Chapter 15

Manufacturing of Telecommunications Equipment

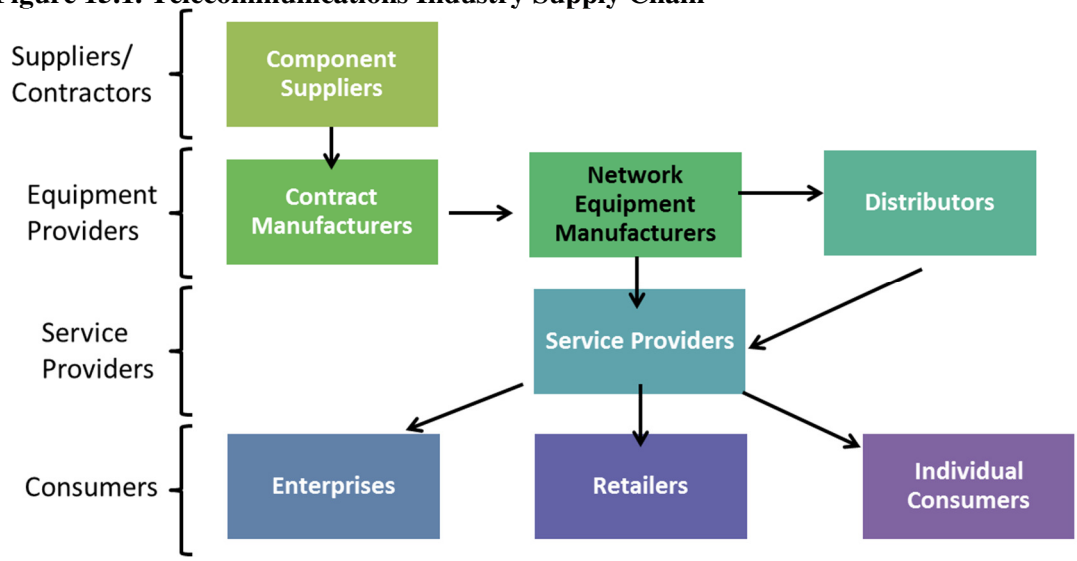
Huani Zhu and Gloria O. Pasadilla[1]

15.1. Industry Overview

Telecommunications equipment manufacturers refer to firms that manufacture hardware and devices related to telecommunications such as modems, circuit-switches systems, routers and base transceiver stations. In the early days, telecoms equipment mainly referred to those equipment used in a telephone network. Nowadays the term includes a much broader range of equipment with more sophisticated devices and more embedded functions as technology evolves.

As shown in Figure 15.1, main participants in the telecommunications industry include component suppliers, telecoms equipment makers, telecommunications network service providers, customers and regulators. Telecoms equipment manufacturers source raw materials from component suppliers, conduct their own research & development (R&D), create and design their devices and establish their distribution channels. This case study focuses on a Chinese telecoms equipment manufacturer based in Shenzhen, China, which has a growing international business.

Figure 15.1. Telecommunications Industry Supply Chain

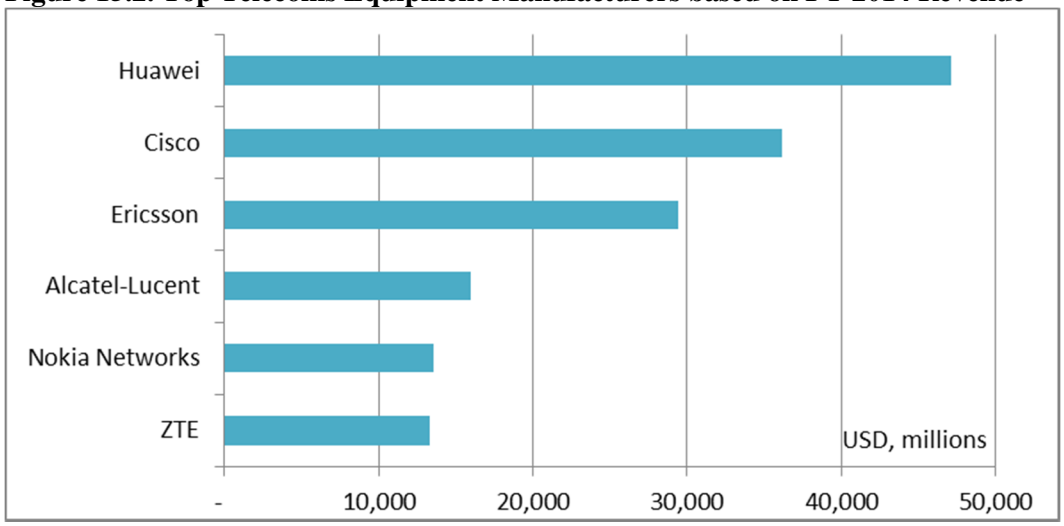


Source: Reyes, P., Raisinghani, M. and Singh, M.

Telecoms equipment manufacturing industry is dynamic – it has experienced robust growth in the past decade driven by factors such as economic growth, technological innovation, increased demand for communication services, and growth of internet and wireless communication. At the same time, transformation has been taking place towards greater usage of wireless network, especially on mobile handsets. Telecoms equipment makers also evolved from simply manufacturing switches to developing their own-developed equipment and integrating their service offerings with their products. The industry is relatively concentrated with only a few established players (see Figure 15.2) primarily because of high capital investment, in particular in R&D which is critical for anticipating technological changes and maintaining its market position.

[1] Researcher and Senior Analyst, respectively, at APEC Policy Support Unit

Figure 15.2. Top Telecoms Equipment Manufacturers based on FY 2014 Revenue

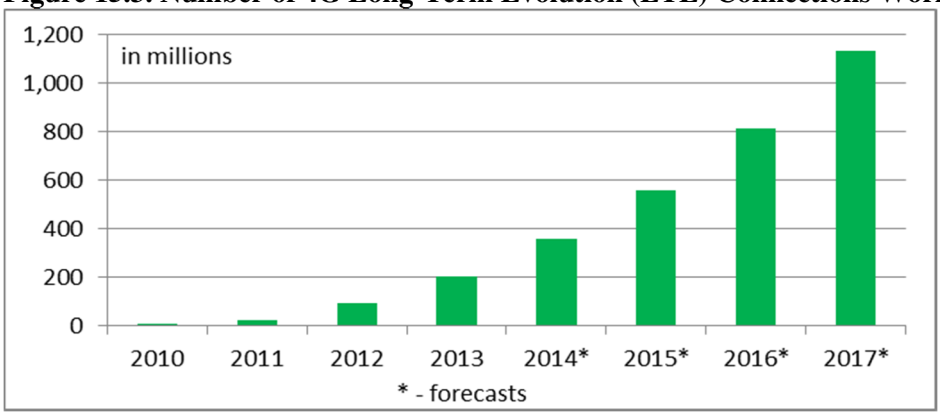


Source: Company annual reports; Infonetics Research; IMF IFC database, APEC Policy Support Unit estimates

The business model of telecoms equipment vendor is highly technology-driven. Firms compete through their technology innovation and capacity for sustained deployment of new products and services. Furthermore, the shortened life span of telecoms products brings additional pressure on equipment manufacturers to coordinate research, design and production in order to ensure a sustainable product portfolio. The industry has also evolved towards greater emphasis on services especially because of the software-based functions of hardware telecommunication products. In addition, new product creation also gives rise to new opportunities to develop new services in various contexts, such as integration services and management of big data.

