacting is a jungle of contractual hazards, asymmetric information, agency problems, and opportunism; by contrast, the world of producing – the business of figuring out what to make and of learning how to make it – is a carefree land of perfect information and given blueprints. But surely knowledge must be as imperfect and costly in production as in transacting.…a growing group of writers has begun to see as central the problem of how economic agents and their organizations acquire economic *capabilities* – the limited and costly knowledge of how to produce." (Langlois, 2003, p. 5)

[8] Williamson puts this in terms of identifying the most economical governance structure: "for each abstract description of a transaction, identify the most economical governance structure — where by governance structure I refer to the institutional framework within which the integrity of a transaction is decided. Markets and hierarchies are two of the main alternatives" (Williamson, 1979, pp. 234-235).

The second notable feature is that transaction costs are confined to efforts to deal with the problem of opportunism. Alternative perspectives, discussed further below, argue that there are other transactions costs — often referred to as "mundane transaction cost" — that have clear role in determining firm boundaries. Various authors have pointed to costs of coordination that arise during transactions that are unrelated to opportunism.

The third notable feature of the Williamson relates to how to reduce opportunism risk. Williamson argues that in the face of contractual complexity there are three options:

- Reduce transaction costs by eliminating the features in the product that require asset-specific investment. This means sacrificing functionality or cost by resorting to a more standardised product.
- Develop more complex governance arrangements to manage the uncertainties of the transaction — "preserve the design but surround the transaction with an elaborated governance apparatus, thereby facilitating more effective adaptive, sequential decision-making" (1979, p. 254).
- Vertically integrate (1979, p. 254).

However, as will be seen below, the analysis of Sturgeon (2002) and others on modular production networks argue strongly that mundane transaction costs can be reduced through the standardisation of interfaces between firms. Industry standards play an important part in this process. This point is taken up below.

3.2 Property rights theories

Property rights theories operate in the same broader terrain as that of the transaction costs approach. Once again, the issue is the make-in/buy-out decision in the context of bounded rationality (Aghion & Holden, 2011, pp. 182-183). Firms are treated as owners of assets that take decisions about whether to bring assets in-house, or allow them to be owned by another business (supplier or customer). The key factor determining this choice relates to how ownership impacts upon the incentives firms have to invest in assets and use them productively. In this sense, the theory differs from the transaction costs approach in that this introduces the issue of capabilities and productive efficiency. The locus of decision-making about the use of assets (and hence the quality or

timeliness of the product or service provided by the use of these assets) and how the distribution of bargaining power is affected by who owns the assets (Holmström & Roberts, 1998, p. 77), and this, in turn, has consequences for the division of the benefits generated by the joint activities of the businesses. In this case, distribution is not determined by opportunism, but by the bargaining powers granted by different patterns of asset ownership.

This means that the determinants of firm boundaries do not have to refer either to the presence of transaction-specific assets or uncertainty. As shown by Aghion and Holder, hold-up issues can emerge between two businesses even when there is no uncertainty about the future. Contracts are incomplete not only because they cannot be written so as to specify adaptations to all unforeseen future circumstances (which is the main issue broached by Williamson) but also because it is not possible to completely specify performance and provide means of verifying it.

The focus on incentives in the property rights approach highlights the importance of contractual arrangements in changing the level of efficiency at which firms operate, rather than merely distributing a set level of benefits between the parties. This issue is evident in the analysis by Bakos and Brynjolfsson (1993) of the optimal number of suppliers. This latter paper argues that if a company sources from a smaller number of suppliers any increase in supplier power resulting from the curtailment of range of options open to the buyer might be offset by the fact that each of the remaining suppliers would have a greater incentive to invest and to increase efficiency, given that the buyer is more committed to them.

This observation points to a more serious challenge, and one which is brought to the fore by Holmström and Roberts (1998). After discussing the relative merits of both the transaction cost and property rights theories of firm boundaries, they observe that many buyer-supplier relationships appear to be more complex and involve higher levels of interdependency than might be imagined from these theories. They point to buyer-supplier relationships in Japan, and in particular in the automotive industry, where an extensive literature grew up in the 1970s and 1980s on the existence of long-term supplier relationships, interdependence and support provided by buyers to suppliers. These issues are discussed further below.

4 Knowledge-based and resource-based theories of the firm

Knowledge-based theories of the firm start from the perspective that firms combine the knowledge of different actors. Within the firm, the goal is to minimise the costs of transferring knowledge. This means that when integrating the knowledge of different specialists within a production process, the goal is to restrict information transfer to that which is necessary for the overall efficiency of the operation. The aim is not for everyone to know everything, but each person to know only the minimum required for effective participation in the collective act of production. This is linked to the concept of "information hiding" within systems theory, which is discussed further below.

Particularly important in this regard is the distinction between two types of knowledge: implicit/tacit knowledge, on the one hand, and explicit knowledge on the other. This distinction is used in two different ways in the literature. The first is to argue that many aspects of production required tacit knowledge, and the integration of owners of tacit knowledge into teams requires firms, as argued by Grant (1996, p. 112):

> "the existence of the firm represents a response to a fundamental asymmetry in the economics of knowledge: knowledge acquisition needs more specialisation than is needed for its utilisation. Hence, production requires the coordinated efforts of individual specialists who possess many different types of knowledge. Yet markets are unable to undertake this coordinating role because of their failure in the face of (a) the immobility of tacit knowledge and (b) the risk of expropriation of explicit knowledge by the potential buyer. Hence, firms exist as institutions for producing goods and services because they can create conditions under which multiple individuals can integrate their specialist knowledge."

The second argument refers to the difficulties of turning knowledge into a commodity. Tacit knowledge, by definition, is difficult to transfer between actors. Explicit knowledge can be codified and transferred easily, but it is difficult for an owner of such knowledge to appropriate its benefits. It can be reproduced easily, and buyers need to obtain the knowledge in order to judge whether it is worth buying before the act of purchase (Grant, 1996, p. 112).

This line of argument can be extended to transfers of information between firms, and this provides a contrast between the transaction cost approach and a knowledge-based-approach, as discussed by Hoetker. In the context of a discussion about how businesses collaborate with suppliers during the design process, he states that:

> "One concern of the firm when organizing the production process will be to choose the supplier best able to produce each component….Transaction cost economics suggests that firms organize to minimize the risk of opportunistic behavior by the organizational units involved in the design process. The knowledge-based view suggests that firms organize to maximize the ease of communication— the transfer of knowledge—between the units involved in the product design process. These literatures also suggest strategies for achieving these goals and the resulting implications for the modularity of the firm's organization." (Hoetker, 2006, p. 502)

The strategies referred to by Hoetker include changing the points of interface between businesses (as will be discussed below) and codifying information so that the cost of transfer are reduced. This focus on the transfer of knowledge between "the units involved in the production design process" introduces a second category of transaction costs — those relating to coordination of knowledge flows rather than the management of opportunism. Clemons and Row described the difference between them:

> "We argue that it is useful to divide transactions costs into coordination costs and transaction risks. Coordination costs are the direct costs of integrating decisions between economic activities. Transaction risk is the cost associated with the exposure to being exploited in the relationship." (Clemons & Row, 1992, p. 11)

These coordination costs are also referred to as mundane transactions costs. The minimising of the costs of communication can be achieved without sacrificing functionality or cost and without resorting to vertical integration (as discussed at the end of Section 3.1 above).

