Air cargo services and the electronics industry in Southeast Asia

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Abstract
Air cargo services are among the most important producer services for manufacturers with internationalized production networks. In the context of supply chain management strategies, such services allow firms to respond more effectively to competitive forces in global markets. Our research aims to relate to and deepen the theoretical literature on advanced producer services and global production networks by examining the demand for air cargo services in the electronics industry in Southeast Asia, an industry and a region in which air cargo services are particularly significant. Using an air cargo intensity index for each of over 120 firms from Singapore, Penang, Kuala Lumpur, and Manila, we show that the diversity of air cargo usage is related to several aspects of firm structure and operation. Our research suggests that product type, internationalization, localization, product cycle (obsolescence), and other factors such as a firm’s material management strategy are especially critical. New directions for research that will build upon these findings are noted.

Keywords: producer services, air cargo, electronics industry, Southeast Asia, global production networks, supply chain management, logistics

JEL classifications: L93, R41, L63, O14

Date submitted: 14 October 2002  Date accepted: 2 June 2003

1. Air cargo services in the global economy
The thousands of routes operated by the world’s airlines have become vital arteries of trade. Between 1980 and 2000, the volume of international air freight traffic, measured in freight tonne-kilometers, grew fivefold (ICAO Journal, 2001). With its growing importance, air cargo has taken a prominent place among the services from which states, regions, and firms can derive competitive advantage in global markets. Air cargo has become the principal mode of international transport for a wide variety of (especially knowledge-intensive) goods. The range of ‘air-eligible’ goods continues to widen as more firms look to the speed and precision of their supply chain management strategies as sources of competitive advantage. At the same time, air cargo services facilitate the internationalization of production networks at new scales, better enabling firms to leverage the assets of more distant regions.

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We examine the use of air cargo services in Southeast Asia, a region that is distant from the world's principal economies and important as an electronics export platform. Air cargo services are vital, of course, to the incorporation of peripheral regions like Southeast Asia into the international economy, but because the quality and capacity of air cargo services (including ground-based air logistics services performed in airport-adjacent logistics parks) vary spatially, such services can be a source of competitive advantage to firms and to the regional and national economies in which those firms are embedded (Figure 1). In turn, the quality and capacity of air cargo services are dependent, in part, on the policies of national states and the importance of air-eligible products (e.g., especially light-weight, high-value electronics) within regional economies. In this context, we argue that air cargo services can play a critical role as an advanced producer service that 'holds down' global production networks in particular places, a theme we explore in detail below.

Air cargo services include both the airport-to-airport carriage of goods performed by airlines as well as related air logistics services performed on the ground, usually by freight forwarders. Air logistics include, for instance, truck transport from an airport to a client firm's manufacturing plant but also highly customized services that use information technology and airport-adjacent third-party warehouses to accelerate the distribution of finished goods and minimize the inventory of component parts. A growing number of manufacturers rely on such services to secure an advantage in international competition. As suggested in Figure 1, the competitive advantage enjoyed by air cargo services firms (e.g., the degree to which they are 'world class' or based in a city with unusual centrality in global airline networks) can be the basis for competitive advantage in a user firm.

In this paper, we seek to understand variation in the intensity of air cargo services usage among electronics manufacturing firms in Malaysia, the Philippines, and Singapore. These firms use such services both as shippers (when exporting components or

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1 In the context of logistics services, third-party refers to a firm that carries out logistics services like warehousing and distribution on behalf of either the shipper (first party) or consignee (second party).
finished products) and as consignees (when importing components and raw materials). We relate the insights drawn from the analyses of over 120 interviews with firms, both locally and foreign-owned, to the existing literatures concerning global production networks and advanced producer services. We argue that foremost among the major factors influencing firms’ air cargo services usage are the degree to which production has been internationalized, the nature of the good being produced, the importance of speed in a firm’s supply chain (and distribution chain), and the degree to which a firm is a logistics decision-maker or decision-taker in the production networks in which the firm is positioned.

While air cargo still accounts for only a relatively small share of world trade (particularly when compared with the physical volume of sea freight), its importance has risen rapidly in the past two decades. The expansion of air cargo has been driven by several interconnected factors. First, the development of faster, larger, longer-range aircraft has contributed to a long-term downward trend in real air freight rates of about 3% per year, rendering air cargo services more affordable for more goods (Boeing Commercial Airplane Group, 2000). The introduction of the Boeing 747–400F, especially in the Pacific Basin, during the past decade was very important in this regard; and the launch of the ultra-large Airbus A380 freighter in 2008 will perpetuate the same trend. Second, the liberalization of air freight services in many markets has permitted an expansion of services and an intensification of competition, reinforcing the decline in air freight rates. Third, the internationalization of economic activity and concomitant disaggregation of production networks have increased the significance of air cargo services not only to firms but also to regions and nations. Fourth, the proliferation of just-in-time material management practices has helped to redefine air cargo for many firms from an emergency recourse to a regular feature of supply chain management strategies.

The term supply chain management denotes the ever-increasing emphasis on managing the external relations of production and the control of resource flows from source to consumer (Mentzer, 2001). The purposes are: first, to aim for improvement in logistics performance including greater reliability, smoother flow through the chain, and more efficient connections between the various links in the chain and second, to realize the lowest possible cost for the chain as a whole. The nature of the supply chain and, we would argue, its incorporation of air cargo services depend on several factors. These are the complexity of the product, the number of available suppliers, and the distances over which the supply chain is stretched (Lambert, 2001, pp.103–105). Supply chain management is raised here as a key factor in the explanation of the demand for air cargo service (Sturgeon, 2001). Porter (1990) argued that the competitive advantage of firms rests on product cost and/or differentiation. Air cargo services, as part of a supply and value chain management strategy, can contribute to both product cost and/or differentiation: through inventory minimization in the case of the former and speed-to-market in the case of the latter (see Gallacher, 1998 and Meersman and Van de Voorde, 2001, on time-based competition).