Global telecommunications market is growing fastest in Asia Pacific[2] and other emerging markets. Moreover, the focus of investments has started to shift towards construction and optimization of mobile broadband as the deployment of 3G and 4G networks is expected reach greater depths[3] (see Figure 15.3).

Figure 15.3. Number of 4G Long-Term Evolution (LTE) Connections Worldwide

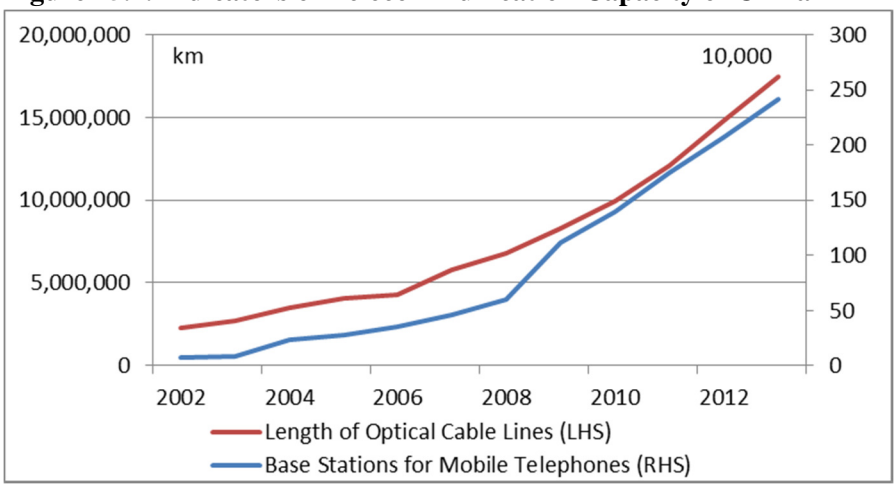


Source: The Mobile Economy 2014, GSMA

[2] In 2009, Asia Pacific accounted for the world's largest share of telecommunications investments, surpassing North America and Western Europe.
[3] Cisco Visual Networking Index: "Global Mobile Data Traffic Forecast Update, 2014 – 2019"

For the case study firm that will be discussed subsequently, growth of the Chinese telecommunications market is important since it obtains roughly half of its revenue from the domestic market. Its telecoms equipment sales growth benefited from investments made by telecoms service network providers. These investments are evident in improved telecommunications infrastructure and capacity as shown in Figure 15.4.

Figure 15.4. Indicators of Telecommunication Capacity of China



Source: China Statistical Yearbooks

15.2. Background Information on the Firm[4]

The case study firm is an integrated telecoms equipment manufacturer with a significant presence in both the Chinese domestic market as well as the international market. The predecessor of the firm was established in 1985 based on companies under the former Ministry of Aerospace Industry. The firm started as an original equipment manufacturer by taking in orders to manufacture small electronic goods. In the late 1990s, the case study firm was restructured as a publicly listed enterprise and decided to specialise in telecoms equipment industry. As of 2014, the same state-owned corporation remained the largest shareholder of the case study firm with around 31% of the shareholdings.

Headquartered in Shenzhen, the firm has more than 100 subsidiaries globally across six continents. Majority of the subsidiaries are sales offices of its telecommunications products, distribution points of contact and engineering services stations. The firm employs roughly 65,000 staff globally, with around 60,000 based in China. Its global production sites include China, India, Pakistan, Venezuela, Indonesia and the United States. Locating factories in developing economies with relatively cheap labour give the firm competitive advantage. Locating close to the local market likewise helps it minimise logistic expenses.

The firm leveraged its growth on a strong emphasis on R&D. The firm has consistently invested around 10 percent of its revenue in R&D, transforming strategic research direction into product development ideas. It established 18 R&D centres in China, France, the United States and Sweden with over 30,000 research professionals employed – representing more than one-third of total employees. It also actively collaborates with Chinese research institutes and universities and participates in some of technology research projects funded by the government. According to patent filling statistics from the World Intellectual Property Organization (WIPO), the firm has always been one of the top three enterprises that filed the most patents since 2010.

[4] Information on the firm has been sourced from its corporate website and annual reports.

With products and services being used in more than 160 economies, the firm's principal activities include designing, developing, producing, distributing, installing and maintaining a wide range of telecoms equipment and systems. As shown in Table 15.1, its products fall into three broad categories: i) carriers' network; ii) handset terminals and iii) telecoms software systems, services and other products. Products under carriers' networks, with the highest operating profit margin, have consistently been contributing around half of the total revenue.

Table 15.1. Selected Products and Services Offered by the Firm

Handset	Terminal	Smart Phone; Pad; Data Card; Convergence Terminal
Carriers' Networks	Wireless	GSM systems; CDMA systems; 4G LTE; Base Stations;
	Fixed Access	Integrated Service Access Platform; DSL Systems
	Core Network	Voice Communication; Packet Core; Convergence User Data
	Bearer	Optical Transmission; Data Communication; Routers; Ethernet Switch;
Telecoms Software Systems, Services & Others	Cloud-Computing & IT	Cloud-Computing Infrastructure; Operating Support Systems; Server; Storage
	Services	Maintenance Support Services; IT Integration Services
	Energy & Infrastructure	Telecoms Power System; Telecoms Tower; UPS (Inverter Power Supply)

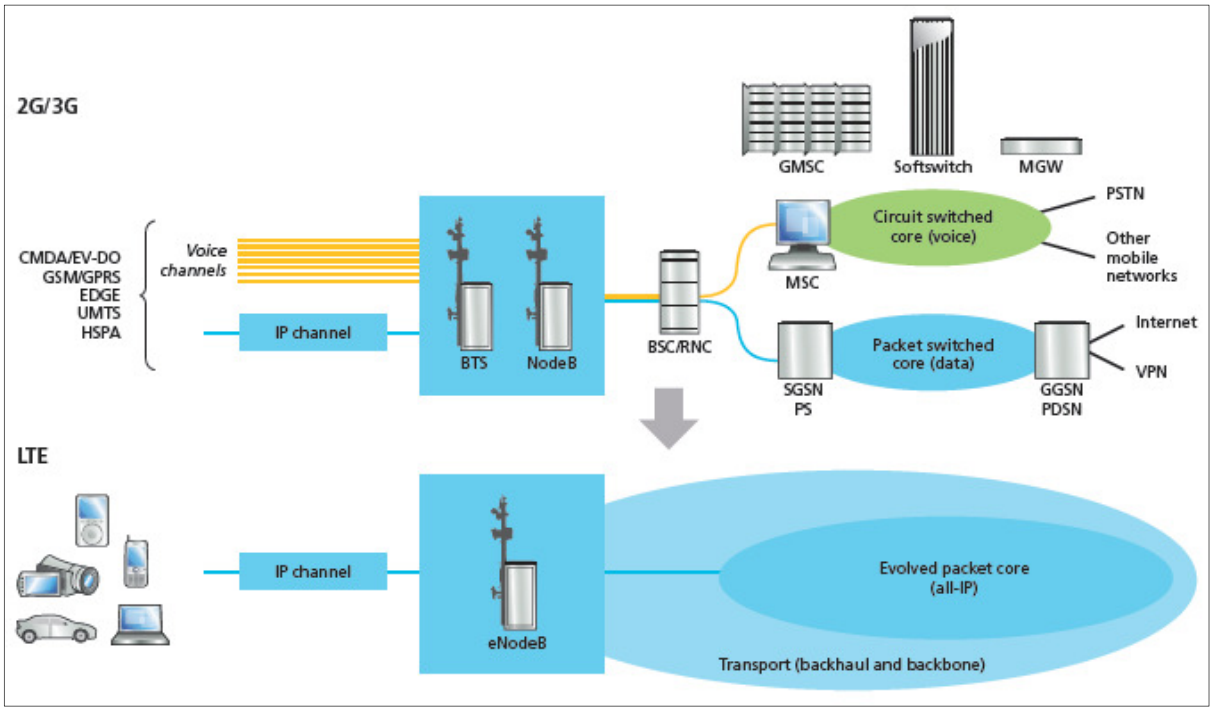
Source: Company website and annual reports

