LEARNING FOR UPGRADING

The "Controlled" Growth of the Japanese Aircraft Firms

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1. Introduction

The structure of international trade has transformed significantly since the late 20th century. Especially, the trade of intermediate goods has been increasing. Trade economists explain it as the rise of "global production sharing" (Feenstra 1999; Yeats 2001). It refers to the physical disintegration of a production process at global scale. The main driving force behind the global production sharing is that transnational companies (TNCs) have vertically disintegrated their production networks (UNCTAD 2002). To gain and sustain the competitive advantage in the ever-severe global competition, the TNCs have come to more focus on nurturing the core competence while outsourcing the non-core activities in many different parts of the world.

Those non-core activities include the medium value-added ones, such as component designing and manufacturing. They can be more profitable than the traditional off-shoring outsourcing, which are usually labor-intensive and low technology. For the firms in developing and latecomer countries (thereafter, called as the latecomer firms), the expansion and deepening of the TNCs' sourcing have opened the "window of opportunity" to upgrade as suppliers by carrying out the higher value-added sourcing activities (Kimura forthcoming).

What to be emphasized is that such upgrading of suppliers is far from a neutral or power-free process. But rather supplier upgrading occurs under control and coordination by lead firms that are dominantly powerful in global production networks. The purpose of this paper examines how the upgrading process of suppliers can be controlled by lead firms.

In regard to the vertical control against suppliers learning in a production system, transaction cost economics (Williamson 1975) and internalization theory of international business (Buckley and Casson 1985) mainly focus on the problem of asset specificity. They argue that supplier's opportunism should be averted by direct ownership – that is, vertical integration. Meanwhile, network literature and game theory (Axelrod 1984; Powell 1990) assert that trust and mutual reputation in repeat transaction prevent the supplier's opportunistic behavior without direct ownership. More comprehensively, global value chains literature (Gereffi, Humphrey et al. 2005) argues that the vertical control will be tighter when the architecture of inter-firm relationship is integral rather than modular (Baldwin and Clark 2000), and when the suppliers are more likely to cause "competence failure" (Sako 1992).

The existing literature discussed above have advanced our understanding about how lead firms could control their suppliers behaviors in the way to align with their competitive strategies. However, it has largely failed to examine the dynamic aspect of vertical control – that is, the control over the supplier's growth in long run. The lead firm tries to control learning and upgrading process of suppliers. In so doing, the lead firm tries to prevent its suppliers from becoming competent enough to encroach into its core competence for executing dominant power in global value chains (GVCs), and/or for gaining and sustaining competitiveness in the global market. Therefore, this study aims to contribute our understanding about how the lead firm may control over supplier's learning and upgrading process without direct ownership.

The structure of the paper is following. Section 2 conceptualizes the upgrading process as climbing up the chain hierarchy. Section 3 examines the dimensions and the nature of supplier learning for upgrading. The logic of control over such learning is also analyzed. Section 4 discusses, as for the case study, the post-war growth of Japanese aircraft firms as the Boeing's suppliers. It illustrates how the Boeing has controlled the learning and upgrading process of the Japanese firms without direct ownership. Section 5 concludes the study.

2. Upgrading Process

The upgrading process can be described as a process in which suppliers increase the value-added of their sourcing activities. In order to do so, the suppliers should execute the wider scope and/or more sophisticated and complex sourcing activities. Such upgrading process can be described in the way that the suppliers upgrade their status in GVCs by climbing up the chain hierarchy. The chain hierarchy places the suppliers in o one of the three tiers of the chain hierarchy according the unit scale of their products as well as to the scope and the technological complexity of their sourcing activities. Figure 1 illustrates the chain hierarchy of the commercial aircraft industry.

=== Figure 1 ===

Explaining from the bottom of the hierarchy, (1) a *piece-part subcontractor* solely provides the manufacturing service to the prime contractor. Asanuma (1985: 49-50) calls this lowest status supplier a "drawing-supplied (DS)" supplier, as the entire design for sourcing parts is carried about by the buyers. The second tier supplier is (2) *a sub-system supplier*, which undertakes the detailed design and assembly of the supplying sub-system. In aircraft production, for instance, those sub-systems include wing skins and major fuselage panels. Compared to DS suppliers, Asanuma calls them "design-approval (DA)" suppliers, as they draw the detailed design themselves and then submit it to buyers for approval (Asanuma 1985).[1] Nevertheless, the prime contractor still decides

[1] There are various terminologies for categorizing suppliers in different industries. For example, DS suppliers and DA suppliers are often called 'own equipment firms (OEM)' and 'own design firms' (ODM) respectively in the electronic and automotive industries Lee, J.-R. and J.-S. Chen (2000). Dynamic Synergy Creation with Multiple Business Activities: Towards a Competence-Based Growth Model for Contract Manufacturers. Research in Competence-Based Research. R. Sanchez and A. Heene. Stanford, CA, JAI Press: 209-229..

the basic design, such as the shape and specification of the supplying components.

The first tier supplier is (3) a *module system maker*, which builds a complete module system. Sturgeon (2002) coined this type of supplier as “turn-key suppliers”, as they provide the full-rage of product-related services (Sturgeon 2002). What is to be noted here is that a module system maker is not only in the highest status of suppliers, but also often behaves like a lead firm in the industry whose product architecture is of modular rather than integral nature. A product unit of integral architecture is in close proximity to or has a close spatial relationship with elements in other units, and together they are tightly synchronized (Fine 1998: 134-5). In contrast, a module is a unit whose structural elements is powerfully intra-connected but is relatively weakly connected to elements in other units (Baldwin and Clark 2000: 63). Component interfaces with a module are standardized.

The significant point is that the product architecture shapes the relationship between a system integrator and a first-tier supplier (Gereffi, Humphrey et al. 2005). In the case that the product architecture is integral, a lead firm needs to control the first-tier suppliers strongly in order to achieve tight synchronization of the system integration. On the other hand, the module product architecture makes the first-tier supplier independent from the system integrator, particularly when a module maker has direct access to the customer. For instance, the personal computer industry has highly modularized product architecture. First-tier suppliers and module makers, such as Intel for semiconductors and Microsoft for software, have direct access to customers and enjoy high independence from the system integrators, such as IBM or Dell.