Supply chains embedded in the Pacific Rim are particularly reliant on air cargo services. Though air cargo has grown rapidly in markets worldwide, its expansion in Asia has been stunning. Air cargo on routes to, from, and within Asia-Pacific grew at an average annual rate of 9.8% from 1980 to 2000 (Boeing, 2002), faster than for any other region. By 2001 nearly half of the world’s freighter aircraft capacity was deployed on Asia-Pacific routes (Bowen, 2004). Until the onset of the Asian financial crisis, cargo growth on routes within Asia exceeded those between Asia and the rest of the world. Intra-Asian cargo flows
manifest the increasingly complex relationships among Asian economies (Poon, 1997). In the computer industry, for instance, Singapore, Taiwan, Malaysia, and Thailand occupy different niches with a consequent flow of components among them. Much of this traffic is intra-firm, reflecting the empowerment of the transnational corporation as manager of the new international division of labor (Yeung, 2001). The increasingly complex overlay of manufacturing and services in these markets exemplifies the concurrence of industrialization and tertiarization in some developing economies, while the most advanced economy in the region (Singapore) better fits the conjunction of deindustrialization and tertiarization in the developed world (Williams, 1997, p.18).

2. Air cargo services as advanced producer services

The stature of air cargo services in the contemporary international economy illustrates several features of services more generally. First, services facilitate economic transactions and play a vital role in development (Daniels and Moulaert, 1991; Daniels, 1993; Begg, 1994; Illeris, 1996). Second, services may be used to secure competitive advantage in the global economy (Porter, 1990, 1996; Dicken, 1998). Third, national economies are becoming less insular and more interdependent, a process that is inextricably linked to the presence of ‘enabling technologies’—transportation, communication, and organizational innovations that aid in the internationalization process (Dicken, 1992, pp.106–107). Together these changes are manifest in the marked increase in production, consumption, and trade of services, especially producer services (Wood, 2002).

One aim is to situate our work in the theoretical literature on advanced producer services (Daniels and Moulaert, 1991). In this regard we seek to show the degree to which prevailing explanations of demand for producer services apply to air cargo services (e.g. Goe, 1990, 1991; O’Farrell, 1993; O’Farrell et al., 1993; Beyers and Lindahl, 1996). At the outset it is worth noting that air cargo services have received little attention in the broad economics (e.g. Button, 1990; Fennes, 1997; Button and Owens, 1999) and geographical literatures (e.g. Raguraman, 1997; Rimmer, 1997; Loughlin, 1998) and virtually none in the producer services literature (Nusbaumer, 1987; O’Connor and Hutton, 1998; Ho, 1998). The neglect of air cargo services, along with other transport services, by producer services researchers is rooted in the perception that transport services lack the sophistication (e.g. skill requirements, specialization) of ‘advanced producer services’ (Harrington, 1995) and consequently display a ‘more even spatial distribution’ (Williams, 1997, p.34), thereby minimizing their impact on urban and regional development. At least in the case of air cargo, this perception is contradicted by the development, especially in the 1990s, of specialized air cargo and ancillary logistics services whose supply and sophistication vary across the hierarchy of world cities in a fashion that is similar to other producer services.

Our exploration of air cargo services is intended to respond to the call for research on services and the new economy (Beyers, 2002; Wood, 2002). In this regard, our research draws upon several themes in the advanced producer services (APS) literature (e.g. Daniels and Moulaert, 1991, and special issues of Growth and Change: A Journal of Urban and Regional Policy, Vol. 22, No. 4, 1991 and Papers in Regional Science, Vol. 75, No. 3, 1996). Most critical to our work are the factors affecting demand. In deepening our understanding of the demand for producer services, we must distinguish among those factors related to the structure of firms, industries and regional economies. For example
what is the importance of scale of both production and corporate organization? Scale may be neither a necessary nor sufficient condition for a greater and more diversified demand, as the actual structure, development phase, and strategy of the firm further complicate the picture. In particular, firms covering several stages of the production process (vertically integrated) may demand a wider range of services. The type of industry and product (as well as its life-cycle stage) also affect demand. The demand for producer services by a firm manufacturing standardized products for mass markets will differ from one offering customized products for a specialized market. At the same time, the innovative content of products and processes will likely affect the nature of demand (Martinelli, 1991, p.25).

A separate, important theme of the producer services literature has been the performance and competitiveness of business service firms. This aspect of the literature is critical because the competitiveness of a business service firm can be a source of competitive advantage for a user firm, especially if the latter is the focal (or dominant, organizing) firm in a production network. For example, one study examined the effectiveness of producer services in promoting the efficiency of manufacturing enterprises in regional economies (O’Farrell and Hitchens, 1990). That research attempted to develop methodologies to test the effectiveness of producer services in promoting the efficiency of manufacturing firms in peripheral areas by measuring the utility of service inputs and the quality of producer service firm outputs. Still another study has pointed to the role of producer service outsourcing in the innovative performance of manufacturing firms (MacPherson, 1997).

Another related line of inquiry concerns the externalization of services functions by manufacturing firms. Conventional wisdom suggests that the growth of producer services has been attributable to cost-driven factors and vertical disintegration processes. Yet research in this field shows that cost-driven externalization is not the most important force underlying growth. Rather the need for specialized knowledge combined with a variety of other cost, quasi-cost, and non-cost driven forces are critical (Beyers and Lindahl, 1996). Evidence from still another study suggests that the expansion of demand is the primary cause of increasing business service output and not restructuring strategies as predicted by a flexible firm model (O’Farrell et al., 1993).

The externalization of services may seem taken for granted with respect to transportation services since they have been so seldom performed by manufacturers themselves (in contrast, for example, to in-house legal services). But in fact the trend towards externalization has affected the air cargo services industry, too. Both the search for specialized knowledge and the desire to reduce costs have been important drivers in the rapid growth of third-party logistics that are increasingly provided in conjunction with conventional transport services. Since the mid-1990s, freight forwarders and other firms have begun to offer more customized logistics services to manufacturers enabling the latter to minimize inventories, more tightly time production and delivery schedules, and reduce transit times. Such services are most advanced in the United States where third-party contract logistics grew faster than gross domestic product for eight consecutive years to 2002 (Armbruster, 2003); but they are also growing rapidly in Asia (South China Morning Post, 2002). The quality and availability of such services varies widely (Bowen and Leinbach, 2004).

O’Connor and Hutton (1998) examine the applicability of advanced producer services themes more generally to the Asia Pacific region. In a special issue of Asia Pacific Viewpoint, Daniels (1998) explores the idea that in this region the relationships between economic growth, industrial transformation and the rise of producer services appears to be different
from those found in North America and Europe (e.g. the role of ethnicity in shaping business linkages) and such services are less prominent than expected. K. C. Ho (1998), in the same issue, sketches the locational dynamics of regional functions in the Asia Pacific region, emphasizing how generic factors such as proximity to company affiliates and market access apply. Among his findings are that industry-specific dynamics for air delivery and online information services relate to location and competitive advantage. Our research casts further light on the demand for producer services in this dynamic region.