The firm has sustained a strong foothold in the Chinese telecoms equipment market for several reasons. First, it has long established relationships with leading telecoms providers in China. Second, it has developed a broad range of products based on common technology platforms with integrated end-to-end solutions, leveraging on its technical know-how and R&D. Third, it has maintained a low cost structure evidenced by its stable operating profit margins in major segments over the years.

For the purpose of identifying a specific value chain, this study focuses on a set of products under the core network group that provide voice communication services, integrated core network gateway and centralised management of systems. The firm enjoys great success in their LTE network products by signing more than 140 LTE/EPC contracts around the world, breaking industry performance records and winning award for its product at the LTE World Summit in 2014[5]. Figure 15.5 demonstrates the architecture of EPC, a new all-IP mobile core network for the LTE that unifies two distinct mobile core sub-domains into a single IP domain.

[5] Based on the firm's press releases; 26th June 2014

Figure 15.5. Evolution from Separate Circuit Switched (CS) and Packet Switched (PS) Core Sub-Domains to One Common IP Core



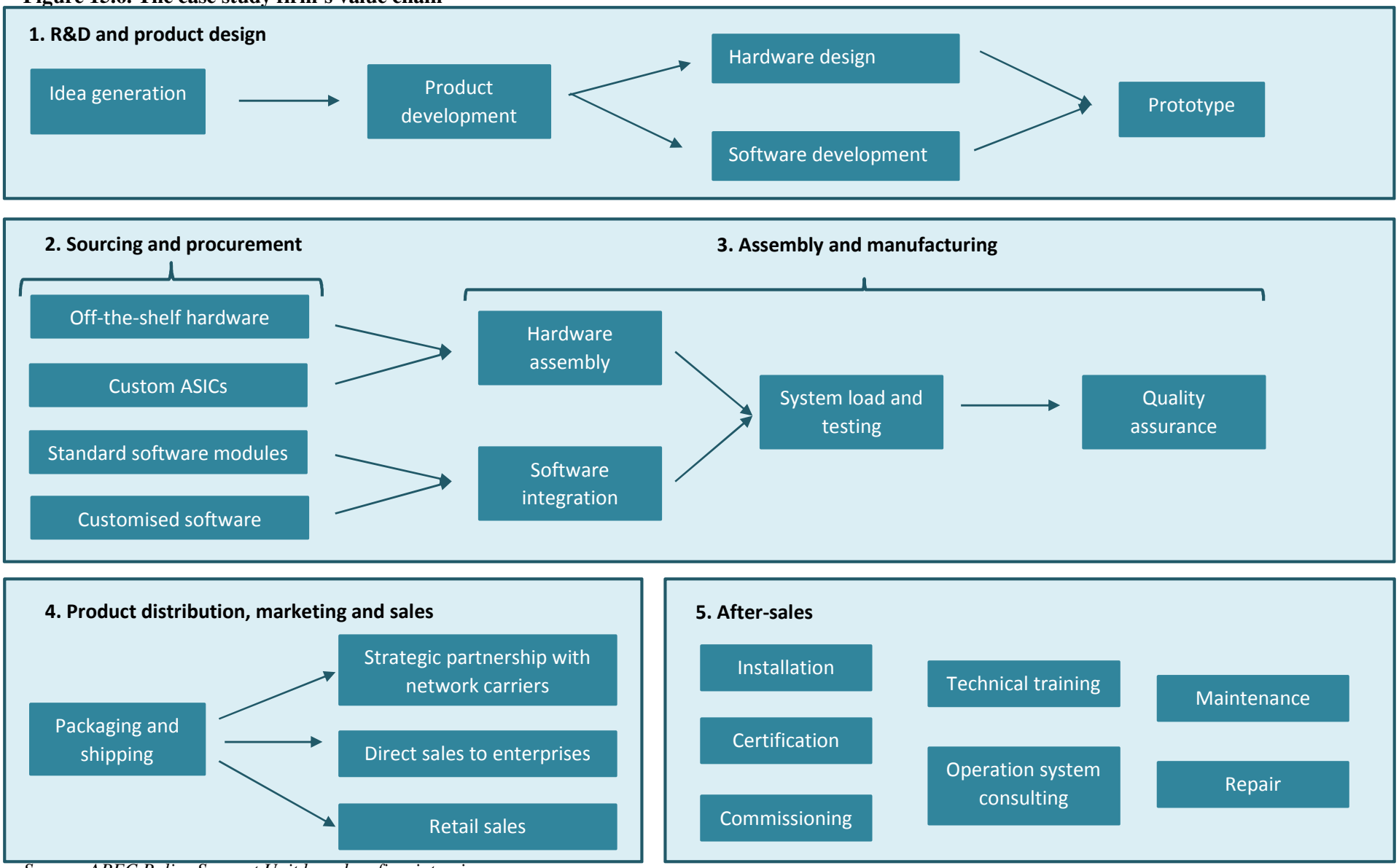
Source: Alcatel Lucent

15.3. Description of the Value Chain

Telecoms equipment providers normally sell their products by grouping them for an end-to-end solution to enable them to gain extra revenues from services, installation and deployment. In general, the case study firm has separate production lines for its products under carriers' networks and handset terminals as the products from the former category rely more on R&D and bear a greater proportion of core technologies. This study focuses on a group of wireless communications products under the carriers' networks category. These products have consistently generated more than half of the firm's revenues. As the rapid deployment of 4G networks and the firm's active involvement in pre-5G and 5G development, these wireless products also provide enormous potential for the firm going forward.

Figure 15.6 presents the supply chain of the firm's wireless products. It involves five main stages, namely – i) R&D and product design; ii) sourcing and procurement; iii) assembly and manufacturing; iv) product distribution, marketing and sales; and v) after-sales services.

