Chapter 1
Re-focusing and re-shifting – the constant restructuring of global production networks in the electronics industry

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1. Introduction

In 2010, as a result of the tragic 14 suicides (and four more suicide attempts) at Foxconn the world came to learn more about how the electronics industry operates.[1] Although lauded as a high-tech industry, the electronics industry in general, and one of its most prominent representatives Foxconn in particular, is characterized by inhumane working conditions: low wages, long working hours, neglect of health and safety regulations and forced labour, to name just a few (Chan and Pun 2010; SACOM 2010; Verité 2014). Despite visual differences between factories in the electronics industry and in the garment and shoe industry – here the super clean and bright plants and there the frequently cluttered, dim and hot sweatshops – labour conditions are often comparable, as workers' earnings barely exceed minimum wage levels, working hours are characterized by excessive overtime and a depreciating work organization that hinders any professional development (Gereffi et al. 2002).[2]

The world also learned that many electronic products are not manufactured by brand-name companies themselves. Although their smartphones, laptops, monitors and MP3 players are branded by Apple, Dell, HP or Sony they are manufactured by companies that most people have never heard of. This led some authors to dub this production model 'stealth manufacturing' (Sturgeon 1997, 1999; Lüthje 2001). This production model – contract manufacturing – has enjoyed incredible success in the electronics industry over the past 25 years and is the centre of the ongoing restructuring of its global production networks (Henderson

1. Number of reported suicides at Foxconn's factories: 2011: 4; 2012: 1; 2013: 2. Foxconn is not the only company where suicides and suicide attempts occur, but due to its size and public exposure as Apple's biggest supplier most reports focus on Foxconn.
2. Minimum wage levels are constantly below subsistence levels. For further information on the living wage see the discussion at: www.goodelectronics.org

1989; Henderson et al. 2002). Through fragmentation and specialization, the entire electronics supply chain has gradually been segmented into individual and decentralized units linked by market-based relationships. Electronic products that in the past were produced by a single vertically integrated company, such as IBM, are now developed and manufactured through a complex supply chain comprising myriad – often highly specialized – suppliers. However, economic dynamics and control imperatives have spurred a dialectical development whereby re-integration and centralization at specific points in the complex supply chains have occurred.

Fragmentation and centralization (Ernst and O'Connor 1992) have facilitated dynamic, ever-changing development of the organization of the electronics industry, as companies are constantly re-focusing on the product markets they serve, their capabilities and their functions. Specialization is facilitated by technical modularization that makes it possible to divide an electronics system along the lines of particular components by standardizing the interfaces between them and to allocate the manufacturing of these components to different suppliers. Although brand-name companies – or original equipment manufacturers (OEM) – are divesting from manufacturing, product design and increasingly also development activities they are still able to control their global production networks through standard-setting and procurement strategies (Lüthje et al. 2013). Re-integration occurs on the manufacturing level, as specialized contract manufacturing companies such as Foxconn, Flextronics, Quanta or Pegatron have not only grown to enormous sizes, but are constantly looking for opportunities to integrate new functions, as well as product categories. Simple contract manufacturing companies have developed into electronics manufacturing service providers (EMS) and original design manufacturers (ODM), becoming powerful network organizers themselves. Their ability to offer standardized manufacturing and product design services worldwide has standardized the organizational interfaces in the electronics industry, allowing brand-name companies to easily hand-off production and switch between suppliers.

Internationalization through the relocation of manufacturing and product development operations has been characteristic of the electronics industry since the 1960s (Angel 1994). The industry is in a constant process of re-shifting as it searches relentlessly for the optimal geographical structure of its global networks of production and innovation, within an ever-changing framework. Its search for low-cost manufacturing locations has had a devastating effect on electronics

industry locations in Europe and North America, where almost all manufacturing capabilities have been offshored. With their highly fragmented work organization, low wages, poor labour conditions and anti-union stance EMS and ODM companies do a disservice to workers and to the regions where they set up shop.

Foxconn is currently the largest contract manufacturing specialist worldwide. The Taiwanese company has changed the electronics industry fundamentally with its focus on vertical integration. Before Foxconn demonstrated that a highly integrated EMS company is not only able to survive but to outpace industry growth, the entire industry saw further vertical specialization as the only remedy to the ever low and falling profit margins of contract manufacturing specialists. Most other EMS/ODM companies have followed suit, while utilizing various forms of integration, ranging from building up in-house capabilities to tightening control over their own supply networks through long-term relations. However, the contract manufacturing model has a built-in glass ceiling as EMS and ODM companies cannot venture into the profitable area of own brand-name products without losing their manufacturing customers.

By describing the development of the complex structure of the electronics industry this chapter argues that the hierarchical networks of the EMS/ODM model with their complexity and flexibility are characterized by structural problems that negatively impact work organization and labour conditions. The EMS/ODM model allows brand-name companies to push cost pressures down the chain, which almost always affects the weakest link – the workers (Palpacuer 2008). To develop this argument, first we present some data on the current situation in the electronics industry, with a special focus on contract manufacturing. Second, we give a detailed account of the evolution of the contract manufacturing production model in the electronics industry. In the last part of this chapter we discuss the enormous social costs of the highly flexible industry organization in more detail.