3. Air cargo services in global production networks

Producer services, including air cargo services, have not only facilitated the internationalization of economic activity but have also fostered the development of more sophisticated production relations. Especially important has been the development of more sophisticated supply chain management practices. In fact one of the most significant paradigm shifts in modern business management is that individual businesses no longer compete as solely autonomous entities, but rather as supply chains (Lambert, 2001, p.99). A remarkable shift in corporate strategy and operational activity has occurred over the last decade with the externalization of production rendering many corporations heavily reliant on external resources (Meersman and van de Voorde, 2001, p.69). A result is that a significant proportion of competitive advantage rests with the management of these external resources (Hall and Braithwaite, 2001, p.81). Dicken and Thrift (1992) have pointed up that the production chain is a complex, dynamic system and note that ‘the inter-firm structure of large corporations is better represented as a network than a hierarchy’. But increasingly we have learned that even small and medium enterprises reveal a large degree of network organization to enhance flexibility, delivery and cost competitiveness (Hall and Braithwaite, 2001, p.94).

These developments are manifest most in the emergence of the global production network, a term used to describe ‘the globally organized nexus of interconnected functions and operations through which goods and services are produced and distributed’ (Coe et al., 2003, p.18). In the context of contemporary internationalization, regional development is contingent upon the ‘coupling’ of the strategic needs of ‘trans-local’ firms and region-specific assets (e.g. low-cost labor) through a global production network. The term network refers to ‘both a governance structure and a process through which disparate actors and organizations are connected in a coherent manner for mutual benefits and synergies’ (Yeung, 2000, p.302). Relational networks have been propounded as ‘the foundational unit of analysis for our understanding of the global economy, not individuals, firms or nation states’ (Dicken et al., 2001). Such networks unfold across multiple scales and are powerfully shaped by the state.

How do producer services, in general, and air cargo services (and related logistics services), more specifically, factor in global production networks (Figure 2)? First, the cost, capacity, and reliability of producer services help to define the scale over which such networks are realized. Despite the fascination with globalization, much of the internationalization of economic activity has not been global in scale but has instead been concentrated within Europe, within North America, and within East Asia (Poon, 1997; Yeung, 2001; Lai and Yeung, 2003). There are a number of reasons for this pattern but one is the continued high cost (in terms of money, time, and managerial complexity) of maintaining truly global supply and distribution chains. The development and elaboration of advanced producer services mitigates those constraints. In particular,
the continued decline in real air freight rates and the expansion of air freight networks facilitate the rescaling of production networks.

Second, beyond their role as an enabling mechanism for internationalization, producer services play a more specific role in funneling the extension of global production networks along certain corridors. The geography of internationalization has created an ‘archipelago economy’ (Veltz, 1996, cited in Coe et al., 2003) in which places well integrated into the global economy are surrounded by less privileged places that are not. Air cargo services, like other dimensions of the distributive infrastructure (Martinelli, 1991) of the international economy, reflect and reinforce that geography. Firms evaluate the viability of a new node in a global production network based in part on the cost and availability of transport and communications infrastructure tying that node to others already in the network. In Asia-Pacific, for instance, the density of global production networks and the density of transport networks (represented by the overlap of production linkages and high capacity corridors in Figure 2) augment one another.

Third, producer services are, like the service sector more generally, still subject to pervasive state regulation, illustrating the refusal of the state to ‘whither away’ as an influence upon the global economy (Smith et al., 2002). On the contrary, the territorially specific policies of the nation-state create bounded spaces within which global production networks are articulated ‘in highly differentiated ways’ (Coe et al., 2003). The state’s influence on air cargo services and, through those services, its influence on the structure of global production networks is manifold. States regulate airline competition to varying degrees (thereby affecting the quality, quantity, and costs of services provided), play an important (though diminishing) role in infrastructure provision, and implement

Figure 2. Air cargo services and global production networks.
labor policies that affect the cost of air cargo services. And yet, the importance of attracting investment by trans-local firms in global production networks means that states, especially small states, are compelled to pursue similar strategies in creating business-friendly environments. In Asia-Pacific aviation, for instance, the 1990s were characterized by massive investments in new airport infrastructure across the region and an almost region-wide shift towards liberal ‘Open Skies’ policies that permit much greater freedom of operation to international airlines (Oum, 1998).

Fourth, air cargo services, broadly defined, are an important aspect of the region-specific assets with which the needs of trans-local firms are coupled in global production networks. Indeed, regional development has become dependent, to some degree, on the effectiveness with which producer services expertise interacts globally, nationally, and regionally to support productive demand (Wood, 2002). As noted earlier, the growth of air cargo volumes has been accompanied by the proliferation of related logistics services; in their most sophisticated form, these services become highly customized efforts to restructure a client-firm’s supply and distribution chains. Such services are highly uneven in their development across the global economy (represented by the uneven distribution and size of logistics parks in Figure 2). In Southeast Asia, for instance, Singapore hosts large warehouses from which major air freight forwarders provide region-wide logistics management services. Such specialized services enable Singapore to better enhance and capture value in the global production networks in which the city-state is incorporated. In this respect air transport linkages and services ‘hold down’ global production networks (particularly in the vicinity of major hubs like that at the center of Figure 2) and may unleash, or conversely constrain, regional potential.

Fifth, global production networks are governance structures through which power is effected; air cargo services and related logistics services can be a conduit through which such power is exercised. For instance, an important development in air cargo services has been the development of electronic tracking that permits an unprecedented degree of precision for firms monitoring the movement of components. Many major manufacturers have developed rigorous standards that supplier firms must meet; focal firms then use the information from electronic tracking to evaluate the suppliers’ performance. Consequently, production linkages, such as those shown in Figure 2, are characterized by reciprocal flows of goods and information, with both types of traffic moving at unprecedented speed and in unprecedented volumes.

An alternative way of viewing air cargo services as a conduit for the governance of a global production network is to distinguish between push supply chains and pull supply chains (Hall and Braithwaite, 2001, p.71). In the former, costs are transmitted up the chain with little control over the cost structure of the entire chain. In contrast, a pull supply chain operates on the principle that the supply chain must be able to deliver a product to market at an affordable level. In a global production network organized around a pull supply chain, the focal firm often orchestrates the logistics management strategies of other firms in the network.