The aircraft industry has also been visibly modularized at an aero-engine. The module makers, such as the Rolls Royce, the General Electronics, and the Pratt & Whitney for an aero-engine, often

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However, these terms have changed their meaning along with the evolution of production systems in their industries Sturgeon, T. J. (2001). "How Do We Define Value Chains and Production Networks?" IDS Bulletin **32**(3): 9-18.. I here refer to Asanuma’s terminologies, developed based on the automotive industry, because they clearly indicates who undertakes the drawing function and avoids confusing the definitions of OEM and ODM.

have direct access to customers when the airline operators have the option to select the brand of aero-engine or avionics to be installed on their aircraft. In such cases, the value-chains of the modular systems can be seen as *independent* branches, which are sub-sets forming part of the integral GVC of aircraft production. The modular system makers may act as lead firms (i.e., modular lead firm) in these module value-chains.

3. Learning for Upgrading

The diving force for growth of the firm is organizational *learning*[2], in which the firm acquires and adapts competences over a period of time in order to carry out higher value-added activities (Dosi, Richard et al. 2000: 16). Having acquired the higher level of competences through learning, a latecomer firm may upgrade its supplier status from the lowest-tier of chain hierarchy, i.e., a piece-part subcontractor, towards the higher tiers; i.e., a sub-system supplier, and further towards a module maker in global value chains. Then, what kinds of competences do the latecomer firm have to learn for upgrading?

3.1. The Dimensions of Learning

To gain the competitiveness in the world market, the lead firms must make sure that the suppliers are sufficiently competent to meet their business needs effectively and efficiently (Jarillo 1988; Sydow 1992). They thus decide what kinds of competence are required for selection for each

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[2] For a good review of the literature on organizational learning, see Bell, Whitwell and Lukas Bell, S. J., G. J. Whitwell, et al. (2002). "Schools of thought in organizational learning." Journal of the Academy of Marketing Science **30**(1): 70-86., Easterby-Smith, Crossan and Nicolini Easterby-Smith, M., M. Crossan, et al. (2000). "Organizational learning: Debates past, present and future." Journal of Management Studies **37**(6): 783-796., and Huber Huber, G. P. (1991). "Organizational Learning: The Contributing Processes and the Literatures." Organization Science **2**(1): 88-115..

supplier status.

From the suppliers' point of the view; to achieve upgrading by being selected for the higher status in the chain hierarchy, they must advance through distinct learning phases, each with specific learning dimensions (Radosevic 1999: 217). In short, the lead firms set the specific learning dimensions for each level of supplier; while the latecomer firms must achieve those learning dimensions in order to be selected as suppliers. Consequently, the lead firms control the rate and trajectory of growth of latecomer firms by setting learning dimensions for each stage of the upgrading process. Table 1 summarizes the learning dimensions of the three major stages in the upgrading process

=== Table 1 ===

(1) To begin with the lowest status of supplier, the learning dimensions for becoming a piece-part subcontractor consist of the basic product-related competences to achieve "drawing-supplied" manufacturing at the required level of quality-cost-delivery (QCD). Furthermore, those under severe competitive pressure might also be expected to bring about the value engineering (VE) and the value analysis (VA), i.e., cost cutting prior to and during the mass production process by improving component design (Asanuma 1989: 20).

(2) The learning dimensions for upgrading towards sub-system supplier status include technical and process competences sufficient to carry out detailed component design and medium-scale assembly according to the product specifications laid down by the prime contractors. For a sub-system supplier to be successful, it must at least achieve competitive QCD. It must also be able to thoroughly understand the prime contractors' specific needs and to efficiently accommodate them. Asanuma (1989) calls such competences *relation-specific skills*, which enable a supplier to

respond flexibly to the prime contractor's specific needs (Asanuma 1989: 21). Suppliers can acquire relation-specific competences[3] only after repeated interaction with the particular prime contractors through a close and collaborative inter-firm relationship.

To upgrade to sub-system supplier status, therefore, a latecomer firm needs to attain relation-specific competences with the particular prime contractor, in addition to the general product-related competences required for competitive QCD. Moreover, those relation-specific competences could constitute significant barriers to entry for suppliers because it is time-consuming and expensive to develop them through repeated interaction. The prime contractors would also incur the cost of switching suppliers, from those which have already acquired the relation-specific competences attuned to their specific needs (Monteverde and Teece 1982b).

(3) The learning dimensions required to upgrade to the status of module maker consist of all the product-related competences at the module system level, such as module basic design and module system integration, and sometimes contributing to product conceptualization. Module system is normally interchangeable because its interface with other components is highly standardized. Hence, module makers might not be required to acquire a high level of relationship-specific competences. Instead, they need to impose effective supplier management throughout a module value chain. They may also have to acquire market-related competences - such as market risk evaluation and after-sales service - in the case where the end-users choose among the various makers which module system is to be provided in the final product. This is the case for aero-engines for medium and large commercial aircraft. Aero-engine makers - such as General Electronics, Pratt

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[3] The term *skill* used by Asanuma is here expressed by the term *competence*. This is because in the literature on resource-based view of the firm, *skill* refers to capabilities residing at the individual base while competence connotes both resources and capabilities at the organizational base. The latter is the case here Nelson, R. and S. Winter (1982). The Evolutionary Theory of Economic Change. Cambridge, MA, Harvard University Press, Dosi, G., R. Richard, et al. (2000). Introduction: The Nature and Dynamics of Organizational Capabilities. The Nature and Dynamics of Organizational Capabilities. G. Dosi, R. Nelson and S. Winter. Oxford, Oxford University Press**:** 1-22..

and Whitney and the Rolls Royce – carry out the full range of product- and market-related competences. Indeed, they act as the module lead firms in an aero-engine GVC.

3.2 Nature of Suppliers' Learning

The supplier's learning process is dominantly incremental and cumulative in nature rather than radical and path-breaking because they are usually lagging the technology and market frontiers (Hobday 1995: 46-47). Hence, its core learning process is to absorb external knowledge that already exists in other firms as well as in the market. The learning potential of a latecomer firm is largely a function of (1) the scale and scope of the new external knowledge to which suppliers are exposed; (2) the ability to absorb the new knowledge and apply it to sourcing activities in an innovative way, and (3) sufficient financial resource to invest in learning.