2. Current situation in the electronics industry

The electronics industry is dominated by huge companies that churn out electronic devices for increasingly worldwide markets and organize innovation processes at almost frantic speed. Customers know the electronics industry through the brand-names they read on their

notebooks, smartphones or monitors. The myriad complex and simple components inside these devices, as well as the process of developing and manufacturing a functioning system is hidden from them. The basic organizational characteristic of the complex supply chains that allows the production of these devices is the disintegration between product development and product manufacturing. While lead firms – such as Apple, Cisco, Dell, HP, HTC, Lenovo, LG, Microsoft and Sony – are increasingly focusing on product development and marketing, contract manufacturing companies specialize in manufacturing these electronic devices in huge industrial complexes that are located around the world (Sturgeon 1999; Sturgeon and Lee 2004; Lüthje et al. 2013).

Foxconn[3] is currently by all accounts the biggest contract manufacturing company (see Table 1). By revenue the Taiwanese behemoth is bigger than its four followers taken together, while considering its workforce, with over one million employees worldwide, the company dwarfs the entire electronics industry. Even compared with lead firms Foxconn's 2013 revenue only trailed Samsung and Apple and was on a par with HP (Table 2). Foxconn's dominant position has effects on both the way contract manufacturers organize their production systems and Foxconn's relations towards lead firms. Foxconn is known for its high level of vertical

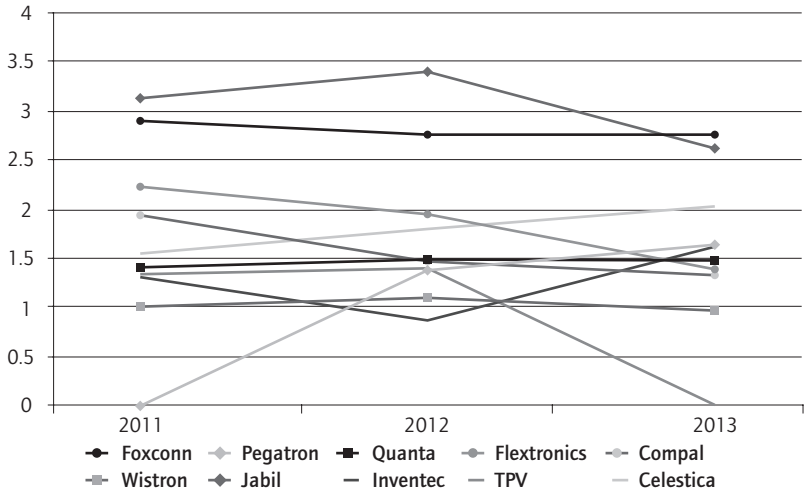
Table 1 **Top 10 contract manufacturing companies, 2013**

Company	Nationality	2013 Revenues (US$M)	Employees worldwide, app. (in thousands)
Foxconn	Taiwan	115,697	1,230
Pegatron	Taiwan	31,439	104
Quanta	Taiwan	29,134	60
Flextronics	US (Singapore)	24,680	150
Compal	Taiwan	20,944	43
Wistron	Taiwan	20,658	700
Jabil Circuit	US	18,293	177
Inventec	Taiwan	15,265	23
TPV	China	11,973	32
Celestica	Canada	5,796	22

Source: Circuits Assembly, http://circuitsassembly.com/ca/index.php/magazine/23871-ems-top-50-1406, Bloomberg, author's research

3. Foxconn Technology Group is the trading name of Hon Hai Precision Industry Co, Ltd. Sometimes the names are used interchangeably.

Figure 1 **Top 10 contract manufacturing companies, operating margins, 2011–2013 (in %)**



Note: Operating margin is defined as: Operating margin = Operating income ÷ Net sales
Source: SEC Filings, Company Annual Reports

integration. The company does not focus only on system assembly, but manufactures many of the (simple) components of the system, ranging from plastics, through cables to metal parts.[4]

System assembly is characterized by mostly low profit margins, leading to 'razor thin' margins at most contract manufacturers, and huge problems during the reoccurring crises (see Figure 1; Harris 2014; Lüthje et al. 2013). Its high level of vertical integration, in addition to its enormous size, allow Foxconn to realize higher profit margins than its competitors (Figure 2). Most of Foxconn's profits derive not from system assembly but from producing various components which the company then provides through its production system for its customers. Companies such as Jabil are able to achieve high profit margins with their focus on high margin products, such as medical technology.

4. Additionally, Foxconn is constantly expanding its business focus. In recent years the company has entered such field as manufacturing automation and robotics, solar power, mobile network services and online retailing, to name just a few.