Figure 15.6. The case study firm's value chain



Source: APEC Policy Support Unit based on firm interview

R&D and product design

The firm's supply chain starts from R&D. Products are conceptualised mainly from two sources: international standards (GSM, CDMA systems; 4G LTE) and interaction with clients, including telecom carriers around the globe. The firm noted that there are increasing numbers of idea generation coming from introduction of international standards. However, far from a passive recipient of international standards, the firm has become actively involved in the establishment of industry standards. Such engagement ultimately helps the firm to develop products that meet industry standards in a timely and cost-effective manner.

The firm's 18 R&D centres around the globe are highly-specialised in a way that each of them concentrates on a specific product family. These R&D centres collaborate via technology sharing and transfer. In general, those R&D centres based in developed economies focus more on developing technological innovation since these economies are at the technological frontier. This knowledge is then transferred back to the R&D centres based in China, which focus more on product development. The case study firm always retains its own core technologies protected by patents in order to maintain and enhance its competitive strengths.

The case study firm starts from modifying the existing products as technology development in telecoms equipment industry continuously evolves. After an idea is generated, the firm will develop product architecture, design software and hardware, create prototype and conduct testing. When a concept of a new product is developed, the firm gathers a team from different divisions to evaluate the feasibility of the product before formally launch a project. The feasibility study includes input from technical assessment, financial analysis and market research etc. Decisions for the project to proceed are made by high-level management in every stage during the product development process.

The firm has an in-house team taking care of patent application and acquisition since the firm needs to retain its core competency by maintaining confidentiality. The same team is also in charge of licensing services for the right to use trademarks, franchises and other intellectual property products from other companies. For instance, when the firm's core network products use software developed by another company or to use a particular telecoms technology it needs to obtain licenses.

Sourcing and Procurement

Despite having separate production lines for carriers' networks products and handset terminals, the firm has a centralised procurement policy for both units in order to gain economies of scale. Required inputs for manufacturing carriers' networks product typically include: off shelf hardware, standard software modules, custom software and custom application-specific integrated circuits (ASICs). Electrical and electronic components like circuit boards and ASICs are the main raw materials the firm uses to manufacture their products.

The firm has developed and formulated a set of internal qualification and bidding procedures to determine a potential supplier's product quality and price before appointing it as an approved supplier. After forecasting the required amount of raw materials and components, the firm invites qualified suppliers to submit their bids. Successful bidders will then enter into a Purchase Framework Agreement which specifies product types, quantities and prices, quality specifications, delivery schedules, locations and modes of delivery and other contract details. When a negotiation with a supplier takes place, the component prices are normally determined on an arm's length basis and on normal commercial terms.

The firm obtains around 20 percent of its purchases from its five largest suppliers as of 2014. In order to prevent over-reliance on a particular supplier, the firm tries to have at least two suppliers for each type of raw material, with some exception.

Transportation of raw materials is mostly outsourced to third-party logistics providers. Except when the material is supplied in-house, short-distance transportation is supplied either in-house or from affiliated companies.

Assembly and Manufacturing

Products are mainly manufactured in-house with production organized based on product lines. While the firm used to manufacture, assemble and test their products primarily in China, it now has an expanding list of overseas manufacturing centres. Besides being nearer to the end market, considering rising Chinese wages, another advantage of establishing overseas production base is cheap labour costs.

For production base located in China, the firm covers most of the activities in-house, from managing warehouse, manufacturing, and product testing to supporting activities such as security, maintenance and specialized cleaning of manufacturing equipment. One exception is the mandated tests on products required by the authorities such as U.S. Federal Communications Commission, Certification and Accreditation Administration of China or independent safety science company like Underwriters Laboratories for the UK market. Such tests normally concerns security issues or electromagnetic compatibility or radiation. The firm normally outsources this to a third-party. For overseas manufacturing centres, supporting services are largely outsourced to third-parties.

Once the manufacturing process is completed, the responsibility of ensuring product quality normally rests on the quality control department based in the headquarter Shenzhen.

Product Distribution, Marketing and Sales

The firm designs and packs most of its products in-house while outsources transportation services to its affiliated companies or third-party logistics providers. The firm has an associate[6] that specialises in end-to-end supply chain services including transporting goods and handling customs-related services.

The firm has separate sales channels for its telecoms equipment products and handset terminals since these two product categories are very different in terms of complexity, core technologies involved and target customers. Telecoms equipment is distributed mainly through business-to-business (B2B) channel. For instance, the firm sells its products through telecoms systems contracts. Under such sales arrangement, products from several segments can be sold at the same time and it gives the firm opportunities to provide additional services such as customization, installation and integration.

For core network products, the firm manages sales in-house given its well-established network of sales offices. Such arrangement allows the firm to maintain close relationship with major customers, gain knowledge about customers' demand and subsequently anticipate their needs. Subsidiaries with sales function in various regions participate in the tendering process organized by telecoms services providers on the firm's behalf. These subsidiaries are responsible for negotiations and contracting if their bidding was successful. Similarly, for sales to international markets, the firm's overseas sales offices liaise with local telecoms services providers to analyse their requirements before designing and proposing customized solutions. Ideally the firm prefers to establish direct relationship with the network service providers. In certain jurisdictions where there is restriction on foreign companies' participation in local telecommunications sector, the firm enters into bidding by setting up cooperative arrangements with local partners.

[6] Associate refers to a company for which the case study firm only possess a minority stake in the ownership of the company.