Resource-based theories of the firm are closely linked to knowledge-based theories, with Grant arguing that knowledge-based theories are a variant of resource-based

theories. Grant (1996, p. 110) defines this theory in the following terms "The resource-based view perceives the firm as a unique bundle of idiosyncratic resources and capabilities where the primary task of management is to maximize value through the optimal deployment of existing resources and capabilities, while developing the firm's resource base for the future." In a similar vein, McIvor (2009, p. 46) states that the resource-based theory "views the firm as a bundle of assets and resources that, if employed in distinctive ways, can create competitive advantage."[9]

This view about resources and capabilities has implications for vertical integration. One argument is that it is not always possible for businesses to internalise activities, and therefore they may be forced to manage complex relationships with suppliers. Drawing on the work of Penrose, Gereffi, Humphrey and Sturgeon (hereinafter referred to as GHS) argue that vertical integration is frequently not available as an option to businesses:

> "The literature on firm capabilities and learning, by contrast, argues that the learning required to effectively develop the capability to engage in certain value chain activities may be difficult, time-consuming, and effectively impossible for some firms to acquire, regardless of frequency or scale economies." (Gary Gereffi, Humphrey, & Sturgeon, 2005, p. 81)

Making the same point 12 years earlier, Bakos and Brynjolfsson (1993, p. 38) outlined the implications:

> "Since there are a number of situations in which internal production is not a viable option, we start with the assumption that the decision to outsource is been made, and proceed to analyse the optimal strategy for a buyer firm that must choose the number of suppliers it will employ."

[9] Capability theories refer to resources/capabilities that are valuable (they enable a business to be competitive), rare (so that there are few other companies that have the resources), inimitable (not easily copied) and combined with an organisation that can appropriate the benefits arising from the deployment of these resources.

These two arguments explain why vertical integration may not be possible in all circumstances. It is equally possible to point to situations in which in contrast, vertical integration is the only option open to businesses. Langlois (2003) cites the case of the Ford Motor Company in the early part of the 20th century and its high levels of vertical integration. His explanation is that mass production required a new approach to the production of components and that existing suppliers were not sufficiently good enough or committed enough to meet Ford's requirements for quality and price. In these circumstances, it was better to vertically integrate until such time as a new supplier industry had developed. This argument is similar to the one advanced by Gawer and Henderson (2014) to explain Intel's shift towards greater vertical integration:

> "Intel's first entry into connector markets was in 1994, when Intel invented a new "bus architecture," the Peripheral Component Interface PCI, which increased bus speed by a factor of 5 and provided fast links to other crucial components of the PC, such as the hard disk. Intel first decided to leave the production and commercialization of the PCI to the traditional chipset makers on whom Intel had historically relied, but after being disappointed with their performance decided to enter the market itself." (Gawer & Henderson, 2014, p. 12)

These points can be reconciled along the lines suggested by McIvor (2009), who argues that the basic determinant of the choice to make-in or buy out is the relative capabilities of businesses and their suppliers. If a business has a capability advantage relative to its suppliers (or if suppliers do not exist – as Langlois argues is common when new industries emerge), the business will keep activities in-house. If there are more capable suppliers available, then it pays to contract out as long as the transaction costs are not too great.

This idea is taken further by Jacobides and Winter. They argue that "behind the facade of 'the market' lies another firm. 'The market' does not produce anything; it is the thin interface through which the product or service of another firm is purchased" (Jacobides & Winter, 2005, p. 398). This argument is used to point out that an individual firm does not decide on its own whether to buy out the product. There has to be another firm able and willing to make it. Furthermore, this other firm has to be able to do this more effectively than the potential outsourcing firms. Jacobides and Winter then use this

argument to suggest that the extent of vertical disintegration is associated with the degree of heterogeneity in capabilities within a sector. The more heterogeneous firm capabilities are, the more scope there is for buying out. It also follows that as heterogeneity increases and the benefits of buying out rise, so the importance of transaction costs will fall — greater efficiency in the firm selected for outsourcing offsetting the increased transaction costs. Conversely, the more homogeneous firms are, the more transaction costs come into play (Jacobides & Winter, 2005, p. 399).

5 Modularity theory

The third approach is modularity theory. This emerged out of systems thinking, and in the context of industrial organisation and interfirm relations the reference point is product architecture. Wikipedia provides an initial definition of modular design:

> **"Modular design**, or "modularity in design", is a design approach that subdivides a system into smaller parts called modules or skids, that can be independently created and then used in different systems. A modular system can be characterized by functional partitioning into discrete scalable, reusable modules; rigorous use of well-defined modular interfaces; and making use of industry standards for interfaces."[10]

A broad definition of modularity is provided by Schilling (2000, p. 312):

> "Modularity is a general systems concept: it is a continuum describing the degree to which a system's components can be separated and recombined, and it refers both to the tightness of coupling between components and the degree to which the 'rules' of the system architecture enable (or prohibit) the mixing and matching of components."

This argument contains a number of different elements of modularity. The first is separation and recombination. A modular product design allows for different elements of the product as a whole to be recombined. A number of different components can be easily included or excluded from the product. Good examples of this potential for

[10] https://en.wikipedia.org/wiki/Modular_design.

recombination are found in the microcomputer and stereo component industries, as discussed by Langlois and Robertson (1992). Second, the definition relates to coupling. In order for separations and recombination is to take place, there must be standard interfaces between the different components so that they fit together without further adjustments being required. Third, the quote refers to the "rules of the system architecture". A modular system requires both the specification of the overall architecture of the product, how modules interface, and a set of rules that specify the limitations on the design of each module that so that they function together correctly within the overall product. These latter are known as design rules and relate to the functions allocated to each of the modules and the interfaces between modules.

Modular product architecture is contrasted with integral architecture. In the case of integral product architecture, the various parts of a product interact strongly with each other. A change in one part of a product may have consequences for the functioning of one or more other parts of the product. This would then have ramifications for the design process.

The case of the bicycle industry provides a good illustration of both modular product architecture and situations in which this modularity might break down. An extreme example of a modular product architecture would be a racing bicycle in the 1970s. Its characteristics are discussed by Galvin and Morkel (2001). In spite of consisting of many discrete parts — frame, saddle, handlebars, brakes, wheels, cranks, gears, gear changer, etc. — it was possible to create a bicycle by purchasing each part from many different manufacturers and combining them together. This has four implications:

1. The bicycle has been partitioned and decomposed into modules. Different modules can be substituted without endangering the overall functionality of the bicycle. Different types of wheels could be used, different brakes, different gearing options, different types of handlebars, etc.
2. Langlois, referring to the work of Baldwin and Clark, characterises the partitioning of product design activities as a "partitioning of information into *visible design rules* and *hidden design parameters*" (Langlois, 2002, pp. 22, stress in original). The visible information is about the product architecture (what the modules are, what their functions will be, and how particular functions are mapped onto the physical components of the module), the interfaces between

the modules (how they connect together and what passes between them — information, energy, etc.) and the standards for checking both performance and compliance with the design rules. The manufacturers of each of the components follow the visible design rules. For example, brakes have to be fitted to the frame in such a way that the brake blocks can be put in contact with the rim of the wheel in order to reduce velocity. This requires that the frame and the placing of fittings for brakes are within certain established parameters.[11] It also requires that the wheels remain within a certain diameter. Wheel width could vary, but only within certain tolerances. Without design rules, modularity breaks down.

3. If the design rules do successfully reduce interdependencies between modules, this allows for what is known as "information hiding". The designer of the braking system needs to know relatively little about other parts of the bicycle. From the perspective of a knowledge-based theory of the firm, this reduces the costs of knowledge-handling. The more that information is hidden, the less resources are required to participate in the design process.[12] Or, seen from the opposite perspective, what happens within a particular module of the bicycle does not need to be transmitted outside of the module.
4. In order to create a modular system with design rules that preserve modularity, it is necessary that the interdependencies between the different parts of the product or system are well understood. These may be clear for a bicycle, but for a more complex product, it may be difficult to established these, and Langlois (2002, p. 23) argues that designing for modularity is difficult and incurs additional costs.
5. There may be reasons for the degree of modularity of a modular product architecture to be reduced. Williamson's discussion of asset specificity argues that businesses may choose to purchase products that require transaction-specific investments if this option increases cost efficiency or functionality. Similarly, if

[11] This places constraints on the designs of wheels and frames, and also requires the manufacturers of brakes to allow adjustments to adapt the product to all interfacing items that are within the design parameters.

[12] But, as has been noted elsewhere, changes in functionality or design can break down modularity. Mountain bikes, for example, were a new product in the 1980s that required a very different approach to brake performance and brake design.

a non-modular design option increases functionality, then modularity may be reduced.