Sixth and finally, air cargo services facilitate the realization of relational rents in global production networks (Kaplinsky, 1998; Khan and Jomo, 2000). Relational rents are abnormally high profits secured through a firm’s superior relationships with other firms or with institutions of the state (e.g. cronyism). Rent is partially contingent upon access, and because air cargo services shape patterns of access within a global production network, such services can engender relational rents. Links among firms that can foster an overwhelming competitive advantage (i.e. the ability to secure rent) such as the much faster acquisition of spare parts or raw materials and components, may depend upon the availability of
sophisticated producer services such as air cargo. Much as a family connection in an important government regulatory agency might enable a firm to achieve an artificially high profit margin, so too an unrivaled connection to a supplier through a network of air cargo services might enable a firm to also realize relational rent.

In sum, air cargo services are, for a growing number of firms and a growing variety of products, an integral part of supply chain management which is in turn a system through which goods, services, money, and power flows among the actors linked by a global production network. Our principal interest is in better understanding variation in the demand for air cargo services among electronics manufacturers in Southeast Asia. All of these firms are incorporated into global production networks, most into multiple networks. Almost all are under great pressure to accelerate their supply and distribution chains. And yet, as shown below, their reliance on air cargo services varies widely. We model that variation as the function of product, firm, and place characteristics.

4. Data gathering

A basic survey instrument was constructed using a series of categorical and ranking questions. In addition several open-ended questions were included to generate discussion by respondents of key factors linking a firm’s use of air cargo services and the firm’s competitive advantage (Schoenberger, 1991; Fowler, 1993; Markusen, 1994). The instrument was field tested in Singapore prior to beginning formal interviews. Data was gathered from a total of 126 firms in three markets with the following breakdown: Penang (41 firms), Singapore (38), Manila (24), and Kuala Lumpur (23) (see Figure 3). Firms were selected through a random sample stratified by market location. Business directories for each market were used to generate lists of electronics firms. Firms were then contacted by telephone to arrange survey and interview schedules.

For the purposes of this study, firms were classified using definitions modified from the 1997 North American Industry Classification System (NAICS).² Five firm classes were used:

1. Precision Equipment \((n = 22)\)
2. Wires and Cables \((n = 21)\)
3. Consumer Electronics \((n = 20)\)
4. Computers and Peripherals \((n = 28)\)
5. Semiconductors \((n = 35)\)

These classifications are subdivided into manufacturing, assembly, and sales and service or headquarters firms. The majority of firms surveyed are involved in manufacturing activity. These firms produce components on-site, which distinguish them from assembly operations, which do not.

The survey instrument was administered either on-site at each firm in a face-to-face situation, or via fax/email when scheduling for face-to-face administration was not possible. Nearly all of the responses to the survey instrument were obtained by administering the questionnaire on-site at each firm in a face-to-face situation. Of the 126 firms interviewed, only nine preferred to respond by fax/email. The survey instrument comprised four sections of which Section 1 contained questions regarding firm type, employee characteristics, firm ownership, and geographical location of operations.

Section 2 sought data on principal logistics for a firm’s primary product moving by air cargo. This section requested data on the geography of source materials, transport mode, product path from firm to customer, and final product destination. A sub-section dealt with the use of special logistics services used by firms (e.g. overnight delivery; third party logistics). Section 3 contained questions regarding a firm’s interaction with the air cargo industry including use of freight forwarding services and criteria for the selection of air cargo carriers. Finally, Section 4 included several ranking and open-ended questions regarding air cargo services and firm competitive advantage.

5. Characterizing the sample of air cargo user firms

Though Singapore, Malaysia, and the Philippines share a dependence upon the electronics industry and were selected as study settings for that reason, they occupy different places in the global electronics industry. Those differences are apparent in some of the basic characteristics of the 126 sample firms. First, firms classified as manufacturers or assemblers dominate the samples in Penang, Kuala Lumpur, and Manila but represent only about 60% of the sample in Singapore (Table 1). A large

![Study region](image)

**Table 1.** Sample firm characteristics by place

<table>
<thead>
<tr>
<th>Sample size</th>
<th>Singapore</th>
<th>Penang</th>
<th>Kuala Lumpur</th>
<th>Manila</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent manufacturing/assembly</td>
<td>63.2</td>
<td>90.2</td>
<td>82.6</td>
<td>95.8</td>
</tr>
<tr>
<td>Percent sales/service/regional HDQ</td>
<td>36.8</td>
<td>9.8</td>
<td>17.4</td>
<td>4.2</td>
</tr>
<tr>
<td>Percent locally owned</td>
<td>32.4</td>
<td>11.4</td>
<td>13.6</td>
<td>15.8</td>
</tr>
<tr>
<td>Percent knowledge intensive</td>
<td>50.0</td>
<td>17.1</td>
<td>17.4</td>
<td>33.3</td>
</tr>
<tr>
<td>Mean air cargo intensity index</td>
<td>5.39</td>
<td>6.02</td>
<td>3.16</td>
<td>6.34</td>
</tr>
<tr>
<td>Mean cycle time (days)</td>
<td>33.9</td>
<td>18.1</td>
<td>27.6</td>
<td>8.9</td>
</tr>
<tr>
<td>Mean DISTANCE* (kilometers)</td>
<td>6,649</td>
<td>7,873</td>
<td>6,180</td>
<td>5,946</td>
</tr>
</tbody>
</table>

*See Appendix for variable definition.
share of the Singapore firms comprises sales, service, and/or regional headquarters reflecting the shift in the city-state towards a postindustrial economy.

It is important to note that the large share of non-manufacturing firms does not mean that air cargo services are becoming less important to the economy of Singapore. On the contrary, most of the non-manufacturers interviewed there specifically cited the availability of air cargo services as a significant factor in the decision to locate functions in Singapore. For example, one joint Japanese-American firm in the sample, AVX-Kyocera, had shifted the manufacture of passive components (e.g. capacitors and resistors) out of Singapore to nearby Batam, Indonesia and Penang in the 1990s but transformed its Singapore operation into a large global distribution center. The distribution of products by the firm is critically dependent on the ample air cargo capacity from Singapore as well as Singapore’s status as a free trade zone (in which it is less expensive to hold stocks).

Second, the four sample sites were also distinguished by the types of electronics firms that were interviewed (Figure 4). The 126 sample firms were categorized into five groups based on their principal product: computers and peripherals (28 firms), consumer electronics (20), precision equipment (22), semiconductors (35), and wires and cables (21). It should be noted that not all firms were assigned easily to one of these categories. To improve the accuracy of assignment, several individuals with expertise in the electronics industry were consulted.