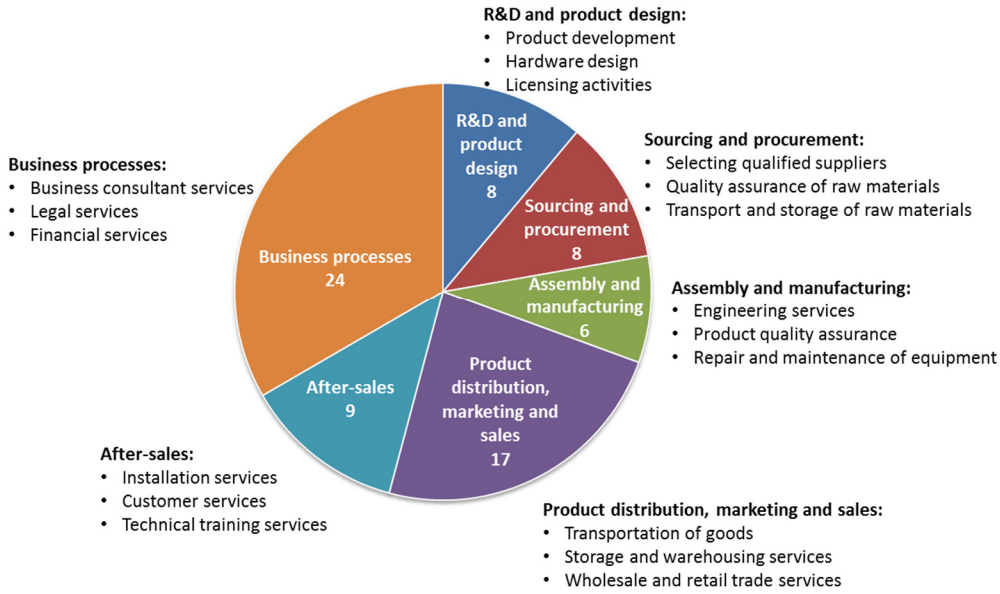
After-sales Services

Due to the sophisticated nature of telecoms equipment, after-sales services play an important role for the case study firm. Customer support services that the firm provides include installation, certification and commissioning services, maintenance and repair services, technical training and operation system consulting services. Most of the firm's after-sales services are provided in-house, except in cases when the required service falls outside of the firm's core operation. For example, when the firm needs to build a base station (as part of its product delivery) in a developing economy, it typically outsources the construction to a third-party construction company. For repair services, the decision to supply in-house or outsource depends on the complexity of the problem. For overseas clients, locally-based specialists take charge of standard maintenance and simple repair services. For more sophisticated breakdowns, the faulty component is normally shipped back to China while the firm sends the spare parts to the customer. In order to ensure timely repair services, the firm usually keeps spare parts in the warehouse alongside other inventories.

15.4. Services along the Value Chain

A total of 72 services have been identified in the case study firm's value chain, which can be divided into the following stages: i) R&D and product design; ii) sourcing and procurement; iii) assembly and manufacturing; iv) product distribution, marketing and sales; v) after-sales and vi) business processes.

Figure 15.7. Breakdown of services by stage



Source: Compiled by APEC Policy Support Unit

It is not difficult to infer that the most important service inputs are the ones in the earliest and the latest stages, namely i) R&D and product design; and v) after-sales. Services that support the R&D and product development activities are vital because telecoms equipment vendors build their core competence and develop their competitive advantage based on technological innovation. After-sales services provide more value-added opportunities for the firm beyond selling the equipment. On the other hand, that the manufacturing stage and business processes consist of the most number of services imply that services are indeed integrated pervasively into its manufacturing value chain.

The importance of services can also be demonstrated from the case study firm's employee headcount. While employees devoted to manufacturing activities constitute around one-fifth of total headcount, service-oriented segments such as customer service, marketing and sales make up another 18 percent and 17 percent of the workforce respectively. The largest proportion of employees, around 36 percent, works on R&D-related activities, which is again heavily reliant on services. In total, service-related employees account for roughly 70 percent of the firm's total workforce.

The 72 services identified in the value chain these can be further disaggregated into 126 detailed services. Out of the 126 services, our analysis estimates that 46 services are supplied in-house, 53 are partially outsourced and 27 are fully outsourced as shown in the Table 15.2.

Table 15.2. Number of services by source

Sources of services		Number of services (percentage of total)
Fully in-house	In-house	35 (28%)
	In-house & affiliated companies	8 (6%)
	Affiliated companies	3 (2%)
Partially outsourced	In-house & third-parties	31 (25%)
	Affiliated companies & third-parties	11 (9%)
	In-house & affiliated companies & third-parties	11 (9%)
Fully outsourced	Third-parties	27 (21%)

Source: Compiled by APEC Policy Support Unit

There are several reasons why the firm choose to outsource its services. In general they can be grouped into the following categories: i) the services lie outside the firm's core operations, such as advertising and utilities supply; ii) as the firm continuous to expand internationally, it outsources some of the services for its overseas operation, such as storage of products and installation of equipment; iii) some of the government mandated testing was outsourced; iv) the firm lacks expertise in providing specialised professional services such as market research; v) to gain economies of scale in area such as transportation.

Besides its core services in areas such as R&D, product design, patent acquisition, quality assurance, maintenance and repair services, the firm also supplies a considerable amount of supporting services in-house such as packaging, retail trade and human resources. This is partly due to economies of scale given the firm's sizeable presence in its headquarter, which comprises more than 85% of the workforce. However, this may change going forward as Chinese wages continue to rise and the firm face greater pressure to remain competitive.

15.5. Policies Affecting the Value Chain

The following section identifies policies that affect the firm's value chain. While telecoms equipment industry is known for its stringent standards and registration regulation, i.e procedures to follow and requirements to be fulfilled by equipment manufacturers seeking to register their telecoms equipment for sale and use, the firm nevertheless does not experience any challenges in registering or obtaining certifications of their products. Majority of the policy challenges identified by the firm are linked to its international expansion.

Cyber-security concerns

Rapid development of technology and the increasing complexity of the supply chain increased security vulnerabilities given the fact that technology is designed, developed and deployed in and from various geographic locations.

The case study firm identified cyber security as an issue of great concern to them. The firm's effort to expand sales in developed markets such as North America, Europe and Australia has faced setbacks after reports identified foreign, especially Chinese communications equipment, as posing a perceived potential threat to their cyber security, especially if the network is used for carrying government communications. Hence, under a security exemption, either the firm's telecom equipment are prohibited from government procurement in these economies or banned from bidding for government-funded broadband network.

As a result, the case study firm faces considerable obstacle in expanding into certain overseas markets. Although it can sell its handset terminals abroad, its more profitable system products for core network are not welcomed.

Anti-dumping

The firm faced antidumping investigation from some regulators about alleged unfair competition through its heavily subsidized activities, driving big price wedge between Chinese telecoms equipment producers and their local counterparts. The case was subsequently settled but it dented the firm's confidence in a possible expansion project and launching of more products and services, as well as technology investment in the region.

Local content requirements

The firm indicated that some emerging economies have protectionist policies in place to force localisation of production. In one ASEAN economy, the regulations require importers of 4G LTE smartphones to produce, starting in 2017, 30% 'local content' in the territory. Such regulation implies that, for the case study firm to comply with the regulations, its subsidiary in the economy will have to do the assembly of various components and parts that the company will export to its own subsidiary. Since assembly cost is lower in China, such arrangement would result in higher production costs.

Another pending local content requirement being contemplated in this economy would apply not only to hardware products but also to software and R&D and design development. If this policy is approved, the case study firm is likely to face problems related to the difficulties finding enough qualified researchers locally.

Intellectual Property

Safeguarding intellectual property is vital for telecoms equipment manufacturers since this gives them a competitive advantage. Intellectual property disputes between telecoms equipment makers are common because they would use each other's licensed technology in their own products occasionally. In cases when they adopt other's patents, the case study firm pays or establishes agreements with the patent holder. Companies might accuse others of demanding excessive prices for their patents or over-

asserting the essentialness of their patents which affect any potential patent infringement decision by the courts[7].

The case study firm has an in-house legal team dedicated to intellectual property management. Normally the firm establishes licensing agreements with major players in the industry for the rights to use each other's patents in their products. A fair price is agreed upon most of the time since the firm indicated that their royalty payment cost is manageable.

Labour mobility

Due to the complexity of telecoms equipment, engineering resources often need to travel to the customer site to resolve technical issues as part of its after-sales services. Because of visa issues, the firm cannot make use of their vast pool of experienced technical specialists in China. If engineers from its Chinese headquarters are required, the visa requirements and the length of time waiting for their issuance affect the timeliness of their repair service.