Exposed External Knowledge

First of all, the extent of external knowledge to which a latecomer firm is exposed in turn depends on (i) the intensity of information sharing with lead firms in sourcing relations; and (ii) the knowledge inflow from the institutional setting, in which the firm embedded. Furthermore, it is also determined by the nature of the component to be supplied. For example, piece-part subcontractors have very limited information sharing with lead firms because they simply manufacture exactly according to the designs handed over from the latter - i.e., "drawing-supplied" manufacturing. In this case, knowledge inflow to latecomer firms is largely limited to what is necessary to put the pieces together at the required level of QCD and no more.

On the other hand, by playing a part in product development, sub-system suppliers can expect a much larger scale and scope of knowledge inflow from lead firms. This is because to design and manufacture the sub-systems that fit smoothly into the whole system, the latecomer firm has to learn beyond 'component knowledge' particular to its own work package. To a certain degree, sub-system suppliers need to acquire 'architectural knowledge' of the whole system.[4] In product development of multi-component/multi-technology products, firms are required to "know more than they make" (Brusoni, Prencipe et al. 2001) to achieve coherence in a GVC (Takeishi 2002). It would lead to considerable information sharing with lead firms. Such information sharing would be particularly intensive for 'significant' suppliers – such as a risk-sharing/a program partner – in the international collaboration project. Thus, those high-level supplier positions in the GVC are likely providing a latecomer firm with the platform for learning. .

Absorptive Capacity

Secondly, to make the knowledge inflow actually productive, latecomer firms should be able to efficiently assimilate the *external* knowledge, and to put to use in carrying out sourcing activities effectively and innovatively. As briefly described earlier, Cohen and Levinthal (1990) term such firm's ability "absorptive capacity" (Cohen and Levinthal 1990). Drawing on the classical work of cognitive psychology, they assert that a firm's absorptive capacity is largely a function of the level of prior related knowledge. Cohen and Levinthal refer to studies in the area of cognitive and

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[4] The concepts of 'component knowledge' and 'architectural knowledge' in product development were originally put forward by Henderson and Clark (1990). They defined the former as "knowledge about each of the core design concepts and the way in which they are implemented in a particular component", and the latter as "knowledge about the ways in which the components are integrated and linked together into a coherent whole" Henderson, R. M. and K. B. Clark (1990). "Architectural Innovation: The Reconfiguration of Existing Product Technologies and the Failure of Established Firms." Administrative Sciene Quarterly **35**: 9-30.. Like Burusoni, *et.al.* (2001), some advocates of the 'knowledge-based theory of the firm' - which was pioneered by, for example, Demsetz, H. (1991). The Theory of the Firm Revisited. The Nature of the Firm: Origins, Evolution, and Development. O. E. Williamson and S. G. Winter. New York, Oxford University Press: 159-178, Kogut, B. and U. Zander (1992). "Knowledge of the Firm, Combinative Capabilities, and the Replication of Technology." Organization Science **3**(3): 383-397. – have adopted those concepts, and presented an antithesis to the transaction cost economics position in the research on the boundary of the firm. For a detailed account, refer to the special issue of *Organizational Science* (1990, Volume 7, Issue 5) on the theory of the firm.

behavioral sciences at the individual level, which suggest that prior knowledge enhances learning in a cumulative and self-enforcing way (Lindsay and Norman 1972; Bower and Hilgard 1981). Those studies imply that, according to Cohen and Levinthal, the learning is self-enforcing - "learning performance is greatest when the object of learning is related to what is already known" (Cohen and Levinthal 1990: 131).

Although Cohen and Levinthal (1990) only consider the assimilation of *external* knowledge, the notion of absorptive capacity also has relevance for experience-based *endogenous* learning, such as learning-by-doing and learning-by-using. The firm can bring about endogenous learning by reflecting on its own experience - finding lessons to be learnt from its own experience and implementing them in their future activities. A firm's capacity to reflect its own experience is also largely a function of the level of prior related knowledge. In this case, therefore, the object of learning is *internal* to the firm rather than *external* to the firm.

Furthermore, applying the notion of absorptive capacity to the upgrading process, a supplier with long experience of manufacturing, for example, is likely able to learn product-related competences (such as component design and assembly) more efficiently than the market-related competences (such as marketing and after-sale service). More generally, this suggests that the learning process required to upgrade from a piece-part subcontractor to a sub-system supplier is usually easier than that from a sub-system supplier to a module maker or to a system integrator. In the former case, the learning dimension is largely contained within the product-related knowledge (i.e., acquiring the related knowledge to enhance what is already known). Whereas in the latter case, the latecomer firm needs to acquire the market-related competences, which may be unrelated to what the firm already knows.

We have thus far discussed absorptive capacity in general terms. Nevertheless, a latecomer firm must also attain the so-called "relation-specific" competence in relation to the *particular* lead firm. Relation-specific competence enables a latecomer firm to be sufficiently responsive to understand and accommodate the lead firm's specific needs (Asanuma 1989). Hence, relation-specific competence can be regarded as that special absorptive capacity, by which a latecomer firm may effectively assimilate and utilize the knowledge inflow from a *particular* prime contractor. It can be attained only after repeated interactions with the particular lead firm. Relation-specific competence is particularly critical for a sub-system supplier that needs to have intensive information sharing with its lead firm. In turn, such intensive information sharing will bring about a larger knowledge inflow into the latecomer firm.

Financial Resource

Thirdly, for a supplier learning is not free nor is it an automatic process, such as what traditional neoclassical economics assume to be the international technological 'diffusion' (Baumol 1986; Dowrick and Gemmell 1991). Successful learning actually incurs significant costs in carrying out continuing innovation to further the original knowledge – such as (i) molding to fit particular conditions of use in a widening range of specific situations, and (ii) further improvement to attain higher performance standards beyond those originally achieved (Lall 1992; Bell 1997: 86).