Perhaps most strikingly, the proportion of sample firms classified as semiconductor firms differed markedly across the four cities. Singapore, which was a key player in the semiconductor industry in the 1960s and 1970s, has now lost much of this business, particularly the lower value-added assembly operations. It remains, however, an important center in the fabrication of valuable silicon wafers from which the semiconductor chips are cut. Malaysia occupies an intermediate position in which both high-end (wafer fabrication) and low-end (cutting and processing of chips) functions are undertaken. And the Philippines’ semiconductor industry remains concentrated in labor-intensive operations.
Firms in other product categories balanced the smaller proportion of semiconductor firms in Malaysia and Singapore. In particular, a large number of firms in both Penang and Kuala Lumpur produce consumer electronics; examples include walkie-talkies and color television sets. In Singapore, precision equipment firms comprised a disproportionately large share of the sample; examples include the manufacturers of specialized alternators and motors.

Finally, once more reflecting differences in the level of development across the four sample markets, Singapore’s sample was distinguished by the higher level of local ownership and a higher proportion of knowledge-intensive operations (Table 1). Nearly a third of the Singapore firms were locally owned. In contrast, the same proportion was below 15% in the other three sampled markets. And half of the Singapore respondents described their workforces as mainly knowledge-intensive. Conversely, more than 65% of Philippine firms and 80% of Malaysian firms described their workforces as mainly labor-intensive.

6. Analysing the intensity of air cargo usage

As a comprehensive measure of the intensity with which firms use air cargo services, an index was formulated based on firms’ responses to several questions. The index was constructed by assigning points to firms that had certain characteristics or exhibited certain behaviors. The number of points earned for each characteristic or behavior is necessarily somewhat arbitrary, but we have drawn on our knowledge of the industry and that of our interviewees in developing an index. For example, the disparity in the number of points a firm earned for using express air cargo services on a regular basis versus only in emergencies was based on the difference in costs associated with express air cargo services versus conventional air cargo services. After evaluating alternative ways of formulating the index, we are satisfied that the approach presented below offers the best approach for estimating an air cargo index that is both reliable and valid.

The index incorporates elements measuring:

1. The degree to which a firm used air cargo services in general. A firm was assigned points (in parentheses) for this index based upon the following conditions:
   - on a regular basis (3.0)
   - to meet peak season demand only (0.5)
   - only in emergencies (0.25)

2. Whether a firm used mainly air cargo to move the most important raw material or component and the second most important raw material or component used to make its principal product. A firm earned 1 point for each of the two inputs moved mainly by air freight.

3. Whether a firm used mainly air cargo to move its principal product to its most important destination market and its second most important destination market with each index increment weighted by the proportion of the firm’s output that went to each destination. A firm could earn a maximum of 2 points for this item if each of the two destination markets were served principally via air cargo services and if those two markets absorbed all of the firm’s output.

4. The degree to which a firm used express air cargo services. A firm was assigned points (in brackets) for this index based upon the following conditions:
   - on a regular basis for most or all products (5.0)
on a regular basis for some products (2.5)
to meet peak season demand only (1.0)
only in emergencies (0.5)
no express (0)

The measure was constructed by adding the four components with the appropriate weights being assigned to individual elements noted above. The resulting air cargo intensity index ranges between 0 and 12. For example, AVX-Kyocera in Singapore has an index value of 6.3 because it uses general air cargo services on a regular basis (3.0 points), it uses mainly air cargo for the import of both of its two main raw materials (tantalum and ceramic capacitors) (2.0 points), it delivered goods to its second most important destination market (South Korea which absorbed about 40% of the firm’s output) by air (0.8 points), and uses express for emergency situations (0.5 points). The mean value of the index for the 126 sample firms was 5.4. The index is somewhat bimodal, with one peak near zero and a second, stronger peak just above the overall sample mean.

The intensity index showed a marked variation across the five product categories (Figure 5). Unsurprisingly, the highest mean index was recorded by firms grouped in the semiconductor category (7.6) and the lowest by firms in the consumer electronics category (2.5). Semiconductor firms produce goods that have an extremely high value-to-weight or value-to-volume ratio and therefore a high capacity to bear the costs of air transport. More importantly, semiconductors have very short product life cycles and semiconductor manufacturers are under great pressure to shorten cycle times—that is the elapsed time between a new order being placed and the order being filled at the customer’s premises. Conversely, consumer electronics (e.g. computers, printers, refrigerator ice-makers) are bulkier; less valuable; and less sensitive to corrosion at sea and are characterized by somewhat longer product obsolescence cycles. Moreover, the long experience of the semiconductor industry in the use of air cargo services to integrate global production networks is reflected in the greater sophistication of semiconductor firms in the use of such services and in the willingness of many such firms to accept higher transportation costs to secure speed-to-market advantages.

Figure 5. Cycle time and air cargo intensity by product class.
The air cargo intensity index also varied by location, with Manila recording the highest average value and Kuala Lumpur the lowest (Table 1). The variation across the four markets can be largely explained by the aforementioned differences in the proportion of different product categories (e.g. the preponderance of semiconductor firms in Manila and consumer electronics manufacturers in Kuala Lumpur).

7. Analysing the use of air cargo services

In attempting to learn more about the variability of the use of air cargo services and its correlates we examined a variety of plausible firm characteristics represented by eight independent variables (variables are listed in the Appendix). In the initial stage of ordinary least squares modeling, the most significant variable in the analysis was DISTANCE (Table 2) with which the response term was significantly and positively related. DISTANCE is a ratio scale variable measuring the distance associated with both the backward (major inputs) and forward (major destination markets) linkages for a firm’s principal product. Greater distances are indicative of greater internationalization in which the effort to leverage uneven factor endowments in dispersed economies is often predicated on the regular use of air cargo services.

The importance of this variable in a specific context is revealed by the example of Seagate Technology, the world’s largest manufacturer of disk drives. The Seagate plant at Penang has been operating there for 12 years and currently employs approximately 4,000 workers. The principal product is a ‘slider’ (read-write device). The main input material is the wafer, which is shipped to the Penang manufacturing plant ‘just-in-time’ from the US and Ireland. The finished slider is then shipped to both Bangkok and Seoul where it is mounted on a head gimbal or arm of the disk drive. Subsequently, the loaded gimbals move forward in the production chain from those nodes to computer assembly operations (principally Dell and Acer) across Asia. The distances over which this global production and distribution network is spread and the necessity for speed mandate the use of air cargo services.