Visa applications also affect the firm's ability to participate in overseas tendering process. For instance, when their potential customer from overseas calls for a tender, bidders need to be present on site. When a project is sizeable, a team with personnel from various divisions is normally required to be present to assist the proposal submission and to demonstrate what the firm is capable of doing. Again, the visa restrictions for Chinese nationals and the uncertainty of obtaining the required visa on time, make it difficult for the case study firm to deploy the necessary number of persons to the tendering, thus hampering their ability to exhibit the firm's full capabilities.

15.6. Conclusion

This case study demonstrates the importance of embedded services in the manufacturing of telecoms equipment. Services evidently play a vital role due to the significance of R&D and innovation in the telecoms equipment manufacturing along with the development of more value-added services especially in the after-sales market.

On the policy front, some of the issues in telecommunications are thorny in nature due to the complex interplay of politics and economics. Bilateral, regional, or multilateral agreements to open each other's market in telecom and cooperate in R&D and technical standard-setting will foster healthy competition and encourage knowledge transfer.

The restriction on movement of specialised personnel due to visa issues impedes the firm's ability to provide the best after-sales services in a timely manner. This might negatively affect the firm's customer satisfaction level and hinder future business opportunities. From the end user's point of view, such restriction on labour mobility does not best represent their economic interests either because the delay in repair services might be costly to their operation.

Similarly for the protectionist policies such as local content requirement, the final consumers are worse off since those policies push up the production costs which are ultimately passed on to end consumers. Therefore, it is in the economy's own interest to formulate policies that balance between supporting local manufacturing industry and consumers' welfare.

[7] The firm identifies Europe as the main market where it faces thorny intellectual property issues. A court case last year led to an injunction restricting the case study firm from selling equipment that could infringe on the disputed patent. Other lawsuits are afoot involving rival firms in 4H and camera technology patents. Continuous legal battles increase the firm's legal costs, affect the firm's corporate image and put the firm in an unfair competition if the anti-competitive antitrust complaint is found to be credible.

Abbreviations

3G	3rd Generation
4G	4th Generation
ASIC	Application-Specific Integrated Circuit
BSC	Base Station Controller
BTS	Base Transceiver Station
CDMA	Core-Division Multiple Access
CS	Circuit Switched
DSL	Digital Subscriber line
EDGE	Enhanced Data rates for GSM Evolution
EPC	Evolved Packet Core
EV-DO	Evolution-Data Optimized
GGSN	Gateway GPRS Support Node
GMSC	Gateway Mobile Switching Centre
GPRS	General Packet Radio Service
GSM	Global System for Mobile communications
HSPA	High Speed Packet Access
IP	Internet Protocol
LTE	Long Term Evolution
MGW	Media Gateway
MSC	Mobile Switching Centre
PDSN	Packet Data Serving Node
PS	Packet Switched domain
RNC	Radio Network Control
SGSN	Serving GPRS Support Node
UMTS	Universal Mobile Telecommunications System
UPS	Uninterrupted Power Supply
VPN	Virtual Private Network

Appendix A

Services along the value chain

Table A.1. R&D and product design

	Service	*Corresponding (CPC) Ver.2 Code*	*Supplied in-house*	*Outsourced to affiliated companies and reasons*	*Outsourced to third-party suppliers and reasons*	*Bundled*
1	Product development / R&D	81129 – Research and experimental development services in other engineering and technology	Yes	Yes (Set up R&D centres in developed economies to take advantage of the frontier technology)	No	n/a
		81400 – Research and development originals	Yes	No	No	n/a
		91114 – Government services to research and development	Yes	No	No	n/a
2	Market research	83700 – Market research and public opinion polling services	Yes	No	Yes (for handset terminals only; reason: efficiency and lack of expertise)	n/a
3	Conception and design of product	83920 – Design originals	Yes	Yes	Yes (for handset terminals only; reason: efficiency)	n/a
		83939 – Other scientific and technical consulting services n.e.c	No	No	Yes (only once; reason: lack of expertise)	n/a
4	Hardware design	83912 – Industrial design services	Yes	No	No	n/a
		83919 – Other specialty design services	Yes	No	No	n/a

5	Software development	8314 – IT design and development services	No	No	Yes (reason: efficiency and cost consideration)	n/a
6	Patent acquisition	83960 – Trademarks and franchises	Yes	No	No	n/a
7	Licensing services	73330 – Licensing services for the right to use R&D products	Yes	No	No	n/a
		73340 – Licensing services for the right to use trademarks and franchises	Yes	No	No	n/a
		73390 – Licensing services for the right to use other intellectual property products	Yes	No	No	n/a
8	Prototype testing	83443 – Testing and analysis services of integrated mechanical and electrical systems	No	No	Yes (for government mandated testing; reason: efficiency)	n/a

Table A.2. Sourcing and procurement

	Service	*Corresponding (CPC) Ver.2 Code*	*Supplied in-house*	*Outsourced to affiliated companies and reasons*	*Outsourced to third-party suppliers and reasons*	*Bundled*
9	Assessing and selecting qualified suppliers (organising tendering, verifying supplier qualification, negotiation)	85999 – Other support services n.e.c.	Yes	No	No	n/a
10	Customer-related services for raw materials imports	67110 – Container handling services	No	No	Yes	n/a
		85999 – Other support services n.e.c.	Yes	Yes	No	n/a
11	Raw material management	83190 – Other management services, except construction project management services	Yes	No	No	n/a
12	Quality assurance services of raw materials	83441 – Composition and purity testing and analysis services	Yes	No	No	n/a
13	Transport services of raw materials	6511 – Road transport services of freight	No	No	Yes (reason: economies of scale)	n/a
		6512 – Railway transport services of freight	No	No	Yes (reason: economies of scale)	n/a
		6521 – Costal and transoceanic water transport services of freight	No	No	Yes (reason: economies of scale)	n/a
		6531 – Air transport services of freight	No	No	Yes (reason: economies of scale)	n/a
14	Repair and maintenance for fleets (if self-owned)	87143 – Maintenance and repair services of trailers, semitrailers and other motor vehicles n.e.c.	Yes	Yes (for short distance transportation only)	No	n/a

15	Freight insurance of raw materials	71333 – Freight insurance services	No	No	Yes (reason: lack of expertise)	
16	Storage of raw materials	67290 – Other storage and warehousing services	Yes	Yes (for overseas operation; reason: cost consideration)	No	n/a

Table A.3. Assembly and manufacturing

	Service	*Corresponding (CPC) Ver.2 Code*	*Supplied in-house*	*Outsourced to affiliated companies and reasons*	*Outsourced to third-party suppliers and reasons*	*Bundled*
17	Product management	83115 – Operations management consulting services	Yes	No	No	n/a
		83117 – Business process management	Yes	No	No	n/a
18	Product quality assurance and compliance with standards	83441 - Composition and purity testing and analysis services	Yes	No	Yes (for government mandated testing; reason: efficiency)	n/a
		83443 – Testing and analysis services of integrated mechanical and electrical systems	Yes	No	Yes (for government mandated testing; reason: efficiency)	n/a
19	Warehousing services for intermediate goods	67290 – Other storage and warehousing services	Yes	No	Yes (for overseas operation only; reason: efficiency	n/a
20	Installation of production equipment	87320 – Installation services of industrial, manufacturing and service industry machinery and equipment	No	No	Yes (reason: lack of expertise)	n/a
		87360 – Installation services of electrical machinery and apparatus n.e.c.	No	No	Yes (reason: lack of expertise)	n/a
21	Engineering services	83310 – Engineering advisory services	Yes	Yes	Yes	n/a
		83325 – Engineering services for telecommunications and broadcasting projects	Yes	Yes	Yes	n/a