More essentially, to take advantage of an effective learning opportunity that would bring about a large knowledge inflow, a latecomer firm must, in the first place, be able to mobilize sufficient finance to take part in the GVC as a significant supplier, such as a sub-system supplier. The amount of finance necessary to be a significant supplier has increased since the system integrators began to adopt lean production principles and to rely upon fewer significant suppliers to provide an ever-larger bundle of goods and services. Especially, securing sufficient finance to bear component development cost is a precondition for a latecomer firm wishing to enjoy large knowledge inflow by becoming a sub-system supplier in a GVC. Component development cost includes, for instance, purchasing and/or creating new tooling, building new facilities, carrying out the trial-and error in designing, manufacturing, and testing new components.

Hence, the latecomer firm must carefully examine the required extent of financial resource for undertaking supplier activities that bring about learning opportunities. It must also discover access to sufficient financial resources. If the firm should not be able to raise sufficient money for the investment internally, it must look for other possible sources of financing externally – such as co-financing with collaborative firms, or loan and subsidy provided by government agencies and/or the business association.

3.3. The Logic of Control over Supplier Learning

Why and What to be Controlled

A lead firm tries to control the dimensions of supplier's learning by restricting the sourcing activities to non-strategic ones. In doing so, the lead firm tries to prevent the latter from becoming a potential challenger by replicating its own competitiveness. As discussed above, the lead firm demands that its supplier should be capable of meeting its business needs effectively. More precisely, the lead firm requires its suppliers to possess the general competences to achieve a satisfactory level of QCD. The former also requires the latter to have relational competence in order to respond promptly and flexibly to its business needs. If necessary, the lead firm will support the suppliers' learning through knowledge and capability transfer.

However, a lead firm must guard against its suppliers becoming so competent and powerful that they may encroach upon the lead firms' dominant power in GVCs. The lead firm must also prevent its suppliers from becoming a direct competitor as a system integrator in the market. So the lead firm must ensure that the learning dimensions of suppliers do not impinge upon the core technologies neither upon those competences underlying the strategic functions. Such "strategic" function is different for different industries. For instance, in the commercial aircraft industry, strategic function includes system integration, marketing, and after-sales service.[5]

How to be Controlled

A firm's learning can be exercised in various ways.[6] Most obviously, learning can take the form of formal education and R&D. Such formal learning may equip a firm with the codified (or tangible) knowledge; for instance, the operational manuals of new equipment that is to be introduced into sourcing activities. In many cases, more significantly, learning is largely experience-based rooted in ordinary economic and social activities, as summarized by Lundvall (1992: 9)

> Such activities involve learning-by-doing, increasing the efficiency of production operations (Arrow 1962), learning-by-using, increasing the efficiency of the use of complex system (Rosenberg 1982), and learning-by-interacting, involving users and producers in an interaction resulting in product innovations (Lundvall 1988).

Such experience-based learning enables a firm to acquire tacit (or intangible) knowledge and to perform given activities better and more quickly through repeated trial-and-error. In a dynamic sense, moreover, both formal and experience-based learning may also equip the firm with the so-called 'absorptive capacity' (Cohen and Levinthal 1990) that enables it to assimilate related, but new knowledge effectively, and apply it innovatively to the firm's activities. This implies that firm

[5] According to the resource-based view of strategic management, the "strategic" functions are based on such competence that are (1) critical for product's performance; (2) difficult to replicate; and (3) scarce Barney, J. B. (2002). Gaining and Sustaining Competitive Advantage. Upper Saddle River, N.J., Prentice Hall International..

[6] The mechanism of firm learning has been mostly scrutinized by the so-called 'learning school' of strategic management research. Refer to Cohen, M. D. and L. Sproull, Eds. (1996). Organizational Learning. Thousand Oaks, Sage. for a useful collection of the important literature on the issue.

learning is a reinforcing process: the more the firm has learned, the more efficiently the firm is able to absorb related knowledge.

Especially, experience-based learning also underlines the path-dependency and domain-specificity of the firm's competence and of the path of its upgrading. To paraphrase the words of Teece, *et. al*. (1997): the notion of path dependencies imply that where a latecomer firm can go in the upgrading process is a function of its current position and the paths ahead. Its current position is often shaped by the path it has traveled (Teece, Pisano et al. 1997: 522). This follows because the firm's learning is cumulative - a set of competences and the absorptive capacity that a latecomer firm currently possesses are a product of what they have thus far learned within the previous domain of activity. As a result, the learning opportunities of the firm might be 'closed in' (Teece, Pisano et al. 1997: 523) to previous activities.

To put it differently, the firm learning dimension could be 'locked out' (Cohen and Levinthal 1990: 136) from unrelated activities. Hence, the firm learning is domain-specific; and such nature of firm learning gives rise to the so-called the 'learning trap' – i.e., the firm is confined to a certain domain of activities (Aoshima and Kato 2003: 172-177).

In turn, the lead firms could exploit such learning traps in order to control the growth of latecomer firms. By strictly restricting the domain of current sourcing activities and keeping them tightly aligned with actual business needs, lead firms can affect the learning path of latecomer firms concentrating on making them into more useful and reliable suppliers for them. Those latecomer firms will be only competent to effectively meet the lead firms' sourcing requests, and they will not possess the competences for directly challenging the lead firms' competitive position. From the latecomer firm's point of view, the closer they align their sourcing activities to those of the lead firms, the more they will link their growth and future to development of the lead firms. By exploiting the social attributes and path-dependency of the learning process, therefore, the lead firms can control the growth of latecomer firms at the deepest level - molding the latter's learning trajectory.

To summarize the logic of the lead firm's control over the supplier's learning, the lead firms carefully determine "what to do" and "what *not* to do", and more fundamentally "what to learn" and "what *not* to learn" in the sourcing activities. On the other hand, to achieve upgrading, the suppliers must pursue a discontinuous learning process by mastering the specific learning dimensions, which the lead firms require for each tier of chain hierarchy. If necessary, they often support their suppliers' learning through the limited knowledge and capability transfer. Nevertheless, they most carefully try to prevent the latecomer firms from upgrading to a higher level – through acquiring the critical, difficult to reproduce, or scarce competences - enabling them to encroach into their dominance in a GVC or to challenge their competitiveness as a system integrator.