Comparing gross profit margins between contract manufacturers and lead firms confirms that the latter are the beneficiaries of the disintegration between product innovation and manufacturing (Figures 1 Figure 2). Global production networks are a form of industry organization that facilitates the polarization of profit opportunities through the uneven distribution of capabilities to capture value added (Linden et al. 2007; Harris 2014). Lead firms focus on product innovation as well as product branding and marketing and simultaneously outsource the highly commoditized process of manufacturing. This allows them to focus on the most lucrative parts in the production process, leaving the capital intensive manufacturing to their suppliers. Contract manufacturers need to offset the margins problem through economies of scale – the sheer size of their operations – standardization and vertical re-integration. However, as we will see below, the picture is not as homogeneous as sketched here. With companies such as Samsung and Lenovo lead firms that are vertically integrated are becoming successful again.

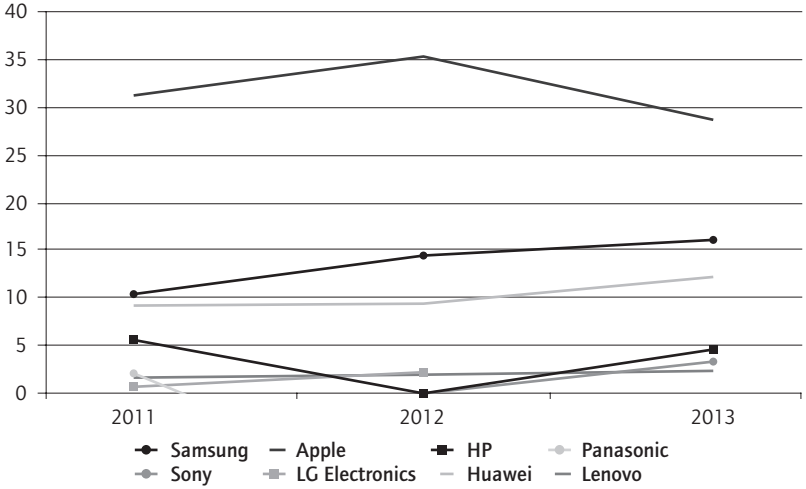
Table 2 **Various electronics lead firms, 2013**

Company	Nationality	2013 Revenues (US$M)	Employees worldwide, app. (in thousands)
Samsung Electronics	South Korea	213,342	326
Apple	US	170,910	98
HP	US	112,298	317
Panasonic	Japan	75,800	293
Sony	Japan	75,410	140
LG Electronics	South Korea	54,237	82
Huawei	China	39,460	140
Lenovo	China	38,870	35

Note: Table 2 summarizes data for brand-name electronics companies. One has to be cautious with the comparison as the scope of activities and markets of these companies varies.
Source: Bloomberg, author's research

The country of origin of lead firms and contract manufacturers reflects the traditional international division of labour, where companies from industrial nations occupy the central and profitable parts of the supply chain, while companies from latecomer countries specialize in manufacturing. However, with Samsung, LG Electronics and especially with Lenovo and Huawei seminal shifts in the international division of labour are already becoming evident. Only recently brand-name companies in

Figure 2 **Various electronics lead firms, operating margins, 2011–2013 (in %)**



Source: SEC Filings, Company Annual Reports

the electronics industry originated from the countries/regions: North America, Europe and Japan. Companies from South Korea and China were not known and these locations were perceived as the workbenches of the world. This has already changed as increasingly brand-name companies from South Korea and in recent years also from China are able to take considerable shares in various electronics markets.

3. Development of complex global production networks in the electronics industry

3.1 Contract manufacturing and beyond

The roots of the contract manufacturing industry can be traced back to the 1980s when highly specialized companies such as Intel, Microsoft and Cisco became increasingly important by specializing on key components of the PC and thereby contradicting the traditional model of production and innovation. The traditional model of vertical integration centred on manufacturing of the key elements of electronic systems and entire systems, combined with technological development and process know-how. The various components of these electronic systems were linked through proprietary standards that closed them off from other competing

firms. The aim of corporate strategies was thus control over technological development and product manufacturing.

Vertical integration was superseded by a new, more modular production system. Based on open but owned quasi-standards defined by Intel's x86 microprocessor architecture and Microsoft's DOS/Windows software, entire systems – for instance PCs – could be assembled using standard components, including microprocessors, memory, motherboards, disk-drives, displays and operating systems (Cusumano and Gawer 2002). This technical modularization facilitated the development of the 'horizontal computer industry' (Grove 1996; see Figure 3) in which the various parts of the whole value chain developed into vertically specialized industries, integrated by increasingly complex global production and innovation networks. Processes until then organized within the boundaries of one firm were now commercialized and distributed among highly specialized suppliers. Borrus and Zysman (1997) coined the term 'Wintelism' for this modular industry organization, blending the names of the central firms of this model – Windows and Intel – into one expression. 'Wintelist' firms derive control solely from technological development that enabled the creation of new markets through a constant flow of breakthrough innovations. Manufacturing and process knowledge was now only regarded as an unnecessary cost factor. The interest of financial markets in fast profits and share price growth were an important driver in realizing the potential technical modularity that provided for development of the horizontal electronics industry.