22	Repair and maintenance services of machines and equipment	87156 – Maintenance and repair services of commercial and industrial machinery	Yes	No	Yes (reason: efficiency)	n/a
		87130 – Maintenance and repair services of computers and peripheral equipment	Yes	No	Yes (reason: efficiency)	n/a
		87152 – Maintenance and repair services of electrical machinery and apparatus n.e.c.	Yes	No	Yes (reason: efficiency)	n/a

Table A.4. Product distribution, marketing and sales

	Service	*Corresponding (CPC) Ver.2 Code*	*Supplied in-house*	*Outsourced to affiliated companies and reasons*	*Outsourced to third-party suppliers and reasons*	*Bundled*
23	Design of Packages	83919 - Other specialty design services	Yes	No	No	n/a
24	Packaging Services	85400 – Packaging services	Yes	No	No	n/a
25	Cargo handling services for delivery to wholesaler/retailer	67110 – Container handling services	No	Yes	Yes	n/a
26	Customs-related services of products exports	85999 – Other support services n.e.c.	No	Yes	Yes	n/a
27	Transport of goods	6511 – Road transport services of freight	No	Yes	Yes	n/a
		6512 – Railway transport services of freight	No	No	Yes	n/a
		6521 – Costal and transoceanic water transport services of freight	No	Yes	Yes	n/a
		6531 – Air transport services of freight	No	No	Yes	n/a
28	Freight insurance	71333 – Freight insurance services	No	No	Yes	n/a
29	Storage and warehousing services for finished goods	67290 – Other storage and warehousing services	Yes	No	Yes (for overseas operation only)	n/a
30	Wholesale trade services	6128 – Wholesale trade services on a fee or contract basis, of machinery, equipment and supplies	No	No	Yes (form strategic partnership with network carriers; reason:economics of scale)	n/a

31	Retail trade services: by store	6218 – Non-specialized store retail trade services, of machinery, equipment and supplies	Yes	No	Yes	n/a
		6228 – Specialized store retail trade services, of machinery, equipment and supplies	Yes	No	Yes	n/a
32	Retail trade services: by internet or mail-order	6238 – Mail order or Internet retail trade services, of machinery, equipment and supplies	Yes	Yes	Yes	n/a
33	Retail trade services: by other non-store retail trade services	6248 – Other non-store retail trade services, of machinery, equipment and supplies	Yes	No	No	n/a
34	Retail services on a fee or contract bases	6258 – Retail trade services on a fee or contract basis, of machinery, equipment and supplies	Yes	No	No	n/a
35	Retail operation management	83115 – Operations management consulting services	Yes	No	No	n/a
		83116 – Supply chain and other management consulting services	Yes	No	No	n/a
36	Retail site development for new shops	83911 – Interior design services	Yes	Yes	No	n/a
		Group of 546 – Installation services	Yes	Yes	No	n/a
		Group of 547 – Building completion and finishing services	Yes	Yes	No	n/a
37	Security services (cash delivery)	85240 – Armoured car services	Yes	No	No	n/a
		85250 – Guard services	Yes	No	No	n/a

38	Leasing/rental services	Group of 731 – Leasing or rental services concerning machinery and equipment without operator	No	Yes	Yes	n/a
		Group of 732 – Leasing or rental services concerning other goods	No	Yes	Yes	n/a
		71140 – Financial leasing services	No	Yes	Yes	n/a
39	Retail Advertising	83611 – Full service advertising	No	No	Yes (reason: lack of expertise)	n/a
		83620 – Purchase or sale of advertising space or time, on commission	No	No	Yes (reason: lack of expertise)	n/a
		83612 – Direct marketing and direct mail services	No	No	Yes (reason: lack of expertise)	n/a

Table A.5. After-sales

	Service	*Corresponding (CPC) Ver.2 Code*	*Supplied in-house*	*Outsourced to affiliated companies and reasons*	*Outsourced to third-party suppliers and reasons*	*Bundled*
40	Installation services of equipment	87340 – Installation services of radio, television and communication equipment and apparatus	Yes	Yes (deploy local technical specialist; reason: efficiency)	Yes (for overseas operation)	n/a
41	Certification and commissioning services of equipment	83443 – Technical testing and analysis services of integrated mechanical and electrical systems	Yes	No	No	n/a
42	Customer services: general and technical support	85931 - Telephone call centre services	Yes	No	No	n/a
43	Customer services: loyalty program	95999 - Other services provided by membership organizations n.e.c.	Yes	No	No	n/a
44	Maintenance and repair services of equipment	87153 – Maintenance and repair services of telecommunication equipment and apparatus	Yes	Yes (for overseas operation; reason: efficiency)	No	n/a
45	Inventory management of spare parts for replacement	67290 – Other storage and warehousing services	Yes	Yes	Yes	n/a
46	Auxiliary services to ensure successful delivery of products	532 – Civil engineering works	Yes	Yes	Yes (for overseas operation; reason: lack of expertise)	n/a
		85999 – Other support services n.e.c.	Yes	Yes	Yes	n/a
47	Technical training	92919 – Other education and training services, n.e.c.	Yes	No	No	n/a
48	Operating system consulting	8316 – IT infrastructure and network management services	Yes	No	Yes (when the project is highly complexed or	n/a

					the firm is short-staffed)	

Table A.6. Business Processes (support services)

	Service	*Corresponding (CPC) Ver.2 Code*	*Supplied in-house*	*Outsourced to affiliated companies and reasons*	*Outsourced to third-party suppliers and reasons*	*Bundled*
49	Company registration, licensing and business liaison services	91133 – Public administrative services related to the more efficient operation of business	Yes	No	No	n/a
50	Government inspections on fire prevention, health hazards, environmental protection and other aspects	91133 – Public administrative services related to mining and mineral resources, manufacturing and construction	Yes	No	No	n/a
		91137 – Public administrative services related to multipurpose development projects	Yes	No	No	n/a
51	Visa and immigration services for employees	91290 – Public administrative services related to other public order and safety affairs	Yes	No	No	n/a
52	Business consultant services	8311 – Management consulting and management services	Yes	Yes	Yes (reason: lack of expertise)	n/a
		83129 - Other business consulting services	Yes	No	Yes (reason: lack of expertise)	n/a
		83118 – Head office services	Yes	No	No	n/a
53	Banking and finance services	71121 - Deposit services to corporate and institutional depositors	Yes	Yes	No	n/a
		71135 - Non-mortgage loan services for business purposes	Yes	Yes	No	n/a
54	Legal services	82130 – Legal documentation and certification services	Yes	No	Yes (reason: lack of expertise)	n/a
		82120 – Legal advisory and representation services concerning other fields of law	Yes	No	No	n/a