Various authors have pointed to the competitive advantages of modular products. In particular:

1. Innovation is facilitated because complex systems are broken down into simpler components. As long as innovation takes place within modules and is constrained by the design rules, it is easier for businesses to undertake than in the case of complex, integrated systems. This applies within businesses as well as between them.
2. The commonality of parts and their reuse in a range of derivative products allows for economies of scale (the same parts can be used in different products) and economies of scope (it is cheaper to design second and subsequent derivatives than the original product).
3. Modular systems may be able to respond to diverse customer needs more quickly and at less cost than integrated architectures. Products variants can be developed that meet the specific requirements of different types of customers. Customers who require the functionality of high-fidelity music can purchase a sophisticated turntable system or an FM radio, while those that do not might be content with purchasing a cheaper turntable or radio. Both could be inserted into the modular music system (Langlois & Robertson, 1992).[13] Where there is need for adaptation because of evolving needs, or a changing external environment, modularity reduces the cost of adaptation (Baldwin & Woodard, 2009, p. 9).

In the case of bicycles, modularity partially broke down in the 1980s, as described by Fixson and Park (2008). Shimano undermined the modularity of the bicycle by introducing a drivetrain system that increased functionality in at least two ways — by allowing for gear changes to be made in discrete steps removing the requirement of the rider to judge whether the gear sprocket and chain guide were correctly aligned, and by adjusting the freewheel mechanism so that gear changes could be made while the rider

[13] Langlois and Robertson note, however, that the introduction of these technologies also depended upon the provision of complementary equipment/services such as FM broadcasts and high-fidelity vinyl recordings.

continued to apply power to the cranks. These required a degree of interaction between the different parts that the previous level of modularity. The drivetrain as a whole became a module so that items that had previously been designed and produced separately were now interconnected. But this did not necessarily reduce the modularity of this new module with respect to other parts of the bicycle, such as the frame, seat, bottom bracket, etc.

The discussion of de-modularisation of also makes a link between product architecture and industry structure. The argument of Fixson and Park is that prior to the 1980s the modular product architecture allowed for a large number of component suppliers and a de-verticalised industry with many specialist producers. After de-modularisation the parts were supplied by one company as a complete package, and this led not only to vertical integration across these various components but also to a rapid concentration of the industry, with a few key companies providing a large proportion of the total sales of these products.

This link between product architecture and industry structure has been discussed through the concept of the "mirroring hypothesis". According to Henderson and Clark (1990, p. 28): "We have assumed that organizations are boundedly rational and, hence, that their knowledge and information-processing structure come to mirror the internal structure of the product they are designing." This is explained in more depth by Hoetker (2006, p. 502):

> "Mirroring any product design process is a corresponding organization design process. For example, designing a new notebook computer model requires the design of the computer as a whole and of components including the hard drive, display, and keyboard. The notebook manufacturer organizes the design process by choosing a supplier for each component and structuring the coordination between them. During the product design process, which may last many months, the suppliers will develop their respective components, the firm will develop the end product, and they will all work together so that the individual components integrate effectively in the end product."

Baldwin (2008) provides an argument in six steps to explain this congruence between product architecture and the division of labour between enterprises:

1. The fundamental unit of analysis is not the transaction (as in Williamson) but the task.
2. Products are produced by a sequence of tasks, and this creates a task network consisting of nodes (the task themselves) and the links between the tasks. These links consist of transfers between the nodes. These transfers may be of information, materials, or energy (2008, p. 156). This is a network, not a linear sequence of transfers.
3. Transactions are particular types of transfers — those involving payment, and therefore transfers between enterprises. This involves mundane transactions costs (even in the absence of asset specificity) because in order for a mutually agreed transfer to take place, there must be agreement on how the products exchanged are defined, counted and compensated. This is part of transactional design, and therefore should not be considered as an exogenous variable (2008, pp. 164-165).
4. Within the task network, transactions are most likely to occur at "thin" crossing points. These are the boundaries of modules. Within modules there will be complex transfers of information that increase both mundane transaction costs and the likelihood of opportunism. Module boundaries are "thin" in the sense that a module is "minimally dependent on what happens in other modules" (Baldwin, 2008, p. 166). Therefore, information transfers are limited. A lot of information can (and should) be hidden within the module. In terms of knowledge-based theories of the firm, thin crossing-points economise on knowledge transfer. Dividing products into modules and defining "thin" interfaces that are not complex reduces "coordination costs and transaction costs across the module boundary" (Baldwin & Woodard, 2009, p. 8).
5. Conversely, where there are transfers at "thick" crossing points, turning such transfers into transactions creates many costs and allows for opportunism to emerge. Hence, the boundaries of the firm are likely to be fixed at crossing points.
6. The thickness/thinness of crossing points can be changed by various strategies, including introducing design rules, clearly identifying tasks and measuring performance and identifying and severing key interdependencies (Baldwin, 2008, pp. 174-175).

Thin crossing points favour markets and thick crossing points tend to lead to hierarchy. However, it is evident that some transactions take place at thick crossing points. What does modularity theory say about these situations? Baldwin discusses what might happen when information needs to flow across boundaries (with the implication that vertical integration is not an option). She considers "transactions located at thick crossing points in the task network" (2008, p. 169), taking the hypothetical case of the relationship between a company that designs and makes disk drives, and a company that designs and makes laptop computers. The case is set up so that there are interactions between the design activities of the two firms that would require iterative solutions. A "minimal transaction design" in which the laptop company just pays for finished disk drives runs into problems because cooperation is required in the design process, but is not rewarded. Baldwin (2008, p. 171) argues that:

> "In short, a minimal transaction at a thick crossing point is a hotbed of opportunistic behaviour. There is no direct compensation to either firm for transferring information, and there is no promise of a future relationship to provide indirect compensation. Self-interested agents will then skimp on information transfer; ex post holdups are likely; and defensive investments (on both sides) are rational and prudent."[14]

In contrast, a "maximal transaction design" is one where every part of the transaction is defined, counted, valued and paid for. This greatly increases mundane transaction costs, and it is difficult to introduce such a system when the characteristics of design collaboration themselves are so hard to define and anticipate. Paying for everything can also lead to the creation of activities just to ensure payment. In other words, Baldwin is arguing that this strategy does not work either. Businesses might respond to these challenges by changing the crossing point, or eliminating it altogether through vertical integration. However, Baldwin argues that adaptive, relational contracts are often suitable in such circumstances. In this sense, Baldwin follows Williamson's analysis of contractual forms.

[14] A defensive investment is one that seeks to offset transaction risk. In this case, the disk drive manufacturer might design drives that could easily be used by other companies (reducing asset specificity), even if they are not the best solution for the specific customer.

This argument about modularity and firm boundaries provides a deeper understanding of why transactions arise and the characteristics that they take. However, two shortcomings should be noted. First, the explanation of modules and boundaries largely takes place in the context of the clear understanding of the characteristics of modules and their interrelationships. It is not so clear how businesses deal with situations where current and future modules (and the relationships between them) are not fully understood. Second, unrelated to this, there is no discussion of risk and capability. Businesses are assumed to be capable.

5.1 Platforms and modularity

The concepts of platforms and modularity are closely related. A platform is a particular type of module. Baldwin and Woodard (2009, p. 6) use the following definition of a product platform, taken from Meyer and Lehnerd:

> "A product platform is a set of common components, modules, or parts from which a stream of derivative products can be efficiently created and launched."

By definition, a platform is modular. Baldwin and Woodard go on to argue that platforms combine stable core elements that have low variability but a high level of reusability in different products, with peripheral elements that have high variability and can evolve rapidly (2009, p. 7). The same common core can be combined with a range of other parts (modules) to produce a range of different products. They also argue that the variation in the peripheral elements means that the product must be designed to be modular, otherwise changes in the peripheral elements would require redesign of core components — the platform.

Not all modules are platforms. In the case of the stereo component industry analysed by Langlois and Robertson (1992), the different elements of a stereo system (amplifier, tuner, speakers, turntable, etc.) are modules that are compatible with each other and that can be recombined, but there is no common core that forms the platform.