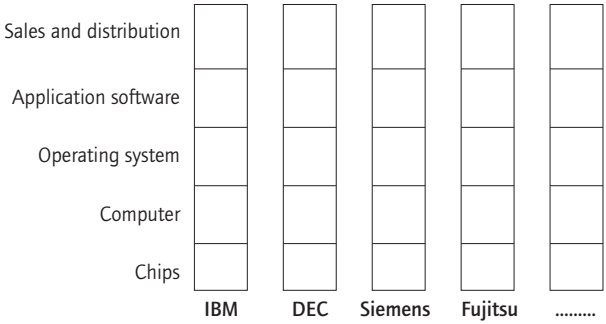
The rise of the contract manufacturing industry

In the 1980s Solectron[5] was the first contract manufacturing company in the electronics industry to supply printed circuit board assembly (PCBA) for IBM's PC business. Other US contract manufacturers such as Jabil Circuits, Flextronics, Sanmina, Celestica or SCI followed suit. In the 1990s these initially small companies specializing in PCBA grew into multibillion enterprises with global operations. Their initial growth was facilitated by outsourcing programmes in the mid-1990s, as manufacturing was no longer regarded as a core competency by high-tech companies but became a cost factor that burdened profit margins (Sturgeon 1997). This development was spurred by financial markets that saw a huge opportunity for fast stock price gains when high-tech companies outsource their manufacturing operations.

5. Solectron, once the leader in electronics contract manufacturing, was acquired by Flextronics in 2007.

Figure 3 **The dynamics of industry organization**

The vertically integrated computer industry (ca. 1980)



The horizontal, or vertically specialized computer industry (ca. 1995)

Sales and distribution	Retail stores		Superstores			Mail order
Application software	Word		Word perfect			etc.
Operating system	DOS/Windows		OS/2		Mac	UNIX
Computer	Compaq	Dell	Packard Bell	HP	IBM	etc.
Contract Manufacturers	Solectron	SCI	Flextronics		IBM	etc.
Chips	Intel Architecture		Motorola			RISCs

Source: Grove (1996)

Lead firms from the United States were the first to sell entire plants to contract manufacturers, securing future product manufacturing through supply contracts. European electronics companies such as Alcatel or Siemens followed suit in the late 1990s. This growth phase resulted in complex and heterogeneous global production networks of contract manufacturing companies as they had to manage various manufacturing operations, with diverse production systems in many locations, in both central and peripheral regions (Lüthje et al. 2002). Their initial strategies included gradually downsizing manufacturing in high-cost locations, while offshoring to newly built-up advanced manufacturing locations in low-cost locations such as Brazil, Mexico, Central and Eastern Europe, Malaysia and Indonesia.[6] Although some manufacturing capacities were also offshored to China, the country was not at the centre of these initial contract manufacturing activities.

6. It is important to keep in mind that low cost locations are not characterized by low wages alone but by a specific political economy. Only the interplay between a regulatory setting (export processing zones, prohibition of trade unions, tax breaks) and an institutional framework (migrant labour, forms of workforce provision) make low cost locations possible.

In their new locations contract manufacturers could establish uniform production systems and supplier networks that allowed for a standardized and flexible high-volume production of various products for different customers within the same plant. Through the development of a differentiated location structure electronic contract manufacturing companies created low-cost, high-volume production capabilities on a global scale and enabled lead firms to organize parts of their production activities in the form of a 'one-stop shop' (Lüthje et al. 2002; Lüthje et al. 2013). This form of production organization was based on highly standardized interfaces between lead companies and contract manufacturers to enable a quick and frictionless hand-over of the developed product and ramp-up of its production. These standardized interfaces facilitated corporate strategies aimed at high flexibility by lead firms. Manufacturing was shifted both between various locations, as well as between contract manufacturing suppliers, while second sourcing arrangements reduced supply risks and in addition lowered dependency on a single contract manufacturer (Pawlicki 2005).

To develop the interfaces between lead firms and contract manufacturers while increasing gains from high-volume manufacturing the standardization on the technical level continued. Similar or even the same components were used in competing products, leading to a reduction of sources to differentiate. Software, especially the user interface and software-enabled services, as well as branding became the central focus of lead firms' strategies for differentiation.

Re-integration for survival

While setting-up their global production networks electronics contract manufacturing companies also started to develop beyond their initial simple contract services. They were moving towards integrated electronics manufacturing services (EMS) through turn-key production networks (Sturgeon 1997). Besides PCBA and systems manufacturing/assembly EMS also comprised new product introduction, component purchasing with supplier and inventory management, global distribution and logistics, combined with customs clearance and after-sales/retail and repair and warranty services (Sturgeon and Lee 2004; Lüthje et al. 2013). One of the major drivers of vertical re-integration on the manufacturing side was the need to find sources of revenue and profits to be able to offset the very low profit margins in systems assembly (Lüthje et al. 2013; van Liemt 2007). Extending their services towards EMS contract manufacturers also became lead firms and organizers of

their own supplier networks, as they used the developing supplier networks in the electronics industry.