Fine (1998) puts it in a metaphoric way: every time that lead firms make sourcing decisions, "it is planting a 'capability seed' that has the potential to grow into a valuable and powerful organizational competency" (Fine 1998: 159). Thus, lead firms must be careful neither to plant those 'capability seeds' to their suppliers beyond what is absolutely necessary, nor to allow them to sprout and grow so powerfully that the suppliers come to pose a potential threat to their own competitiveness. In other words, by carefully confining the sourcing activities into the non-strategic activities, the lead firms must block the chance for latecomer firms to gain experience-based learning in the core technologies and strategic functions. The lead firms often exercise the power to be deaf to the suppliers' demands to take part in strategic activities in the contract negotiation (Kaplinsky and Morris 2000: 66). [7]

[7] Another metaphor can be helpful to understand the lead firms' control over their suppliers. Imagine the relationship between a bear charmer and a show bear. A bear charmer (i.e., a lead firm) wants his show bear (i.e., a supplier) to be capable and strong enough to master the various performances entertainingly and vigorously. At the same time, a bear charmer must keep his bear under control all the time and prevent the bear from attacking him. To

Moreover, such lead firms' control over the supplier's learning seems to highlight the structural limitations of the supplier upgrading in GVCs. It seems to imply that there is a 'glass ceiling' inherent in the upgrading process. Suppliers will inevitably hit the glass ceiling as a result of the 'controlled' growth of the firm in a GVC. In the following sections, the case study on the commercial aircraft GVC will illustrate how the Boeing Company (as lead firm) has controlled learning and growth of Japanese aircraft firms (as the Boeing's suppliers).

4. The "Controlled" Growth of the Japanese Aircraft Firms

4.1 Overview

The post-war growth of the Japanese aircraft firms well illustrates how the supplier learning could be controlled in upgrading through GVCs. The Japanese aircraft firms have successfully upgraded their activities gradually as global suppliers. As the Japanese aircraft industry as a whole, its total production has increased twenty fold from 55 billion yen to over 1 trillion yen between 1965 and 2001 (Figure 2). During the same period, the aircraft export value rose from practically nil to over 350 billion yen. The industry's dependency ratio on military procurement has also been gradually decreased from it peak of near 80 percent in the late 1970s to less than 60 percent in 2001.

== Figure 2 ==

Meanwhile, the Japanese aircraft firms have upgraded their supplier status incrementally. (Figure

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do so, the bear charmer may have to put the bear in a strong cage. Such a cage can be regarded as a metaphor for the lead firms' *restriction* on domains of supply activities and in turn over the learning dimensions of latecomer firms. (I owe the inspiration for this metaphor to a conversation with Professor Peter Nolan, Judge Institute of Management, University of Cambridge).

3) The Japanese firms started their supplier activities as piece-parts subcontractors for Boeing's B747 in the late 1960s. They have expanded the scale and upgraded their activities throughout the 1970s and 1980s. In particular, the Japanese aircraft firms have become the single source sub-system suppliers for B767, B777 and B787 to undertake the detailed designing and production of most of the fuselage and main wing. Such upgrading of supplying activities can also be illustrated by the steady increase of capital intensity and value-added per labor in the major Japanese aircraft manufactures. (Figure 4)

== Figure 3 ==

== Figure 4 ==

4.2 The Current Scope of Activities

However, the Japanese aircraft firms still remain latecomer firms in the Boeing-led commercial aircraft GVC mainly because they lack the high-rank dual-faceted competences essential to carry out the strategic functions and core technologies. Figure 5 illustrates the current competence mapping of the aircraft firms. It clearly shows that the Japanese competitiveness is confined to the product-related competences.

== Figure 5 ==

For instance in the B767 program, the Japanese firms undertook only detailed component design, component manufacturing and sub-system manufacturing. As seen earlier, in the B777 program, they took part in the earlier phases of the value-chain, such as product conceptualization and basic design as a member of the Boeing-sponsored 'design built teams' (DBTs). However Japan's involvement in market-related functions (that is, market research, marketing and after-sales service) was still negligible.[8] In terms of its production share, although Japan's share increased from 15% of the total airframe value in the B767 to 21% in the B777 further up to 35% in the B787, it was still largely concentrated on the fuselage structure. The critical components, such as cockpit and a main wing, were strictly 'black-boxed' to the Japanese.

One Japanese aircraft engineer succinctly described the current state of Japan's aircraft competences.[9] He explained the competitive advantage as follows:

> We have a competitive advantage as component suppliers possessing design capabilities. We are not restricted to small components but can also carry out large-scale investment in plant and equipment. We undertake detailed design as well as contributing to some extent at the conceptualization stage of [large-scale] components. We design components in such a way as to bring about cost reductions at the mass-production stage. So, we are not the type of supplier that simply manufactures according to Boeing's design drawings. Our competitive advantage is our ability to make suggestions [to Boeing] at the conceptualizations stage both making the components cheaper and improving quality.

He went on to point out the weak area of Japanese aircraft competences as follows:

> We do not have the competences for product conceptualization. In order to conceptualize a new commercial plane, you must be able to go further than design capabilities to envisage what kind of plane airlines are demanding; what are the right

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[8] Indeed, a few Japanese representatives actually participated in market-related activities for the B777. However, it was not sufficiently significant to bring about real knowledge transfer to the Japanese aircraft firms: Interview with Vice President of USA Office, Aerospace Marketing and Business Dep., Company I.

[9] Interview with Manager, Civil Aircraft and Aeroengine Dept., Company J.

> size and range for a plane able to accommodate those demands; how many planes you have to sell in order to break-even. We lack these conceptualization competences. They call for market research capability and the marketing capability [to collect information about customers' demands] and the capability to incorporate [those information] in the product concept.

To summarize the above statements, the Japanese aircraft firms currently have competitive advantages in the intermediate goods market as "design-approval (DA)" sub-system suppliers that are able to perform the value analysis (VA). However, they largely lack the market-related competences that are essential to gain and sustain a competitive advantage as a system integrator in the finished product market. Japanese aircraft firms are upper-status latecomer firms in Boeing's GVC. Nevertheless, they do not possess sufficient high-rank dual-faceted competence to seize dominant power as the lead firm in a GVC.