The other significant variable in the initial model was CYCLTIME, which was negatively related to air cargo services intensity. CYCLTIME, a ratio scale variable measuring the number of days from the time an order is received until the goods are

<table>
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<th>Standardized coefficient</th>
<th>t-score</th>
<th>Significance</th>
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</tr>
<tr>
<td>PRODDEST</td>
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<td>-0.100</td>
<td>-1.15</td>
<td>0.254</td>
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Adj. R-square 0.255.
delivered to customer, is a critical dimension of a firm’s logistics management strategy. Short cycle times, often only several days in length, are achieved by trading off the high cost of air cargo (and even express air cargo) for the competitive advantage gained through faster deliveries to customers. Firms with faster cycle times were much more likely to use air cargo services and to use them intensively. For instance, among firms that reported they used air cargo services on a regular basis, mean cycle time was 17.1 days while the mean cycle time for firms that used such services only in emergencies was 46.6 days. In other words, incorporation into a global production network was insufficient to engender reliance on air cargo services. The nature of the product and the manner in which it is produced mediate the influence of spatial disaggregation of production.

Semiconductor firms had shorter cycle times than others and that helps to explain the aforementioned variation in air cargo intensities by product class (Figure 5). The differences in cycle times by product give rise to differences in cycle time by place (Table 1). Interestingly, Singapore firms had the highest mean cycle time. This result is, at first glance, counter-intuitive but makes sense insofar as Singapore has moved towards a post-industrial economy. Within that economy, manufacturing has shifted towards highly specialized, very high value-added operations for which the pressure to deliver finished goods rapidly to a customer has eased. Conversely, many of the semiconductor manufacturers that dominate the electronics industry in Penang and Manila are under intense competitive pressure. Time is a key dimension along which that competition is waged. And yet for firms in each of these markets, despite their varied position along an industrializing-postindustrial spectrum, the quality of and capacity of air cargo services are important aspects of the region-specific assets that help to hold down global production networks.

Another case study further illustrates the importance of cycle times. Intel, a US-based firm, the world’s leading manufacturer of microprocessors, has operations throughout Southeast Asia. Its Manila and Penang branch plants were included in the sample for this study, and both had very high values for the air cargo intensity index (12.0 and 11.6 respectively) but differing cycle times (4 days and 14 days, respectively). Both branches indicated that express air cargo is used for most shipments. With the economic slowdown in the semiconductor industry, Intel in Manila has begun to de-emphasize express services but there are significant constraints on the extent to which it can do so. Indeed the trend towards e-commerce and smaller, door-to-door shipments are likely to increase Intel’s reliance on complex air cargo services (not simply express). In these cases, air cargo services are customized and akin to the custom-based production emphasized by Nilsson (1996, p.8). Custom-based manufacturers cater to the needs of ‘sophisticated and demanding buyers’, much as air cargo service firms increasingly offer specialized, customized services to sophisticated and demanding manufacturers.

The remaining variables (described briefly in the Appendix) were statistically insignificant. This outcome and the sizeable unexplained variation fueled our effort to develop a richer model more consonant with the complexity of firm behavior. Our examination of the data for nonlinearity among variables did not yield any insights, but as described in the next section, the incorporation of several interaction terms in the model was helpful.

7.1. The introduction of interaction effects

In addition to the additive effects of our initial variables, the multiplicative effects produced by certain interaction effects were incorporated into the model (see variable
descriptions in the Appendix). In this fashion, we examine how certain variables mute or enhance or otherwise mediate the effect of others. We were particularly interested in the manner in which the size of firms and the knowledge intensity of their workforces filter or catalyse other variables. For example, the variable CYCL*EMPL is the product of cycle time and the number of local employees. This variable assesses the degree to which the impact of cycle times on air cargo intensity differs between large and small firms. As noted above, cycle time is significantly and negatively related to air cargo intensity. The interaction variable CYCL*EMPL can be used to measure the degree to which the local size of a firm magnifies or minimizes that effect.

The use of interaction terms like those described above may introduce the problem of collinearity (Aiken and West, 1991). To minimize collinearity, we ‘centered’ each interaction term (Draper and Smith, 1998). That is, each variable was expressed in terms of each value’s deviation from the variable mean (e.g. each firm’s value for CYCL*EMPL is the product of its deviation score of CYCLTIME and EMPLOYEE). The use of centered terms largely eliminates the problem of collinearity and its deleterious impact on parameter estimates.

In the enhanced model, DISTANCE and CYCLTIME remain the most significant variables. One more main effect variable emerged as significant in the second model: the binary variable indicating whether the customer has the greatest influence over the choice of air cargo services. Somewhat surprisingly, the sign on the variable is negative suggesting that in firms where the customer drives logistics (‘pull’ supply chains), the intensity of air cargo usage is somewhat lower. Firms that identified the customer as the greatest influence in air cargo usage tend to be firms whose position in relationships with customers is subordinate and that subordination is likely related to the performance of relatively low value added functions. Of the firms that gave the answer ‘the customer’, 36% were assemblers specializing in low value added operations; in contrast, assemblers represented only 27% of the firms where the customer was not the key decision-maker.

Although the knowledge versus labor intensity of a firm’s workforce and employment size did not emerge as directly significant, both were implicated in the interaction-effect terms that were significant in the second model. First, the variable CYCL*KNOW was significantly and positively related to the air cargo intensity index. CYCL*KNOW is a product of CYCLTIME and an ordinal variable KNOWLABR indicating whether a firm’s local workforce was mainly labor-intensive or knowledge-intensive. The significance of this interaction effect variable result can be interpreted as indicating that for firms with knowledge-intensive workforces, longer cycle times were nevertheless associated with high air cargo intensity indices. For example, Advantest, a Japanese-owned firm with a substantial sales and distribution facility in Singapore, has a very long cycle time but is highly dependent on air cargo services. The firm manufactures extremely sensitive automatic test equipment for use in the semiconductor industry. The sophisticated nature of that equipment is manifest in the degree to which the Advantest’s workforce is knowledge-intensive. The firm has a well-articulated logistics strategy within which air cargo services play a decisive role. Advantest’s products may be ordered four to six months in advance of delivery, but once produced the test equipment is so valuable and so sensitive that no mode other than air is suitable for long-distance transport.

The intensity of air cargo services usage is transmitted through the global production networks of which Advantest is a part from semiconductor manufacturers (for whom the intensity of time-based competition is pervasive) to this equipment manufacturer. It is worth noting that the nature of a firm’s logistics management strategy is just one of several
forms of firm practice that are transmitted along such networks. Far more than simply flows of goods, global production networks are also manifest in the flow of money, information, ideas, and practices. The late 1990s Asian financial crisis, for instance, was preceded by the cascade of bullish capacity expansion from one firm to another through the networks that linked them which gave way, when the crisis began, to the flow of mediating strategies from firm to firm (Lai and Yeung, 2003).