In this paper, platform is used predominantly from the perspective of what Gawer calls an "engineering design perspective" (2014, p. 1240). From this perspective, the critical element of modularity is that a product (or part of the product) can be broken down into

discrete units that are connected in some way, but which have a limited effect on each other.

5.2 Tools for mapping interdependencies

Writers on modularity also provide ways of identifying and mapping interdependencies. Baldwin (2008), building on the work of Baldwin and Clark (2000), offers a number of different tools. In particular, she refers to the task structure matrix and the design structure matrix. A task structure matrix identifies the different production tasks carried out by agents (workers). Baldwin takes the case of a hook for an iron pot used for cooking in the preindustrial era (Baldwin, 2008, pp. 166-168). She argues that the team of workers involved in making the hook have strong interdependencies. They communicate with each other as they prepare the raw materials, heat them up, and turn them into a hook. It would not make sense to split this group. There is also a team of cooks that use the hook for the pots they use in cooking. Again, there would be a division of labour and coordination between the cooks in the preparation and cooking of food. Instructions would be given, the timing of activities would have to be coordinated, etc. The interaction between the two teams, however, need not be complex. There is a transfer of materials, but a well-established set of design rules for hooks suitable for cooking (suitable materials, range of sizes, load-bearing capacity, etc.) would make the interface between one team and the other "thin". Equally, this example shows the importance of information-hiding. The users of the pot do not need to know how it is made, and it would be inefficient for them to acquire this knowledge. It follows that in terms of a division of activities across enterprises, the best point at which to divide the activities involved in making and using the hook would be at the thin interface between production of the item (the hook) and its use in cooking .[15]

However, the discussion of industry structure and interdependencies in the modularity literature is predominantly focused on design interdependencies — the characteristics of product architecture that create thin or thick crossing points in product design, with their

[15] Obviously, one could develop this scenario further and consider the implications of changes in cooking technologies, the emergence of new requirements on the part of the cooking team, etc., and how these might be handled. There is a more theoretical discussion of the task structure matrix and different ways in which tasks can be structured in Baldwin and Clark (2000, pp. 59-62)

implications for the management of the design process and the coordination of design activities. There are various ways of constructing a design structure matrix (DSM),[16] but the approach used by Baldwin and Clark (2000) is used here. The design of a product will involve a number of different parts. Design decisions made for one part may have consequences for the design of other parts. For example, a decision to switch from rim brakes to disc brakes on a bicycle might have implications for the way cables are fitted to the frame, the placement of fixing points on the front and rear forks for the brake unit and the fixing of the discs to the wheels. A DSM lists all the design decisions for a product. This takes the form of a matrix. The matrix of design decisions has the sequence of decisions horizontally as column titles and vertically as row titles. An example is given in Figure 1 below. The bold X's represent an interdependence. The direction is from top line down the columns. So, design decision 1 has implications for decisions 2, 3 7 and 11. Design decision 11 has implications for decision 10 and also decision 3. The grey squares are blank because this is the intersection of the same decision.

In the diagram, the product has been divided into three parts each with four decisions. It is clear that quite a lot of the decisions take place within the boxes. Many decisions about each of the three components have impacts on other decisions about those components. The implication is that a team should be working together to manage these interdependencies. If all of the interdependencies were contained within the three square boxes, then the system would be completely modular. There are, however, some decisions that are being made that have consequences for design decisions made outside of these "modules". For example, Decision number 6 on the main board has implications for decision 8 on the main board, but also on decision 3 for the drive system and decision 10 for the LCD screen. An example of such interdependencies might be a decision about how much memory to put on the main board. If a small amount of memory is put on, then there might be much more caching of information on the drive system. There might also be less capacity for this video processing, which would have implications for what type of video card might be needed to process the amount of information required by the display.

[16] One source of information about this is Wikipedia — https://en.wikipedia.org/wiki/Design_structure_matrix.

Figure 1: Hypothetical design structure matrix

		1	2	3	4	5	6	7	8	9	10	11	12
	Decision 1		X	X									
	Decision 2	X		X	X								
	Decision 3	X					X					X	
	Decision 4		X	X	.								
	Decision 5						X	X					
	Decision 6			X				X	X		X		
	Decision 7	X				X			X				
	Decision 8						X						
	Decision 9										X		X
	Decision 10						X			X		X	X
	Decision 11	X		X									
	Decision 12										X		

Source: This model is a greatly simplified version of the task structure matrix in Baldwin and Clark (2000, p. 50).

In this model, the need for communication between the teams designing each module increases with each of the interdependencies that go beyond the module. Furthermore, it may be possible to find cases of "cycling" of decisions. This is shown in Figure 2. The arrows show that a decision about design item 3 has consequences for design decision 11. However, the matrix also shows that design decision 11 has an impact on design decision 3. Some degree of coordination would be required to prevent the designers going round in circles.

Figure 2: Hypothetical design structure matrix with cycling of decisions

		1	2	3	4	5	6	7	8	9	10	11	12
	Decision 1		X	X									
	Decision 2	X		X	X								
	Decision 3	X					X					X	
	Decision 4		X	X	.								
	Decision 5						X	X					
	Decision 6			X				X	X		X		
	Decision 7	X				X			X				
	Decision 8						X						
	Decision 9										X		X
	Decision 10						X			X		X	X
	Decision 11	X		X									
	Decision 12										X		

Design rules can eliminate some of these interdependencies. A design rule fixes in advance certain key decisions. Such decisions have to be made at the beginning of the design process as they would affect how the different design teams would need to interact. However, Baldwin and Clark argue that designers rarely start from a blank sheet of paper, and they will have had experience of other products and be familiar with typical problems that arise and known ways of managing them.

The impact of a design rule is fairly straightforward. Knowing for example, that there is an interconnection between decision 3 and decision 11 in the above matrix, a rule might be introduced that states some constraints on what can be done in the area covered by decision 3 so that its impact on decision 11 does not alter. This may mean that the decision-making element that causes decision 11 to have impacts on decision 3 could be eliminated.

6 Global value chains

GVC theory draws on the literatures just discussed. Its prime focus is the coordination of interfirm relationships rather than the boundaries of the firm. The GVC approach identifies the critical question as how to understand the expanded “middle” between market and hierarchy. GHS populate this expanded “middle” with three distinct types of intermediate governance forms: modular, relational, and captive. When these are added to market (buy-out) and hierarchy (make-in), the result is a typology of five governance types.

The analysis of governance has two distinct elements — the problem to be addressed by governance and the means through which it is addressed. This is seen clearly in Williamson’s work. His “problem” is defined in terms of the threat of opportunistic behaviour. The solution is to adopt "the most economical governance structure” (1979, pp. 234-235). The choice of an appropriate governance structure provides firms with the means to resolve the problem.

So what is the “problem” (or problems) that needs to be addressed by value chain governance? The ‘problem’ was formulated in a particular context. GVC analysis emerged out of earlier work on global commodity chains developed by Gereffi (1992;

1990). Gereffi was attempting to understand and characterise the phenomena of the increasing globalisation of production and the fragmentation of production processes across different companies and countries. Unlike many other writers, Gereffi also emphasised that there were new drivers of globalisation. He points to the role of retailers and branded companies in structuring global procurement and creating (or denying) opportunities for developing country manufacturers to enter major global markets (see, for example, Gary Gereffi, 1994). He refers to such companies as "manufacturers without factories" (Gary Gereffi, 1999, p. 46) in order to highlight that these firms were not themselves manufacturers but they had a big influence on how products were sourced, produced and traded.