4.3 Boeing's Control over the Japanese Firms' Learning

The Japanese aircraft firms' weakness in market-related competences was originally a result of the earlier management failure of national project to develop, manufacture and sell the indigenous YS-11. However, the Japanese firms' market-related weakness has been exacerbated by the Boeing's tight control over their growth by restricting the scope of their activities and learning. Ever since the beginning of the program partnership, Boeing has stringently prevented the Japanese from learning the core technologies and strategic functions - especially the later stages in the value chain, such as total system integration, testing and type certification, sales and after-sales service.

Boeing's control became most clearly apparent in the so-called the Stamper Letter, which Boeing's president at the time, Malcolm Stamper, handed to the Japanese partners in October 1976 during contractual negotiation for the B767 program. Before the Stamper Letter, aiming to keep its 'autonomy' in the collaborative partnership, the Japanese demanded amongst other things: (1) the setting up a joint venture company, (2) responsibility for marketing in Japan and other Asian areas, (3) setting up a final assembly line in Japan (The Editorial Committee of "The History of YX/767 Program" 1985: 146). However, Boeing had no intention of surrendering its full hold over the project, and *unilaterally* announced in the Letter that it was going to freeze the negotiation process in order to carry out an overall re-evaluation of the proposed collaborative development project of B767.

Boeing came back to the negotiation table in February 1977 and told the Japanese that it would not accept any of the three Japanese demands. Boeing clearly affirmed that it would maintain full control over the program and left the Japanese with a 'take-it or leave it' proposal in which they had no option to become a subordinate actor in the program. By exerting power to tell their inferior counterpart what to do and what not to do, Boeing forced the Japanese to settle for latecomer firm status if they wanted to join the Boeing's program.

One important goal of Boeing's authoritarian behavior was to prevent the Japanese from becoming a potential threat to its own competitive advantages both as a lead firm in the GVC and as a system integrator in the finished product market. According to one of the top Japanese negotiators, Stamper used to outwardly assert, "Boeing will never give any opportunity for Japan to grow into our potential competitor" (The Editorial Committee of "The History of YX/767 Program" 1985: 203). In order to do so, Boeing restricted the Japanese domain of activities and learning to the product-related functions; and it *locked out* Japan from learning the strategically significant market-related functions. As seen earlier, the Japanese reluctantly accepted latecomer firm status and became a risk-sharing/ the participant in the B767 program in order to realize its FLI strategic change towards upgrading.

The Stamper Letter turned out to be the climax of the power game in the history of the Boeing-Japan partnership. Subsequently, both sides have been trying to avoid overt antagonism and maintain the collaborative partnership. This could imply that Boeing was very successful in exerting *structural control* over the growth of the Japanese aircraft firms – securing Japan's compliant dependence on Boeing through repeated trust based interaction. The following comment by one executive manager of Japanese aircraft firm seems to symbolize the extent to which Boeing influenced the Japanese thoughts and desires even when no obvious power attempt had been made[10]:

> We don't need to play a power game with Boeing. We are happy with our friendly partnership with Boeing based on the long and trusted relationship. I think that the Japanese and Boeing are both successful because we complement each other.[11]

There is no doubt that the Boeing-Japan partnership has been successful due to its complementary relationship. However, what is also unequivocally clear is that the partnership has been based on an asymmetric power relation, in which the Japanese firms have been content to grow into competent sub-system suppliers for Boeing.

In addition, Boeing has carefully controlled knowledge transfer to the Japanese. In both the B767 and B777 programs, the Japanese engineering effort is restricted to their own work package. Structural testing – and software and models needed to verify results – are only shared if they are necessary for the Japanese to design the parts they will build (National Research Council 1994: 113). At the same time, the collaborative inter-firm relationship, which Boeing later lauded as "Working Together", were actually strictly limited to a 'need-to-know' basis, as the report of the National Research Council – a private think-tank advising the US federal government – vividly

[10] This illustrates the most 'subtle' way of controlling a supplier. (See Luke 1974 as well as Section 4.1.2.2 of this study.)

[11] Interview with Senior Manager, Commercial Aircraft & Space Dept., Company I.

describes as following:

> Through a system of passwords, the access of Japanese engineers on-site and working at the computer system in Japan that Boeing set up for the 777 project is limited. The CATIA design software itself is "locked up," as is work on parts of the airplane unrelated to the Japanese work share. Attempts to get around the system would set off alarms. … On site, the visiting Japanese engineers were given access only to certain buildings, and sensitive manufacturing sites were accessible only with a Boeing escort. …. How did Boeing control the people-to-people flow of technology? First, within Boeing, analysis and testing of the design are done by a separate group of engineers from those who work on design with the Japanese heavies. … Boeing provided a briefing to engineering and manufacturing personnel who would come in contact with the overseas partners, conveying the basic message that they should provide only what would be needed for the partners' work share (National Research Council 1994: 113-114).

In sum, Boeing has controlled the growth of the Japanese aircraft firms – mostly beneath the surface - by restricting the domain of activity and learning as well as by limiting the technology/knowledge transfer to a need-to-know basis. In so doing, Boeing has limited the growth of the firms to competitive sub-system suppliers, retaining their latecomer firm status that would not pose a potential threat to Boeing.

5. Concluding Remarks

In this paper we have examined how the nature and process of supplier's upgrading in the global production network. We argue that the lead firms control the supplier's learning upgrading process in order to prevent the latter from becoming competent enough to encroach into their competitiveness both inside and outside global value chains. Taking advantage of incremental and path-dependent nature of supplier's learning, the lead firms try not to give the suppliers any chance to learn the strategic competent through learning-by-doing. They may control the supplier's learning - even without direct ownership - by carefully confining the sourcing activities to non-strategic ones. To conclude, by focusing learning and upgrading process, this paper attempts to bring the dynamic perspective into the analyses on control and coordination of disintegrated production network.