The crisis of the electronics industry in 2000–2001 led to a restructuring of the EMS industry as lead firms passed on their financial problems to EMS companies, for example, by forcing them to bear most of the costs for huge inventories. This was possible as vendor-managed inventory systems were already in place.[7] Faced with huge costs and overcapacities EMS companies had to lower their cost structure considerably, driving their search for even cheaper labour and more integrated production organization that would allow for economies of scale.

Additionally, the aftermath of the New Economy crisis saw a centralization of relationships between lead firms and EMS companies. HP is an informative example: already before its merger with Compaq, HP started a huge restructuring of contract manufacturing in 2002 and sped up this centralization programme after the merger in 2004. The number of EMS companies was reduced from more than 10 to only three and EMS cooperation was centralized at HP's corporate level. HP also resumed exclusive responsibility for purchasing key electronics components such as chips, motherboards and hard disk drives (Lüthje et al. 2013). These strategic decisions allowed HP to regain power in the supply chain by lowering the bargaining power of EMS companies. As most lead firms followed suit a considerable reorganization of the global production networks of the electronics industry took place. Purchasing key components was an important source of additional revenues and profits for EMS companies that were now forced to cut costs to stay profitable. EMS companies reacted with further vertical integration and the centralization of their own supply chains, reducing substantially the number of their suppliers and standardizing components further.

Foxconn's stellar rise began in the aftermath of the New Economy crisis as it was the first proponent of the very integrated manufacturing model in the contract manufacturing industry. This gave Foxconn a competitive advantage that the company was able to use, while it also forced its

7. With vendor-managed inventory systems lead firms buy components, already stocked at a supplier's plant, only at the moment when they are taken out of the warehouse for production. The bursting of the 'new economy bubble' left EMS companies with a huge amount of electronic components they could no longer sell to their customers and which lost quickly value.

competitors to reconsider their corporate strategies. Its high levels of vertical integration made the cost cuts possible that brand-name companies were looking for, while Foxconn was still able to earn enough money to invest in expanding its business. The Taiwanese contract manufacturer origins of the 1970s lie in plastic components that it later expanded into modules, circuit boards and enclosures. Its huge manufacturing and R&D capabilities in components and modules reward Foxconn with healthy gross margins that help the company to counterbalance the very low margins of system assembly and provide it with a means of underquoting its competitors (Pick 2006). Foxconn's increasingly large manufacturing operations were highly suitable for the centralized supply chain management of brand-name companies as the Taiwanese supplier could deliver a whole range of electronic products.

3.2 Product design as the new game

The organizational re-focusing of the continuously restructuring electronics industry is being amplified by the growing importance of original design manufacturing (ODM). ODM goes beyond providing manufacturing services by offering product design as an additional service. Taiwanese contract manufacturing companies developed this model of integrated product design and manufacturing in the notebook market as early as the 1990s. Their goal was to move beyond simple assembly work to raise their profit margins by gradually refining their design skills for a very narrow range of high-volume products (Sturgeon and Kawakami 2011). Lead firms can choose from a variety of fully developed products and customize these, or cooperate with ODM firms on the development of new products. The final product delivered by the ODM firm – which also owns the design – is sold by the lead firm under its brand name. More than 90 per cent of notebooks are currently produced using the ODM model.

In recent years ODM has become the predominant model of contract manufacturing in the electronics industry. Product portfolios are constantly growing, while product life cycles are shrinking, leaving lead firms with problems keeping up with the competition in product markets and in meeting the demands of financial markets for profit growth. Overhead costs for increasingly growing innovation capabilities seem too big for many companies, especially as many product categories do not generate the required return on investment. In particular, entry-

level/low-cost products are perceived by lead firms as an area in which product design can be outsourced in addition to manufacturing. Furthermore, big lead firms as well as small start-ups can focus on proprietary IP that will allow them to differentiate their products in the market and leave all other product development to their ODM supplier (Carbone 2014). Sourcing from ODM entry-level mature products, which are highly commodified and lack breakthrough innovation possibilities, allows lead firms to focus their resources on leading edge products with higher profit margins and technological leadership opportunities (Lüthje et al. 2013).

EMS providers such as Foxconn and Flextronics now increasingly offer design, development, test and marketization services, by building up and expanding their design capabilities. Some companies – such as Flextronics – have even built up chip design capabilities. For EMS providers the move towards the ODM model promises higher profit margins and higher levels of control over their supply chain. As the complexity of electronics systems is rising, while product life cycles are becoming shorter, the integration of manufacturing process knowledge and experience is becoming essential for successful and fast product development and quick ramp-up of high-volume manufacturing.

A complete reversal?

The proliferation of the ODM model has had substantial effects on the global production networks of the electronics industry. The restructuring during the mid-2000s lead to centralization of the EMS industry and to the integration of numerous manufacturing capabilities, while China has become the centre of electronics manufacturing. The integration of product development and design is a move beyond the manufacturing level and constitutes another major step in the process of re-integration in the electronics industry. However, while product design, engineering and manufacturing once again are integrated within one organization there seems no turning back towards the traditional model of vertical integration. Global supplier networks are so well developed and despite the re-integration on the manufacturing side show such levels of specialization, that they offer unprecedented flexibility that both lead firms and EMS/ODM providers will not abandon.