55	Auditing on financial accounts	8221 – Financial auditing services	Yes	Yes	Yes	n/a
		8222 – Accounting and bookkeeping services	Yes	Yes	Yes	n/a
56	Corporate finance services	71511 – Mergers and acquisition services	Yes	No	Yes	n/a
		71521 – Corporate finance and venture capital services	Yes	No	Yes	n/a
57	Insurance and pension services	71313 – Group pension services	Yes	Yes	Yes	n/a
		71321 – Accidental death and dismemberment insurance services	Yes	Yes	Yes	n/a
		71322 – Health insurance services	Yes	Yes	Yes	n/a
		71701 – Services of holding equity of subsidiary companies	Yes	Yes	Yes	n/a
58	Insurance services for machinery	71332 – Marine, aviation, and other transport insurance services	Yes	Yes	Yes	n/a
59	Corporate communications, marketing and public relationship	83114 – Marketing management consulting servicesf831	Yes	No	No	n/a
		83121 – Public relations services	Yes	No	No	n/a
60	Courier, postal and local delivery services	6811 – Postal services	No	Yes	Yes	n/a
		6812 – Courier services	No	Yes	Yes	n/a
		6813 – Local delivery services	No	Yes	Yes	n/a
61	Estate management	72112 – Rental or leasing services involving own or leased non-residential property	Yes	No	No	n/a
62	Human resources management; Personnel	83113 – Human resources management consulting services	Yes	No	No	n/a

	search and referral services for back-office staff	8511 – Personnel search and referral services	Yes	No	No	n/a
		8512 – Labour supply services	Yes	No	Yes	n/a
63	I.T. and information system management, consulting and support, with webpage development	83132 – Information technology (IT) support services	Yes	No	Yes	n/a
		8315 – Hosting and information technology (IT) infrastructure provisioning services	Yes	No	Yes	n/a
		8316 – IT infrastructure and network management services	Yes	No	Yes	n/a
64	Safety and security services	85230 – Security systems services	Yes	No	No	n/a
		85250 – Guard services	Yes	No	Yes (for overseas operation only)	n/a
65	Telecommunication services	Group of 841 – Telephony and other telecommunications services	Yes	No	Yes	n/a
		Group of 842 – Internet telecommunication services	Yes	No	Yes	n/a
66	installation services for equipment and related wiring	873 – Installation services (other than construction)	Yes	No	Yes	n/a
67	Utilities supply: electricity, gas and water	8631 – Support services to electricity transmission and distribution	Yes	No	Yes	n/a
		86320 – Gas distribution services through mains (on a fee or contract basis)	No	No	Yes	n/a
		86330 – Water distribution services through mains (on a fee or contract basis)	No	No	Yes	n/a
		86340 – Distribution services of steam, hot water and air-conditioning supply through mains (on a fee or contract basis)	No	No	Yes	n/a

68	Worker-related services: catering , dormitory, medical services, retail services, transportation services	63393 – Other contract food services	Yes	No	Yes	n/a
		63220 – Room or unit accommodation services for workers in workers hostels or camps	Yes	No	No	n/a
		93121 – General medical services	No	No	Yes	n/a
		6212 – Non-specialized store retail trade services, of food, beverages and tobacco	No	No	Yes	n/a
		96520 – Sports and recreational sports facility operation services	Yes	No	Yes	n/a
		64114 – Local special-purpose scheduled road transport services of passengers	No	No	Yes	n/a
69	Social insurance for factory workers	91320 – Administrative services related to government employee pension schemes; old-age disability or survivors' benefit schemes, other than for government employees	Yes	No	Yes	n/a
		91330 – Administrative services related to unemployment compensation benefit schemes	Yes	No	Yes	n/a
70	Gardening of the premises; general and specialized cleaning services for machines and equipment	85970 – Landscape care and maintenance services	No	No	Yes (reason: economies of scale)	n/a
		85330 – General cleaning services	No	No	Yes (reason: economies of scale)	n/a
		85340 – Specialized cleaning services	Yes	No	Yes	n/a

71	Sewage water treatment services	94110 – Sewerage and sewage treatment services	No	No	Yes (reason: economies of scale)	n/a
72	Waste collection and recycling services	9421 – Collection services of hazardous waste	Yes	No	Yes	n/a
		94239 – General waste collection services, other	Yes	No	Yes	n/a
		94229 – Collection services of non-hazardous recyclable materials, other	Yes	No	Yes	n/a

References

Alcatel Lucent (2009). "Introduction to Evolved Packet Core", accessed June 2015 http://www3.alcatel-lucent.com/wps/DocumentStreamerServlet?LMSG_CABINET=Docs_and_Resource_Ctr&LMSG_CONTENT_FILE=White_Papers/Intro_EPC_wp_0309.pdf

Cisco (2015). "Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2014 – 2019", February 2015, accessed June 2015 http://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/white_paper_c11-520862.html

Deals Street Asia (2015), "Indonesia smartphones requires 30% local content starting 2017", July 2015, accessed July 2015 http://www.dealstreetasia.com/stories/indonesia-smartphones-requires-30-local-content-starting-2017-8925/

Icegate Solutions Inc (2007). "Telecommunications Equipment Value Chain Study", June 2007, accessed May 2015 http://profnik.moodlehub.com/pluginfile.php/24570/mod_resource/content/1/Background_Documents/0107861e.pdf

Infonetics Research Scorecard (2013). "Telecommunications Equipment Vendor Leadership Scorecard", July 2013, accessed June 2015 https://www.infonetics.com/download.asp?id=37

Reuters (2015), "Indonesia plays hardball with smartphone manufacturers", April 2015, accessed July 2015 http://www.reuters.com/article/2015/04/02/us-indonesia-mobilephone-manufacturers-idUSKBN0MT2GF20150402

Reuters (2013), "U.S. law to restrict government purchases of Chinese IT equipment", March 2013, accessed July 2015 http://www.reuters.com/article/2013/03/28/us-usa-cybersecurity-espionage-idUSBRE92Q18O20130328

Reyes, P., M. Raisinghani and M. Singh (2002). "Global Supply Chain Management in the Telecommunication Industry: The Role of Information Technology in Integration of Supply Chain Entities"; *Journal of Global Information Technology Management*; 2002, accessed June 2015 http://business.baylor.edu/Pedro_Reyes/publications/Global%20supply%20chain%20management%20in%20the%20telecommunications%20industry.pdf

The Independent (2012), "China Telecoms Giant could be Cyber-Security Risk to Britain", December 2012, accessed July 2015 http://www.independent.co.uk/news/uk/politics/china-telecoms-giant-could-be-cybersecurity-risk-to-britain-8420432.html

Wall Street Journal (2014), "EU, China complete deal on telecoms equipment", October 2014, accessed July 2015 http://www.wsj.com/articles/eu-china-reach-deal-on-telecoms-equipment-1413797081

Wikinvest, Networking & Communication Equipment, accessed June 2015 http://www.wikinvest.com/industry/Networking_%26_Communication_Equipment