Another interaction-effect term, CYCL*DIST, has a simpler interpretation. The negative coefficient indicates that, while long production network distances are strongly associated with air cargo services, that association is muted when cycle times are long (and therefore delivery is often less urgent). For instance, Xerox’s Penang branch plant had a moderate air cargo intensity index (5.5) despite the fact that the distances across which its raw materials and finished products move were vast. Xerox manufacturers solid ink printers in Penang. The principal components are sourced in the USA, Japan, and Germany; and the main destination markets for the finished goods are the USA, the Netherlands, and Japan. The attenuation of Xerox’s production linkages is somewhat offset by the more relaxed cycle times (30 days). One result is that while Xerox relies on air freight for the delivery of its most important components, the completed printers are shipped mainly by sea freight.

Finally, DIST*EMPL was significantly and negatively related to the air cargo intensity index, indicating that for large firms the impact of distance was muted. This outcome again contradicts our expectation that large firms would be more likely to use air cargo services. At least in some parts of the electronics sector, large manufacturers may be leading a movement away from air cargo services and their high cost. An important example is Sony whose three plants in the region manufacture 12 different products related to hi-fi component systems, personal audio goods, and data storage devices. In Penang, the firm employs over 10,000 people and was the largest employer in all of our samples in the region. Sony’s intensity index of 4.6 is well under the average of 6.0 for all firms in Penang. Surprisingly, integrated circuits are shipped by sea from China and Japan to Sony-Penang, depressing the Penang operation’s air cargo intensity index. Sony has found that the goods arrive quickly enough if they are sea freighted from East Asia directly to Singapore’s sophisticated cargo handling port and then by truck to Penang.

7.2. Place and industry influences

The addition of the interaction effects variables improved the explanatory power of the model to 44%. Analysis of outliers from this intermediate model pointed to the influence of industry and place-specific factors. Among the positive outliers are a large number of semiconductor firms (44% of the firms with a positive residual exceeding one standard deviation but only 28% of the sample firms). One of the most important influences upon the use of air cargo is the value per weight ratio of a good. Because firms were either unwilling or unable to provide this information, a variable directly measuring value to weight could not be incorporated in the analysis. Yet clearly, the very high value of semiconductors renders air cargo, even express air cargo, a relatively small expense. Moreover, because logistics represents an especially important source of competitive advantage for semiconductor manufacturers, firms in this industry are compelled towards a degree of conformity in their intensive use of air cargo services.

Among the negative outliers are a disproportionate number of Malaysian firms (67% of firms with a negative residual exceeding one standard deviation but only 49% of
the sample firms). One factor behind the preponderance of Malaysian firms is localization. A large number of firms in the Kuala Lumpur region either sourced their principal components in Malaysia and Singapore or sent a large share of their output to these two ground-linked markets. Localization, which attends the development of increasingly dense intra- and interfirm linkages within a regional economy (Coe et al., 2003), is an important counterpoint to the increased dependence of manufacturing firms on air cargo services (and other long-range transport modes). A number of firms interviewed in the summer of 2001 indicated that they had pressured their suppliers to move closer or that they were under pressure to move towards their customers.

The importance of semiconductor firms as positive outliers and Malaysian firms as negative outliers suggest that the explanatory power of the analysis could be improved by adding two binary variables to the terms described earlier. The addition of SEMICON, a variable indicating whether or not the firm belonged to the semiconductor industry, and MALAYSIA, a variable indicating whether or not the firm was located in Malaysia, to the model improved its explanatory power to 47%. In fact, both variables proved significant in the final model, though MALAYSIA only weakly so (Table 3).

### 8. Conclusions

Our research demonstrates the variation in the articulation of air cargo services within the global production networks associated with the electronics industry in Southeast Asia. Because of the increasingly sophisticated nature and variety of these services we argue that they should be treated collectively as an advanced producer service. Much of the literature on advanced producer services has focused on the supply of, rather than the demand for, such services. Our study is among the first to examine the demand for a producer service across several economies at different levels of industrialization and to situate advanced producer services within global production networks.

Much of the variation in air cargo services usage is related to product characteristics that go beyond simply the value-to-weight ratio. For example, the high air cargo intensity among semiconductor firms is driven not only by the high value of their lightweight products but also rapid product cycles and the greater risk of damage associated with

### Table 3. Enhanced model of air cargo intensity

<table>
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<th>Unstandardized coefficient</th>
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<th>t-score</th>
<th>Significance</th>
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<td>CYCL*DIST</td>
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<td>DIST*EMPL</td>
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<td>-3.29</td>
</tr>
</tbody>
</table>

Adj. R-square 0.472.
sea freight. Customer preference and management policy are also often key in explaining
the demand for air cargo. While, as noted above, specific products, such as semi-
conductors, are much more likely to use air transport than are goods defined as
consumer electronics, even within the latter category there is also considerable
variation. The production location with respect to major markets, seasonality, and the
opportunities for local sourcing of inputs are reasons for the varying behavior. Just as
important as types of products as a discriminating variable for air cargo intensity is the
form of production. For example if a firm relies on and utilizes specific inventory control
procedures (e.g. just-in-time), air cargo may be more critical and used more heavily.

One of the most significant findings of the research to date is the extent to which air
cargo usage is associated with the degree to which a firm has internationalized, not only its
production sites and final markets but also its material procurement sites. A measure of
distance associated with forward and backward production linkages emerged as the most
important explanatory factor of air cargo use. A second important variable was cycle
time, an indication of a firm’s material management strategy. In the enhanced model, the
role of the customer as an influence on logistics choices and the interaction among several
other variables pointed to the complexity of air cargo services usage. The interaction
terms, in particular, highlighted the role of firm size and production process (and its
associated knowledge versus labor intensity) as forces that mediate the impact of cycle
times and distance. Our research thus suggests that product type, internationalization,
localization, product cycle (obsolescence), and other factors such as a firm’s material
management strategy are especially critical.

Above all, our research points to the importance of drawing together research on
advanced producer services and global production networks. Producer services make
possible the increasingly global scale of production networks and shape the spatial
configuration of those networks. Some producer services, including those provided by
the air cargo industry, are elements of the distributive infrastructure over which
production networks are elaborated. Producer services are also crucial among the
region-specific assets with which the needs of trans-local firms are coupled in global
production networks. The development of the semiconductor industry in the Metro
Manila region of the Philippines, for instance, has been contingent in part on the
nature of the air cargo services available in that market.