The interfaces within the innovation model of the electronics industry have evolved further, propelled by the rise of ODM. Lead firms had in-depth experience in both system and component development, making

them highly informed and demanding customers for technology providers such as chip companies. Although some ODM companies have invested in chip design capabilities they lack profound experience in components.[8] Chip companies such as Qualcomm, Intel or Mediatek need to provide their experience in both component development and systems design within so-called reference designs to their ODM customers. These reference designs enable ODM companies to complete product design by focusing on application software, drivers and industrial design. While ODM companies acquire engineering and product development capabilities, the major decisions on core technologies are still controlled by lead firms and chip solution suppliers (Pawlicki 2014). The proliferation of the ODM model drives a triangular restructuring (Lüthje and Pawlicki 2009) as technology suppliers such as chip developers and chip foundries are becoming increasingly important alongside lead firms.

Vertically specialized lead firm – the only way?

The vertically specialized and network-based industry organization dominated the electronics industry in the 1990s and 2000s with specialized lead firms, suppliers and EMS companies. However, industry organization is never as uniform as many management consultants and textbooks would like it. The strategic decision to outsource huge parts of a company's value chain to suppliers is always embedded in the home country's formal and informal institutions, financial market pressures, industry relations and management planning periods. The institutional arrangements of a nation's political economy form a framework that facilitates specific tendencies in corporate strategies (Hall and Soskice 2001).

Japanese companies were significant exceptions within the vertically specialized electronics industry. Up until recently they firmly adhered to the vertically integrated model, keeping most of their manufacturing capabilities in-house. The little outsourcing Japanese companies did was with Taiwanese ODM companies, as this allowed for very tight cooperation and strict control over the manufacturing process that yielded the required quality standards. For quite a long time analysts and academics, proponents of vertical specialization, struggled to explain how such integrated companies could be successful. This was also the case with companies such as Nokia. Only recently did Japanese companies start to

8. Knowledge of component development and – even more – of their integration into a working system is the basis of systems development.

outsource considerably more to EMS providers. The adherence to vertical integration was not the main cause of the demise of either Japanese companies or Nokia. Wrong strategic decisions, a sluggish innovation process and missed market opportunities were much more important factors in their current economic problems (Bouwman et al. 2014).

However, the departure of the most important proponents of vertical integration does not imply its disappearance as new dominant players have emerged that favour a corporate strategy centred on manufacturing. Samsung and Lenovo are vertically integrated lead firms that operate their own substantial manufacturing facilities, while making use of the existing highly developed supplier networks in complex and flexible ways. Although Samsung and Lenovo are quite different, as the former is probably the most highly integrated electronics company worldwide, whereas the latter is moving towards a more integrated model, both companies perceive manufacturing as central to their corporate strategy and their innovation model.

The emergence of Samsung and Lenovo is not just another organizational cycle of the constant re-focusing and re-shifting of the electronics industry. Although there is still no substantial body of research on the specific characteristics of Asian companies, initial data suggest that at least companies from China and South Korea are more open to a higher level of vertical integration, as well as longer planning periods. China has already moved beyond being the manufacturing base of the world and now offers a huge and dynamic market, while Chinese companies have started to invest in both developing and developed markets. It will be interesting and important to trace the development of Chinese multinational companies and their impact on industry organization in the future.

3.3 Shifting geographies of production

The cost-cutting strategies of lead firms forced EMS companies to search for locations that allowed for the necessary cost reductions. China, offering very low wages, favourable financial incentives, a specific institutional framework and, in addition, a seemingly inexhaustible workforce, now became the centre of manufacturing activities for the electronics industry. EMS companies started to concentrate their manufacturing in China, focusing not only on the benefits of low wages but also pushing economies

of scale to unprecedented levels by developing huge plant complexes. Within only a few years massive production capacities were built up in China, initially on the coastal Guangdong region, with Guangzhou and Shenzhen, as well as Shanghai, with Suzhou and Nanjing. The Guangdong province in particular has developed into the most important location for high-volume electronics worldwide. Today the production of electronics, especially smartphones, is not possible without companies located in China, as many of them have developed near monopolies in the supply chain (Gordon and Chanoff 2012).

The shift to China affected locations in central and eastern Europe, Brazil and Mexico. Already started or announced production was offshored to Chinese locations, as a previously regionally organized production was abandoned in favour of a more centralized one (Pawlicki 2005). Former high-volume manufacturing locations, such as Hungary, were confronted with huge restructuring problems, as they were now regarded as higher-cost locations. This often resulted in downsizing and refocusing, as production moved from high-volume, price-sensitive products towards low-volume and higher-value products (Plank and Staritz 2013). Additionally, these locations were used by contract manufacturers as flexibility buffers, extending the already existing hire and fire policies that contributed to the poor labour conditions (Lüthje et al. 2013).