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Figure 1. The Chain Hierarchy of the Commercial Aircraft Industry

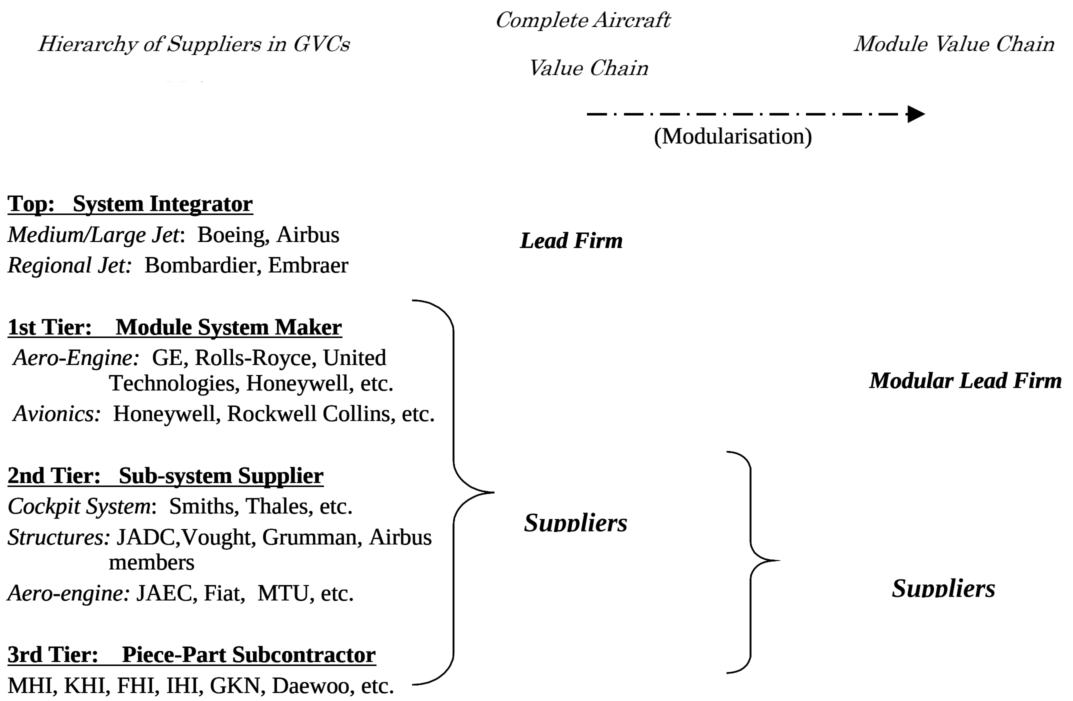
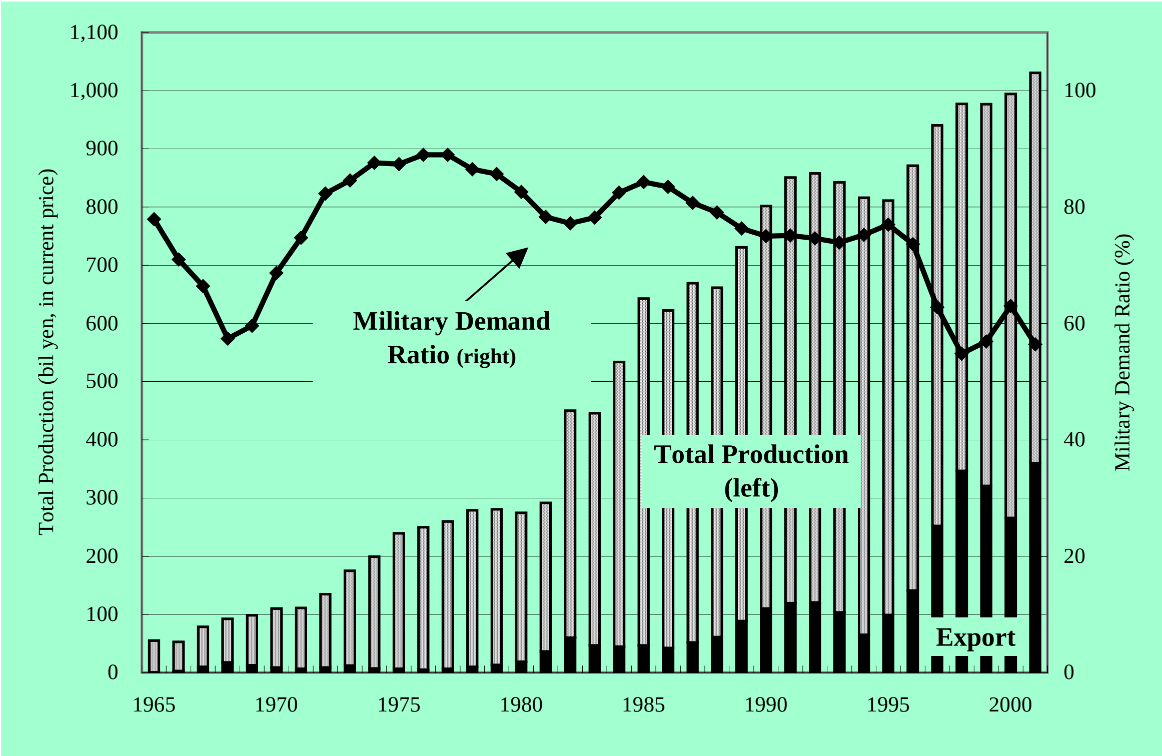


Table 1. Learning Dimensions in the Upgrading Process

Targeted Level of Suppliers	*Learning Dimensions*
(1) Piece-part Subcontractor	QCD for “drawing-supplied” manufacturing Value engineering (VE) / Value Analysis (VA)
(2) Sub-system Supplier	QCD for detailed component design, manufacturing and assembly Relation-specific skill with lead firms
(3) Module Maker	All product-related competences at module level Supplier management in a module value chain

Figure 2. Total Production, Exports and Military Dependency of the Japanese Aircraft Industry



Source: SJAC (Society of Japanese Aerospace Companies various years)(various years)

Original Source: Research Institute of Economy, Trade and Industry, *Kikai Tōkei Nenpō* (Manufacturing Statistics Yearbook).