As businesses sliced up the value chain and sought to reduce costs by relocation and outsourcing, they increased their reliance on these new supply chains. The subsequent discussion of the need for value chain governance by Humphrey and Schmitz (2004) highlighted two "problems" that required solutions. The first was product differentiation (or customisation). This is clearly linked to the preceding discussions about transaction costs, knowledge flows and modularity. The more that businesses try to differentiate products in order to offer a different value proposition to those of their competitors, the more they may be required to source non-standard products. The global brand companies and retailers highlighted by Gereffi and that had been studied by Schmitz (1995) and by Humphrey (Dolan & Humphrey, 2000) focused on product differentiation. In this context, the non-standard characteristics could relate not only to product design, but also factors such as just-in-time delivery, or the use of specific quality control mechanisms to manage quality. Businesses managing these complex procurement channels needed to minimise the mundane transaction costs arising from production fragmented across both businesses and locations.

The second "problem" identified by Humphrey and Schmitz relates to the risks buyers face from poor performance in value chains, particularly when such poor performance is not easy to detect or shows up when it is too late to remedy:

> "Buyers specify and enforce parameters when there are potential losses arising from a failure to meet commitments (for example, delivering the right product on time) or a failure to ensure that the product conforms to the necessary standards. These performance risks, relating to factors such as quality, response

> time and reliability of delivery, become more important as firms engage in non-price competition. For example, UK supermarkets place great emphasis on continuity and consistency of supply. The conformance risks [related to meeting regulations and standards] spring mainly from increasing concerns about product safety, labour standards and environmental standards. These mean that buyers (both retailers and manufacturers) in developed countries are exposed to the risks of loss of reputation if shortcomings are found at their suppliers." (Humphrey & Schmitz, 2001, p. 23)

This second problem has particular characteristics in the context of globalisation and the incorporation of new low-cost production locations in developing countries. The theory of 'latecomer firms' in the global economy identifies two gaps in competence faced by such firms. First of all, there is a marketing gap (businesses do not understand the characteristics of developed country markets). This gap increases to the extent that the businesses described by Gereffi focus on design and product differentiation as sources of competitive advantage. Second, there is a technology gap — developing country businesses did not possess the innovation skills, hard technology needed to meet the production quality requirements of these new global customers. Further, they might even lack the capacity to absorb the soft and hard technologies to bridge the gap. In the face of these problems, global buyers have to communicate their requirements efficiently, monitor the performance of their suppliers and also, where necessary, improve their capabilities.

For this reason, the question of supplier competence becomes central to how firms go about governing value chains. Property rights theory might analyse this issue from the perspective of incentives and the capacity to monitor relevant performance characteristics, and this would determine the make-in/buy-out decision. Businesses choose between using the market and the price system or internalising production and using hierarchical control to direct the behaviour of employees. Value chain analysis views this from a different perspective. It emphasises the potential for forms of governance between market and hierarchy to allow the potential for control without ownership. The 2005 GHS paper uses the concept of "explicit coordination" to express this idea. The term is used 20 times in the paper. It is never defined clearly, even though a reference is made in a footnote to an article by Clemons, Reddi and Row (1993). A

clearer explanation of what the term's meaning is provided in a slightly earlier paper by Clemons and Rowe (1992) that defines explicit coordination as:

> "Explicit coordination is the extent to which decisions reflect and are tailored to a specific relationship, and is distinguished from the implicit coordination of the 'invisible hand' of market competition." (1992, p. 10)

For Gereffi, Humphrey and Sturgeon, this coordination can refer not only to the mundane transactions costs involved in transferring information between firms, but also to the monitoring and control of the behaviour of one business by another. This is similar to arguments put forward by management theorists.[17] For example, Hennart argues that the two fundamental ways of organising cooperation (price and behaviour control) should be distinguished from the institutions that are used to put them into effect:

> "there are only two generic methods to organize cooperation, the exchange of outputs guided by prices and the direction of behavior under hierarchy….Institutions, i.e. markets, hybrids, and firms, combine these two generic organizing methods in variable proportions, with markets using mostly price incentives, but also some behavior constraints, firms using mostly behavior constraints, but also some price incentives, and hybrids using a more equal mix of both" (Hennart, 2013, pp. 5-6).

In other words, the price mechanism is not used solely by market institutions, and behaviour control is not used solely by hierarchically-organised businesses. Value chain analysis argues that behaviour control is used in inter-firm relationships in order to control supplier performance. This is particularly important in circumstances where it is impossible or too costly to monitor performance through testing outputs. Behaviour controls allow the monitoring of processes and procedures within the supplier's operations, as well as mechanisms to incentivise compliance. Such controls may be costly, but in the same way that products standards can create thin crossing points between enterprises (see the discussion on modularity above), so the introduction of

[17] This was not clear to GHS at the time, however.

process standards can reduce monitoring costs, or transfer them from buyer to supplier.[18]

The different ways that value chain analysis draws on the perspectives discussed earlier in this paper are summarised in Table 2. For all the theories, "market" is not a problem. Arm's-length market relationships can manage many types transactions. All of the different theories are more concerned with how to manage more complex transactions. Hierarchy — the other end of the spectrum — is not so easily managed. For Williamson, hierarchy is always an option, and value chain analysis follows this perspective. Hierarchy is presented by GHS as the option to be taken up when none of the other four forms of governance are likely to be efficient. The weakness of this argument is that it does not consider the shortcomings of hierarchy. The limitations and costs of hierarchical governance in the context of international business are the central concern of internalisation theory in management theory (see, for example, Buckley & Casson, 2009). This issue also arises in property rights theory (Gibbons, 2010: 283).

The next governance type for GHS, modular, is strongly influenced by Sturgeon's 2002 article on modular production networks. Sturgeon drew heavily from knowledge-based theories of the firm and work on modular product architecture and production systems. He argued that "electronics design and manufacturing technology have become increasingly codified and standardised" (Sturgeon, 2002, p. 476), resulting in low levels of asset specificity – machinery can be used for a wide variety of customers — reductions in mundane transactions costs and a much lower level of transaction-specific investment. Sturgeon argued that:

> "In the modular network, supplier firms take a 'full-service' stance toward their customers, providing turn-key services that require very little support or input—beyond design specifications—from customer firms….However, transactions may be frequent and important to both parties in the modular network, with a great deal of value and codified information flowing across the inter-firm link. This feature points to a key qualitative difference between the rich streams of data to flow across the inter-firm links in the modular network and the simple price information specifications that form the basis of the traditional

[18] On this point, see the discussion on private standards by Henson and Humphrey (2010).

> characterisation of arm's-length market transactions" (Sturgeon, 2002, pp. 483-484)

It follows that no special governance arrangements (contractual modes from Williamson's perspective) would be required to manage these relationships, but Sturgeon is arguing that the knowledge flows themselves constitute a distinct type of governance arrangement. This perspective is the one used to identify the modular value chain governance.

Table 2: Explanatory factors in value chain governance typology

Governance Form	Opportunism risk	Knowledge-based approaches	Capability-based approaches
Market	In all three cases, market transactions are handled easily. Market transactions involve standard products and simple transfers of information. Mundane transactions costs are low. They involve many buyers and sellers, and so there is no issue of asset-specificity. With many buyers and sellers, firms with the requisite capabilities can be found easily.		
Hierarchy (vertical integration)	Asset specificity leads to the use of hierarchy.	Complex, uncodified information creates high levels of mundane transaction costs. These are best managed within the enterprise if the pertinent capabilities can be acquired.	It is assumed that capable suppliers are not available. If they were, relational value chain linkages might be used.
Modular	For Williamson, the modular form is equivalent to market, as there is no asset specificity involved.	Products are customised to customers' needs, and this requires knowledge transfer. However, the cost of transfer are lowered through codification and standardisation.	Suppliers are assumed to be capable, as discussed by Sturgeon (2002). Supplier specialisation may lead to further capabilities being developed over time.
Relational	High levels of asset specificity require specific governance arrangements to prevent opportunism. Joint ventures are one such mechanism.	Businesses combine competences and solve complex problems jointly. Therefore, information flows will be complex, uncodified and costly.	In a relational value chain linkage, both businesses bring distinct capabilities to the relationship.
Captive	To the extent that buyers need to invest in suppliers, these will be asset-specific investments	Knowledge transfer is codified and easy to handle.	Supplier capabilities are limited, and therefore they need to be developed with the help of the buyer.