The massive influx and build up of manufacturing capacities from various industries – electronics, garments, automotive, chemicals – has led to a very rapid development of China's coastal strip, triggering problems especially for production models based on a low-cost environment. Labour costs have been exploding due to labour market shortages, rising living costs and the strategy of regional and local governments in China to control social tensions through regular and often substantial rises of minimum wages (Butollo and ten Brink 2012; Zenglein 2011). Simultaneously, the continuous stream of tens of thousands of migrant workers to the coastal regions is fading, leaving companies with a huge problem as turnover rates are still enormous. Additionally, the central government's strategy of upgrading industrial production in the already developed regions is pushing out simple manufacturing operations. Since around 2011 many companies – such as Foxconn, Wistron, Quanta, Inventec and Pegatron – have been implementing a strategy of targeting second-tier cities in China's west. Having developed their experience in setting up high-volume production operations in the coastal region they were able to establish major manufacturing complexes in cities such as Chongqing, Wuhan or

Chengdu quickly. This drive to the west was fuelled by tax incentives and favourable policies offered by regional and local governments.[9]

The increasingly centralized supply chain management of lead firms and the geographical re-shifting in the aftermath of the New Economy crisis facilitated Foxconn's stellar rise to become the overall dominant force in the EMS industry. The company was one of the first EMS providers to almost completely focus its manufacturing operations on China. Foxconn's aim for economies of scale is visible in its huge manufacturing locations – the so-called Foxconn factory cities that can house up to 400,000 employees. Its first and up to now biggest complex is Foxconn City in Longhua, Shenzhen, that includes 15 factories, worker dormitories, stores, banks, restaurants and a hospital. Although Foxconn also has a global presence, with regional hubs in Mexico, the Czech Republic and Brazil, its manufacturing operations are still very much focused on China (see Table 3).

Not all EMS companies aim for this level of centralization and vertical integration. Flextronics has integrated industrial parks in China, Hungary, Poland, Brazil and India, while also developing regional integration through the organization of production processes across several locations in one region (Lüthje et al. 2013). Already in 2001 Flextronics started to consolidate its high-volume manufacturing activities in its industrial parks. Within these industrial parks manufacturing and logistics operations are co-located with suppliers, making it possible to provide comprehensive manufacturing services ranging from sheet metal fabrication, PCBA, plastic moulding, system assembly, logistics and even customs services. Currently Flextronics has locations in 21 countries worldwide, mostly in low-cost locations but still also in high-cost locations (see Table 3).

ODM's growing importance entails a further shift towards Asia. Because almost all ODM companies originating from Taiwan have strong historical ties to mainland China, their above average growth in recent years has led to a build-up of even more manufacturing operations in China. Table 3 indicates that companies from Taiwan are fairly conserva-

9. There are initial signs that the 'go west' drive might already be going into reverse as the considerable incentive programmes offered by the new regions and cities are running out. Some big ODM companies have announced plans to re-shift their production to coastal locations.

tive about internationalizing beyond Asia. Even big ODM suppliers, such as Pegatron, have only a few manufacturing locations in other regions of the world. While major parts of electronics manufacturing have already moved to Asia, with China as the main location, the proliferation of the ODM model implies that product design and development is also moving away from its traditional locations in the United States, Japan and western Europe (Lüthje and Pawlicki 2009). This is leading to growth of the geographical dispersion of the global production networks of the electronics industry. While the innovation interfaces to lead firms still often necessitate the location of some product development capacities in the United States and Europe, most EMS/ODM companies' R&D centres are located in Taiwan, China and other Asian countries. As the dynamic lead markets are now in China, India and other Asian countries these specific geographies of the innovation system are about to change (Pawlicki 2014).

Table 3 **Worldwide manufacturing locations of EMS/ODN companies, 2013**

Company	Locations
Foxconn	Taiwan (HQ), Brazil, China, Czech Republic, Hungary, Indonesia, Malaysia, Mexico, Slovakia, Turkey, Vietnam
Pegatron	Taiwan (HQ), China, Mexico, Czech Republic
Quanta	Taiwan (HQ), China; Brazil, Canada, Germany, USA – configure to order final assembly centres
Flextronics	USA/Singapore (HQ), Austria, Brazil, Canada, China, Czech Republic, Germany, Hungary, India, Indonesia, Ireland, Japan, Malaysia, Mexico, Poland, Philippines, Romania, Taiwan, Turkey, Ukraine, USA
Compal	Taiwan (HQ), Brazil, China, Mexico, Poland, Vietnam
Wistron	Taiwan (HQ), China, Malaysia, Mexico, Czech Republic
Jabil Circuit	US (HQ), Brazil, China, Hungary, India, Italy, Ireland, Malaysia, Mexico, Poland, Singapore, Ukraine, Vietnam
Inventec	Taiwan (HQ), Czech Republic, India, Mexico, USA
TPV	Hong Kong (HQ), Brazil, China, Poland, Russia
Celestica	Canada (HQ), China, Ireland, Japan, Malaysia, Mexico, Romania, Singapore, Spain, Thailand, USA