Figure 3. The Upgrading of the Japanese Aircraft Firms

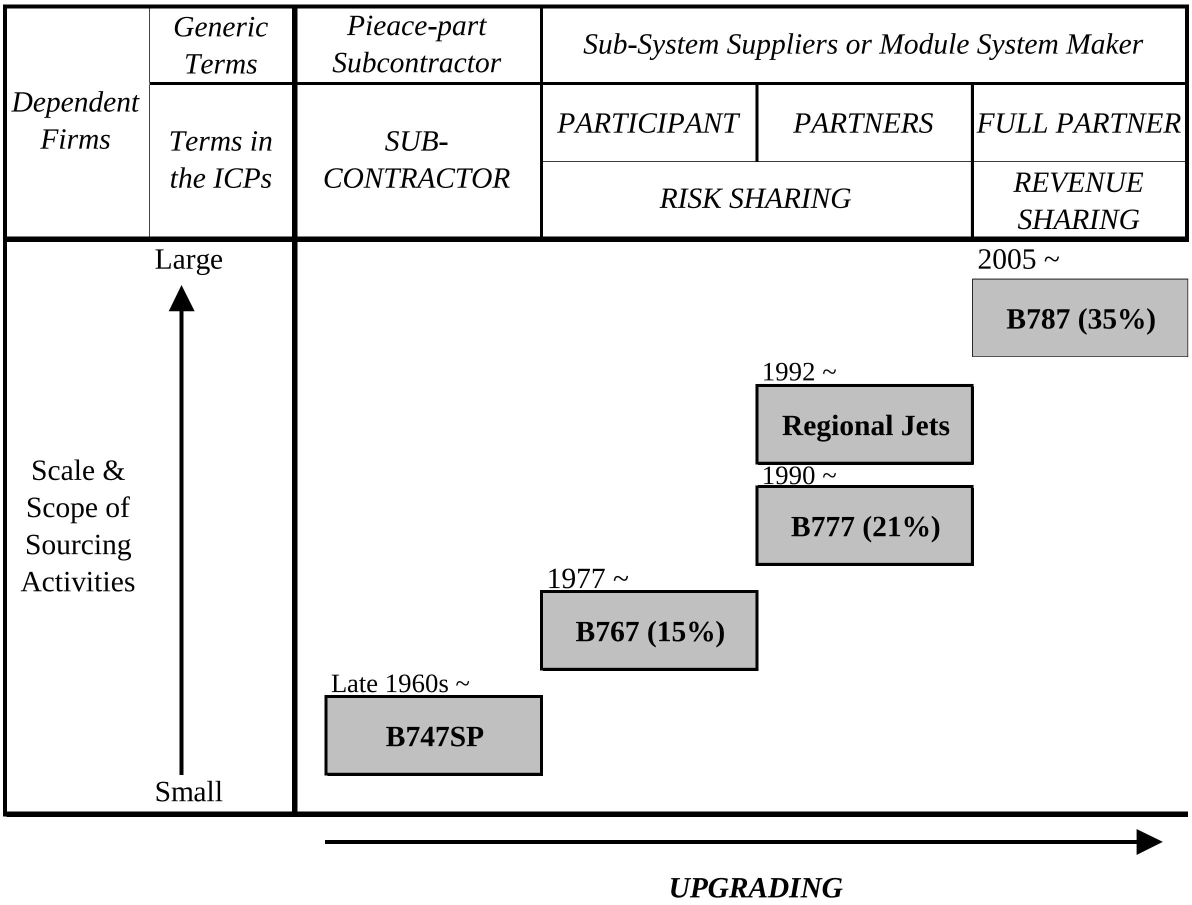
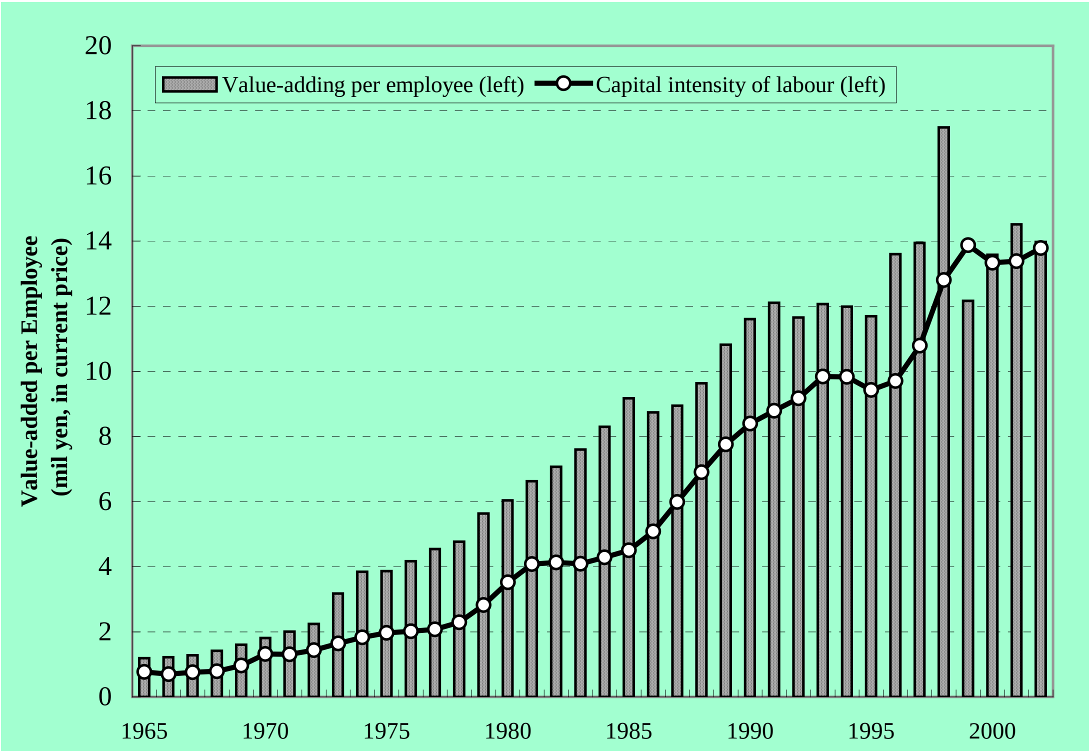


Figure 4. Productivity of Aerospace Divisions of the Major Japanese Aerospace Companies*



Notes: * The major Japanese aerospace companies includes MHI, IHI, KHI, FHI, Nippi, JAMCO, ShinMeiwa, and Showa Aircraft.

(Value-adding per employee) =

(Capital intensity of labour) x (Capital productivity)

Sources: SJAC (various years) *Kōkū Uchū Kōgyō Nenkan* (The Aerospace Industry Yearbook).

Figure 5. The Scope of Activities and Competence of the Japanese Aircraft Firms