The fourth governance category is relational governance. The argument about relational governance refers to mutual dependence between the parties and high levels of asset specificity, and draws on both network theory (which Williamson (1993) views

sceptically) and Williamson's own arguments about hostages and credible commitments (Williamson, 1983) to explain how such dependence might be managed. The obvious reference point for this literature is the analysis of joint ventures between businesses that need to share complex, hard to imitate/develop competences. However, such industries were not the focus of GVC analysis at the time, and it has not figured prominently in the GVC literature.

The final category, captive governance, introduces an explicitly transaction costs-based focus, identifying transactional dependence as a strategy by large buyers to lock in suppliers and protect investments made in them by the buyers — "encouraging the build-up of transactional dependence as lead firms seek to lock in suppliers in order to exclude others from reaping the benefits of their efforts" (GHS, page 86-7). The idea of captive governance is drawn from two sources. The first is the literature on Japanese businesses and *keiretsu* networks. In this case, large companies invest in a captive supplier network, in part to upgrade the capacities of their suppliers so that they can meet exacting requirements. Here, a transaction cost argument could be employed, but equally it might be argued that the "captivity" expresses a commitment on the part of the large, buying company to support the supplier and to invest in the improvement of its capabilities. The incentive structure that this offers might be analysed from a property rights perspective.

The second point of origin is Humphrey and Schmitz (2000, p. 4), who introduced it as one of their four categories of value chain governance, calling it "quasi-hierarchy". It was introduced to provide an understanding of how companies would integrate into their value chains suppliers that would perform a limited range of functions, often with a substantial amount of supervision and technical assistance from the buyers. The GHS discussion of the apparel industry (GHS, pages 91-92) refers to the development of captive networks, putting particular emphasis on the cost advantages of sourcing from low-wage locations. This raises the question of why buyers would choose to source from suppliers with low capabilities rather than operate their own factories in the same locations. There are two lines of argument on this point. The first is that international businesses would not have the local knowledge required to operate efficiently in the new locations, and that in the case of the garment industry and similar industries that use well-established technologies, the offsetting advantages of directly managing production would be low. The second explanation, and the one generally favoured by

value chain theory as, is that the highest profit margins are achieved in design and marketing, which makes investments in production less attractive.

The consequences of sourcing in this way is that global businesses rely on producers that might not have the experience and capabilities to meet the requirements of these globalised chains, resulting in supply failures that are not the result of a lack of "willingness" or opportunism, but rather a lack of capability. It follows that if buyers invest in the capabilities of suppliers, they will not wish the suppliers to use these capabilities to benefit their competitors. Therefore, it pays to adopt mechanisms to make suppliers "captive".

GHS do not see these factors as static. First, following the reasoning of David (1995), they refer to cycles of standardisation and innovation. Standardisation has many advantages in terms of cost and efficiency, but innovations that undermine standardisation may provide greater functionality or lower costs. Second, suppliers may acquire new capabilities over time, through learning-by-doing or through investments in capability by the supplier and the customer, but these value chain capabilities may be undermined by two factors. Establish suppliers may be substituted by new ones as buyers search out new-low-cost locations, and markets and buyers may place new requirements on the supply chain, with the result that new "incapabilities" are created. Such new requirements may arise from opportunities for increasing the functionality products or from external pressures, such as social demands for greater knowledge about the social and environmental impacts of production.

7 Challenges for global value chain analysis

The research programme focuses on transformations in Chinese industries. It is fundamentally about changing industry architecture. This is defined as "templates that emerge in a sector and circumscribe the division of labour among a set of co-specialised firms" (Jacobides, Knudsen, & Augier, 2006, p. 1201). The industry architecture includes levels of concentration at particular points in the value chain, the extent of vertical integration and disintegration in the sector and the way in which interfirm activities are coordinated (value chain governance). While GVC analysis provide insights into industrial organisation, it is important to recognise that the specific case of domestic industries in China also highlights some areas where GVC analysis needs

further development. Three particular are outlined here: the role of lead firms, supportive value chains and the analysis of upgrading and innovation.

7.1 Lead firms

GVC theory puts considerable emphasis on the role of lead firms in shaping value chains. However, the term itself is not clearly defined. Gereffi *et al.* (2005) refer to "lead firm" 27 times, mostly with the meaning of businesses making decisions or coordinating chains, but they do not provide a definition. One way of approaching the idea of the lead firm is to refer to businesses that decide to place a product on the market. Sturgeon (2001, p. 11) states that lead firms are "firms that initiate the flow of resources and information through the value chain by developing and marketing final products."[19] This might be taken to indicate that any firm that takes a decision to initiate production qualifies as a "lead firm", even if they rely totally on readily-available parts and components. In such a case, a small company starting production using entirely of off-the-shelf products (i.e., no customisation, no need to engage with suppliers) and using modular product architecture and well-known principles to assemble the product would count as a lead firm.

However, Sturgeon immediately refers to "initiating and in many cases governing the flow of value creation", implying that lead firms must be playing a much more active role in determining how chains function. Lead firm shape value chains, and this is the way Gereffi, Humphrey and Sturgeon have used the concept in their own work. In Humphrey's first paper on horticultural value chains, there is reference to four key decisions in the value chain that are made largely by supermarkets (Dolan, Humphrey, & Harris-Pascal, 1999, pp. 18-21). These are:

1. Choosing the characteristics of the output of the chain (i.e., selecting the characteristics of the product and hence the target market — typically, in situations where product differentiation is an element of competitive strategy).
2. Inclusion/exclusion — supplier choice. The most visible aspect of this is the impact on individual suppliers, particularly de-listing of suppliers following unacceptable performance. However, the paper says that the more strategic

[19] Cited by Kawakami (2011, p. 19).

decisions relate to sourcing strategies: the number of suppliers, where they are located, etc., and this may include specifying to importers what types of businesses they work with and which countries to source from. Later, these decisions also included ones about the adoption of the mostly private standards to be implemented at farm level and in food processing.

3. Distribution of activities. In horticulture, some activities such as packaging and food processing could be carried out in the country of origin, or the destination country, or even elsewhere. Supermarkets played a role in making this choice, with processing and packaging moving from the UK to sub-Saharan Africa. Such decisions may be complex. A UK fish company has chosen to transport fish caught in the Arctic Ocean to China for processing before it is sent to the UK for incorporation into ready-meals.
4. Monitoring performance. As the performance of the supply chain has nontrivial consequences for supermarkets, they also choose how to monitor chain performance. This can be done through direct monitoring of suppliers, but manufacturers and retailers have increasingly turned to the use of private standards for this purpose.

Gereffi, writing at the same time but independently, also employs this type of reasoning. In his seminal 1999 article, there are seven references to lead firms, all referring to the role of such firms in organising value chains:

> "From a global commodity chains perspective, East Asia's transition from assembly to full-package supply derives in large measure from its ability to establish close linkages with a diverse array of **lead firms** in buyer-driven chains. **Lead firms** are the primary source of material inputs, technology transfer, and knowledge in these [East Asian full package supply] organisational networks. In the apparel commodity chain, different types of **lead firms** use different networks and source in different parts of the world." (pages 38-39)
>
> "upgrading does not occur to a random set of capital-or skill-intensive industries or activities, but rather to products that are organisationally related through the **lead firm** in global commodity chains." (Page 39)
>
> "At the organisational level, industrial upgrading in East Asia's apparel commodity chain was produced by the information flows and learning potential associated with the buyer-seller links established by different types of **lead**

> **firms** (retailers, marketers and manufacturers), and also by a distinctive pattern of organisational succession among these **lead firms**, who placed varied kinds of demands on their overseas suppliers." (Page 52).
> "The **lead firms** in these manufacturer-centred and retailer-centred networks in the North American apparel commodity chain are in a position to play a direct role in upgrading Mexican domestic industry." (Page 68)

A 2013 paper by Gereffi and Sturgeon (2013) also uses the expressions ''lead firm(s)" 19 times in the same sense of making key decisions in driving the organisation of chains, although it does explicitly address the issue of the emergence of new lead firms, including in developing countries.[20]

This concept of lead firm is closely linked to the idea of "explicit coordination" (see the discussion above in section 6). This refers to the active coordination of relations between businesses that takes place once decisions have been made to transact. GHS go further by assuming that one party to these transactions (the lead firm) will have a determinant role in decision-making. From a GVC perspective, the shaping of value chains by lead firms through explicit coordination is the main way in which value chains are shaped. However, the analysis of technology platforms (and possibly two-sided market platforms) show that this is not the only way that value chains can be shaped.