In turn, the development of global production networks, with all of their concomitant
complexity, has spurred the development of more sophisticated producer services. In the
air cargo industry, for instance, conventional airport-to-airport transport services are now
complemented by and integrated with knowledge-intensive logistics services that enable
user firms to more effectively manage the complexity of international operations. In other
producer services industries, too, the emergence of more highly specialized services has
accompanied the globalization of manufacturing. Moreover, the internationalization of
production means that demand for and use of sophisticated services has also been
internationalized, and that is likely to erode the spatial differences in the availability
of such services. To revisit the example of the semiconductor industry in the
Philippines, for instance, that industry’s requirements for complex air logistics compel
third-party logistics firms to offer more sophisticated services in the Manila market,
narrowing the gap between the quality of such services in the Philippines and in the
region’s services hub, Singapore.

In addition we also demonstrate the attachment to the externalization of services
functions by manufacturing firms. Our findings offer a somewhat different perspective
on the point which suggests that cost driven externalization is not the most important force underlying growth in demand in producer services (Beyers and Lindahl, 1996). In the air cargo context, the need for specialized services does indeed drive demand. The use of varied air cargo services in that regard can be likened to the use of other producer services to separate a firm from its competitors (Lindahl and Beyers, 1999).

Lastly, this work points toward several promising avenues of inquiry. First, although we have not tested the flexible firm model which predicts that restructuring strategies cause the expansion of producer service demand (O’Farrell et al., 1993), the relationship between the demand for air cargo services and user firms’ expansion and contraction under varying circumstances is worth exploring. Second, externally provided supply chain management ‘solutions’ have an increasingly important impact on the way firms use air cargo, particularly in developing economies where the sophistication of logistics management has tended to be low in the past. Increasingly, the most lucrative business function of multinational freight forwarders is the development of specialized supply chain systems for large customers in which goals other than simple cost minimization are paramount (interview with Wilson, 2002). An ongoing interest focuses on improving our understanding of the manner in which forwarders design and implement these solutions and how they affect the operations of the forwarders’ customers. Third, although this research has analysed the use of air cargo services in general, there is a subset of such services (including, for instance, time-definite express air cargo), which fit more clearly under the rubric of advanced producer services. We intend to examine how the use of advanced air cargo services differs from that of air cargo services in general.

Acknowledgements

We wish to gratefully acknowledge funding provided by the National Science Foundation, Geography and Regional Science Program for Air Cargo Services and Competitive Advantage in Industrializing Economies under BCS 0078734 (TRL) and BCS 0078621 (JTB). We also gratefully acknowledge assistance from our counterparts in Malaysia: Professor Morshidi Sirat, Dr Hassan Naziri Khalid, and Mohamad Haron Harashid, School of Humanities, Universiti Sains Malaysia, Penang and in the Philippines; Darlene Gutierrez, Daniel Mabazza, and Jonas Gaffud, Department of Geography, University of the Philippines, Diliman, Quezon City as well as support during the fieldwork from the Institute of Southeast Asian Studies, Singapore. Richard Gilbreath and the Cartographic Laboratory at the University of Kentucky prepared the figures. Josh Lepawsky was a valuable graduate research assistant who aided in carrying out interviews, questionnaire design and data analysis in Singapore and Malaysia. He also presented an earlier version of this paper at the 2002 Association of American Geographers Meeting in Los Angeles. Brian Zacho provided assistance in Singapore and the Philippines.

References


Wilson, D. (2002). Vice President Supply Chain Solutions, Asia Pacific Division, FedEx. Interviewed by Bowen and Leinbach in Singapore, 10 July.

**Appendix**

Main-effects and interaction-effects variables

1. **CUSTOMER** a binary variable reporting whether an interviewee answered ‘the customer’ in response to the question, ‘Who has the most influence over the choice of air cargo services?’ Firms that identify the customer as the key force are likely to be under the influence of ‘pull logistics’ (described in the text).
2. **CYCLTIME** a ratio scale variable measuring the number of days that elapse between the receipt of a new order and its fulfillment.
3. **DISTANCE** a ratio scale variable summing the mean distance from the two main raw material or component sources to the firm AND the mean distance to the firm’s two most important destination markets.
4. **EMPLOYEE** an ordinal variable classifying the size of the firm in terms of local employment.
5. **KNOWLABR** an ordinal variable indicating whether a firm’s local workforce is best described as labor-intensive (1), balanced (2), or knowledge-intensive (3).
6. **MCTIME** an ordinal variable indicating the rank given to ‘time’ among several factors influencing forward modal choice.
7. **MATSRC** a binary variable indicating whether the major raw materials and/or components for a firm’s principal product come from the same firm OR from other firms. This variable indicates whether the firm’s backward logistics are predominantly intra-firm.
8. **PRODDES** a binary variable indicating whether a firm ships mainly to other branch plants and subsidiaries of the same firm OR to other independent firms. This variable indicates whether the firm’s forward logistics are predominantly intra-firm.
9. **CYCL*DIST** the product of cycle times and the distance associated with a firm’s production network, this variable shows the way in which the effect of distance may be conditioned by the level of cycle time.
10. **CYCL*EMPL** the product of cycle times and the number of employees, this variable assesses the degree to which the impact of cycle times on air cargo intensity differs between large and small firms.
11. **CYCL*KNOW** the product of CYCLTIME and KNOWLABR, this variable assesses the degree to which the influence of cycle times on air cargo services intensity is conditioned by the nature of a firm’s workforce.
12. **DIST*EMPL** the product of the number of employees and production network distance, this variable is intended to reflect the degree to which the effect of distance is conditioned by the size of a firm.
13. **DIST*KNOW** the product of DISTANCE and KNOWLABR, this variable examines the degree to which the nature of a firm’s workforce mutes or amplifies the influence of the distance in a firm’s production network upon air cargo intensity.
14. **EMPL*KNOW** the product of EMPLOYEE and KNOWLABR, this variable combines two variables that were insignificant in the initial stage of the analysis. Because we had expected both variables to be strongly significant, we incorporate this interaction variable in the second stage of the analysis to help separate out effects that might cloud the importance of either or both of these variables.
15. **MALAYSIA** a binary variable indicating whether or not a firm is located in Malaysia.
16. **SEMICON** a binary variable indicating whether or not a firm is a semiconductor manufacturer.