The role of the Taiwanese company, MTK, in providing platforms for mobile phone handset providers China in illustrates the issue clearly. As has been discussed by many authors, MTK played a key role in shaping value chains for mobile phones in China. Its decision to extend the range of functions (both software and hardware) contained within the chipset made this product more modular and facilitated its adoption by downstream businesses. It enabled the entry of new businesses into the sector and facilitated low levels of concentration and high levels of fragmentation. It also changed the distribution of activities along the chain through its bundling of functions (including software) into the core chipset. In this sense, MTK opens up and closes down different possibilities along the chain. Nevertheless, this was achieved without explicit coordination. The key choices made by MTK did not require transaction-specific communication/coordination

[20] See also the influential paper on GVC methodology by Kaplinsky and Morris (2001).

with any of its customers. If companies such as MTK can be considered "lead firms", they are not leading in the same way as the businesses described in GHS.

This issue is not confined to China. It applies to many cases where companies have an impact on industry architecture, and it has been studied by various authors. In the case of the computer industry, the analysis of Intel's platform strategy by Gawer and Henderson (2014) shows clearly how Intel reshaped the division of labour by incorporating more functions into its own chipset. Once again, it would be possible for Intel to do this without explicit coordination along the value chain. It would be necessary to communicate the implications of product strategy to buyers of the product, but this communication would be directed to buyers (actual and potential) as a whole. In fact, companies in this situation may try to have their innovations adopted as industry-wide standards, which further breaks the link between supplier and buyer.

Jacobides *et al.* (2006, p. 1208) refer to this as "engaging in architectural manipulation", and they argue that it is used to facilitate value capture by innovating companies. Again, referring to the computer industry, and the cases of Microsoft and Intel, they suggest that:

> "What Intel and Microsoft have done…is to shape the architecture of the PC sector. Through a judicious use of standards, they *facilitate* entry and competition in the complementary assets (anything but their core activities), *without* participating actively in these parts of the value adding process. So the success of Intel and Microsoft can partly be attributed to the creation of *convenient rules of the game* that insure they will end up with the lion's share of the benefits although their activities have been joined with many other parties." (Jacobides et al., 2006, p. 1208, stress in original)

7.2 'Supportive value chains'

The second aspect of the MTK case that provides a challenge for GVC thinking is the role of the company in facilitating adaptation of its technology. The role of MTK in providing engineering support to customers and facilitating the use of platforms through the provision of reference designs is widely documented in the literature. Such practices are by no means limited to the mobile phone sector. The support by technology

providers to technology users is seen across many sectors in China. It reflects the limited technological capabilities of the technology users. How is this support to be characterised?

Marukawa has argued that this represents a new form of value chain, the "supportive" value chain. Referring to practices in the automotive, mobile phone, television and personal computer industries, he argues that the relationships between technology provider and customer do not correspond to any of the categories provided by GHS. The description of relationships in the automotive industry illustrate the problem clearly:

> "According to Yanfeng Visteon a foreign-invested supplier of cockpit modules to various automakers in China, international automotive manufacturers such as Shanghai Volkswagen and Shanghai General Motors design the modules and procure the dashboard instruments (such as the speedometer and fuel gauge) that form the parts of the modules themselves. Yanfeng Visteon's role in the transaction with these foreign joint ventures then is only to assemble the cockpit modules using the parts supplied by these ventures according to their instructions. However, in transactions with domestic automakers such as Chery Automobile, Beiqi Futian Automobile and Brilliance Jinbei Automobile, Yanfeng Visteon not only assembles the modules but also designs them and procures the necessary parts. This shows that Chinese automakers depend on the experience of foreign-invested suppliers for the designs of cockpit modules, which are an important part of the car's interior." (Marukawa, 2014, pp. 57-58)

Marukawa goes on to argue that this relationship is driven by a lack of capability in the technology user. Whereas global value chain analysis, which originated in the discussion of the incorporation of developing country suppliers into global supply chains has focused on limitations in supplier capability, in China the lack of capability lies with the downstream user, rather than the upstream supplier. [21] Marukawa introduces the concept of "supportive value chain" to describe the relationship.

[21] This issue is also discussed extensively in for Fujita's analysis of the Vietnamese motorcycle industry (Fujita, 2013a). Fujita notes the bias of GVC theory, "Because the primary focus of Gereffi et al. (2005) is on the *global* value chains that are coordinated by major transnational corporations

In some ways, the supportive value chain might appear to be similar to captive value chain, but with the support for the less capable partner going in the opposite direction. However, value chain relationships are not symmetrical in this way. The logic of captive value chains is that "captivity" enables the buyer to reduce the risk of poor performance on the part of the supplier and to protect any investment in supplier capabilities. These apply only to the specific suppliers with which contracts are made. In the case of supportive value chain model, support might be provided to a wide range of actual and potential customers. Further, the GHS model does not allow additional value chain types to be added at will. The five types of value chain governance are created through the use of three variables: complexity of information transfer, codification and supplier competence. Therefore, any additional governance type would require the whole explanatory framework to be reworked.

This matter needs to be investigated further over the course of the second year of the research programme. This will involve not only discussion of China and supportive value chains, but further investigation of platform leadership and the construction of industry architectures.

7.3 Upgrading and innovation from a GVC perspective

The third issue that requires further investigation is innovation. Work on the project during the first year has pointed to the importance of innovation in determining the evolution of value chains and industry architectures in China. It appears to be the case that technological change has played a particularly important role in transforming the mobile phone sector. In part, the importance of technological change in this sector reflects the fact that the industry at the global level has been profoundly changed as a result of the move from 2G wireless technology to 3G and later 4G and the switch from feature phones to smartphones. At the global level this has led to the disappearance of former industry leaders and the emergence of new companies with quite different value chain patterns. Rapid technological change appears to alter the key determinants of

(TNCs), they implicitly assume that lead firms possess the sophisticated capability necessary to coordinate value chains" (Fujita, 2013a, p. 11).

value chain governance — complexity of information, codification and supplier competence.

As was seen in the case of technology platforms, this finding is not entirely novel and certainly not confined to China. However, discussions of innovation from the value chain perspective have largely been focused on the issue of upgrading. Once again, this reflects the origins of value chain thinking, which focused on the integration of developing country manufacturers into global value chains. In this context, one key concern in the 1980s was the extent to which developing countries would be confined to low-value roles in global value chains. From a development perspective, the desirable outcome would be for developing countries to acquire technological capabilities over a period of time and to take on roles within value chains that required greater capabilities and would be capable of generating greater profits for businesses and higher incomes for workers.

For this reason, the key question within the existing value chain literature has been upgrading rather than innovation. This is frequently expressed in terms of the zero-sum game. How much will developing country businesses get upgrading opportunities, or will these be denied to them? According to Pietrobelli and Rabellotti:

> "The GVC literature stresses the role played by the leaders in the chain in terms of transferring knowledge to their suppliers. For small firms in LDC, participation in value chains is a crucial means of obtaining information on the type and quality of products and technologies required by global markets, and of gaining access to those markets. However, this information needs to be combined with local technological capabilities and this requires substantial technological and learning efforts." (Pietrobelli & Rabellotti, 2011, p. 1262)

There are two critical issues here. The first is how much lead firms (in the sense of those involved in explicit coordination) will support upgrading by suppliers (and what type of upgrading) and the availability of local resources that would enable suppliers to absorb the knowledge that might be offered. The second is the type of upgrading. The literature identifies four different types of upgrading: product (producing more sophisticated goods), process (producing these goods more efficiently), functional (taking on additional roles within the value chain), and inter-sectoral upgrading (where a business

or a country move from one sector to another). The literature tends to be strongly prescriptive, with both an emphasis on functional upgrading as the desirable path and a frequent tendency to argue that more powerful firms in value chains have an interest in limiting the extent of upgrading by weaker firms. Process upgrading is encouraged by buyers because it increases the efficiency of suppliers. Functional upgrading may be discouraged because the literature tends to assume that functional upgrading by developing country suppliers will involve the loss of buyer core competencies [22] However, in complex value chains there may be transfers of functions between businesses that do not affect the lead firm.

In this approach, the GVC literature on upgrading draws heavily from the East Asian model of industrial development, as exemplified by the Asian "tigers", which can be presented as one of how "latecomer firms" that face disadvantages with respect to their knowledge of technology and their knowledge of external markets are able to overcome these disadvantages. Businesses in the Asian Tigers have managed to close these gaps acquiring capabilities through:

1. Learning by doing following incorporation into global value chains — for example, learning manufacturing skills and acquiring knowledge about the needs of export markets.
2. Through licensing technology — in some cases from the same companies that outsourced parts of their production activities to these East Asian manufacturers.
3. Investments in R&D and human capital formation.
4. Support from public entities for knowledge acquisition.

This perspective is incorporated into GVC thinking through the idea of upgrading and the idea of a progression in terms of capabilities. Gereffi (1999, p. 39) refers to "typical trajectories" of export roles and:

> "moving up these chains from labor-intensive activities like export-oriented assembly, to more integrated forms of manufacturing like OEM and OBM production, to the most profitable and/or skill-intensive economic activities such

[22] See the discussion immediately above on industry architecture and core competence.

as breakthrough innovations in new goods and services, design, marketing, and finance."

Based on the East Asian literature, the value chain approach usually refers to four stages:

Assembly. The first stage. The value chain is sliced up and limited tasks or outsourced and offshored. This might be cut-make-and-trim in garments, or semiconductor assembly and electronics. The business outsourcing the activities may provide the raw materials required, or arrange procurement, as well as logistics.[23]

Original equipment manufacture (OEM). Wide range of manufacturing, making more of the product, or complete product, to the customer's design. Full package production in garments would be an example (see, for example, Bair, 2006). Typically, this is not just an acquisition of increased production activities. It might involve an increased role in procurement, acquiring some of the simpler design functions (for example, turning designs into usable drawings, and managing logistics. The simplified set of activities (design, manufacturing, distribution, etc.) often used to describe functional upgrading can be broken down into many smaller activities.

Original design manufacture (ODM). Exporting businesses become more involved in design as well as manufacturing. Initially, exporters may target for low-end markets where the manufacturing challenges are less complex. This is the story of Samsung microwaves in South Korea (Magaziner & Patinkin, 1989). The first export order was to Panama, and then to a US retailer that was seeking a low-priced product that it could badge under its own brand name — JCPenney.

Original brand manufacture (OBM). Company develops its own product line and brand identity. Samsung would be the one high-profile example of this progression.

[23] This is not just a story of business linkages. These developments have also been driven to a very significant extent Facilitated by trade policies such as the US Caribbean Basin Initiative (CBI) and maquiladora programme and the European Union's Outward Processing Trade (OPT). Exporting countries can also adopt facilitating regulations. Special regulations for processing trade also played a big role in Chinese industrial development.

The focus of the upgrading perspective, is therefore, how businesses linked into global value chains take advantage of these linkages to move up this this trajectory, and the extent to which lead firms in value chains facilitate or obstruct this process.

Much of this literature, therefore, does not examine the question of how innovation changes the structure of value chains. Such a perspective is clearly evident in the literature on modularity. Technological change can alter the level of modularity in product architecture (both up and down) and also where thin crossing points are located. Both processes have consequences for levels of vertical integration and types of interfirm linkages. The analysis by Baldwin and Clark (2000) on the consequences of the modular architecture of the IBM 360 computer is focused exactly on the issue of its consequences for industry structure — and in particular, the level of vertical disintegration that it allowed.

The evidence from China also raises further questions for GVC theory:

1. **Do firms want to upgrade?** It is assumed in the value chain model of upgrading that businesses, in general, want to upgrade, and this is certainly the message given by many value chain consultancies. However, the analysis of businesses in the *shanzhai* sector in China has shown that many businesses did not adopt a strategy of seeking to upgrade through acquiring greater technical capabilities. The reliance on platforms to secure access to technology was an effective strategy for some time.
2. **Domestic upgrading paths**. The GVC upgrading model was developed for an analysis of upgrading parts in export-oriented chains linked to the global market. This literature has been extended to the analysis of domestic markets, and specifically to upgrading opportunities. The most common argument has been that upgrading opportunities are limited when exporting to high-income countries. Global buyers might accept or even support, process upgrading, as this makes the suppliers more efficient, but beyond this opportunities are limited. Functional upgrading, in particular, is hard to achieve and might undermine other businesses in the chain. Greater opportunities for product and functional upgrading exist in domestic and regional markets, where firms can develop their own brands and take up activities that global buyers generally perform. This is

the argument put forward by Navas-Alemán (2011). As in the four-stage sequence outlined above, branding is the last stage. However, in the case of China businesses that have weak technological capability are already selling products under their own brand names. This pattern is examined in some detail in the papers collected in the volume edited by Watanabe (2014c). This pattern is a direct consequence of the ability of these firms to outsource many of the requirements for making products such as mobile phones. They relied on platform providers, providers of key components and the services of specialist design houses. For these firms, developing brands in the local market was much less of a challenge than acquiring the technological capabilities needed to make mobile phone handsets.

3. **Upgrading as a zero-sum game**. Some value chain analysts have emphasised obstacles to upgrading, or argued that while lead firms encourage process upgrading (because this makes suppliers more efficient) they might discourage functional upgrading because this could turn suppliers into competitors. In many cases, this approach ends up viewing functional upgrading as a zero-sum game. Functional upgrading is characterised as a transfer of activities between enterprises. This is misleading. First, from an innovation perspective, upgrading might involve a change in technology rather than a transfer of functions. Second, the analysis of the logic of transfers of functions is incorrect even in value chain terms. What counts as a low-value activity for one company, may be a high-value activity for another (particularly in the developing country), and lead firms in GVCs may promote the reallocation of activities between suppliers. These two processes occurred in the UK horticulture industry, when post-harvest processing was transferred from the UK to Kenya. Supermarkets were involved in promoting this shift, even though they did not do this processing themselves, and it can be argued that the shift was part of a broader restructuring of the functions of UK importers from traders to value chain managers which left them with more high-value tasks.
4. **Knowledge resources for upgrading.** Value chain analysis tends to prioritise value chain learning as the most important source of new capabilities. There may, in fact, be a range of sources, and further clarity is required on the conditions under which buyers will invest in the capabilities of suppliers. There is a substantial literature on how suppliers co-evolve with the businesses they supply, and how suppliers invest in their capacities as part of a long-term

strategy to upgrade independently of any particular customer. Sturgeon, in particular, has examine the consequences of the emergence of large, competent suppliers in Asia (see, for example, Sturgeon, Humphrey, & Gereffi, 2011).

5. **Appropriability of the benefits of upgrading.** Many GVC researchers prioritise functional upgrading as the most desirable strategy for developing country firms. However, these analyses do not focus sufficiently on the issue of appropriating the gains from upgrading. This point is been raised recently by Sako and Zylberberg (2015, p. 3), who argue that:

> "We challenge the assumption that upgrading always leads to improving the competitive advantage of the supplier in a GVC. The 'profiting from innovation' model in technology strategy (Teece, 1986) is perhaps the most useful framework to address this issue. It analyzes the mechanisms via which firms may sometimes create but fail to capture profit. Paying attention to regimes of appropriability, the dominant design paradigm, and access to complementary assets ensures that firms profit from upgrading."

These issues will be explored further in the second year of the research programme.

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