Source: Company websites, author's research

4. The price of flexibility

Industry organization, power relations between particular companies and labour conditions in the electronics industry have been driven for at least the past 30 to 40 years by excessive profit expectations, offshoring dynamics and increasingly fast innovation cycles (Angel 1994; Pawlicki 2014). The pace of both organizational and technological change in the electronics industry is unparalleled in any other branch of the global economy. However, as other industries increasingly add electronic components to their products – for example, automotive, machinery, medical – the idea seems to be spreading of a highly flexible industry organization that relies on low-wage work performed under oppressive labour conditions, in countries in which industrial relations are often characterized by weak or even no trade unions.

The very low profit margins are the biggest challenge for EMS and ODM companies, and also one of the biggest drivers of their almost continuous organizational re-focusing and geographical re-shifting. As we have seen, the distribution of profit margins is very unbalanced between lead firms and their EMS/ODM cooperation partners, which are also pressured to take most of the risks, for example, through specific inventory schemes. For lead firms to stay flexible, stabilize their supply chain and keep their dependence on a single supplier as low as possible, second sourcing strategies are widespread, further amplifying the problems of EMS/ODM companies. Additionally, markets for electronics are highly cyclical, characterized by phases of high production volumes followed or preceded by average or even low demand. Christmas season together with the introduction of new product variants are especially important moments of cyclicality. Contract manufacturers have to provide above-normal manufacturing capacities for a short time and then to cope with over-capacity (Harris 2014).

The specific organization of the electronics industry has profound effects on labour conditions and work organization at EMS/ODM companies (for details on these issues see other chapters in this volume). Highly fragmented work organization, low wages and almost permanent overtime – which very often is the only income opportunity that raises monthly wages above the minimum wage level – are characteristic of the industry. During peak season, overtime becomes a requirement for fulfilling the last-minute orders of lead firms. The shares of agency and temporary workers soar during these times. Health and safety standards

are very often not observed, while most of the safety regulations in the industry are in place to safeguard not the workers but the fragile electronic products. Such oppressive labour conditions drive workers to change employers in search of even very small advantages; as a result, there are very high turnover rates at EMS/ODM companies in China of up to 30 per cent (SACOM 2010).

In addition to flexibility the networked electronics industry offers lead firms opportunities to cut costs by locating their manufacturing in locations where workers earn very little and regulations are very lax, while protecting lead firms from possible reputational risks. Although this protection is limited – the various reports by NGOs such as SOMO/Good Electronics or SACOM have prompted widespread public debate – lead firms still often hide behind the fact that the violations regarding overtime, wage, health and safety and so on did not happen within the boundaries of their organization strictly speaking. Accountability within supply chains is reduced to corporate social responsibility reports and schemes and occasional audits performed by external auditing firms. Lead firms often argue that it is not possible for them to have detailed insight into the various manufacturing locations of their numerous supply chain partners. However, as Harris (2014) argues the process of due diligence performed by lead firms before a supplier is awarded a place in their supply chain is so detailed that they are very much aware of the labour conditions in the plants in which their products are manufactured. In an age in which enterprise resource planning systems enable companies to collect, store, manage and interpret data from almost any of their business activities nearly in real time, it is only a rhetorical question why lead firms do not have more detailed insight into their supply chain in relation to urgent questions about labour conditions.

The vertical specialization of the electronics industry allows lead firms to offload costs and risks onto their suppliers. While the dis-integration at the top is developing further, as product design and development are now also being outsourced, there are processes of re-integration at the level of manufacturing. However, this is not leading to further use of already known models of vertically integrated industry organization but rather to an industry model based on hierarchical networks with polarized and simultaneously interdependent partners linked through asymmetrical relations. Additionally, triangular restructuring is increasing the importance of technology suppliers, such as chip developers and chip foundries, which are partly taking over the role of providing system

development knowledge, positioning themselves between lead firms and EMS/ODM companies (Lüthje and Pawlicki 2009; Pawlicki 2014).

Faced with low profit margins and highly cyclical markets and pushed by lead firms to incur most of the risks, costs and a service-based business model EMS/ODM companies are constantly looking for sources of revenue, cost reduction and standardization. The re-integration at the manufacturing level is an important process that is leading to a new phase of industry organization and new geographies of innovation (Lüthje and Pawlicki 2009; Pawlicki 2014). This translates into future problems for Europe as a location for the electronics industry. Western Europe ceased to be a manufacturing location for the electronics industry some years ago. While EMS/ODM companies built up considerable manufacturing operations in central and eastern Europe the dynamic development and upgrading of Chinese operations have had a negative effect on them, reducing their role more often than not to simple regional fulfilment centres (Lüthje et al 2013; Plank and Staritz 2013). The semiconductor industry is an illustrative example of the importance of the interface between manufacturing and R&D. Shifting chip manufacturing towards South-east Asia has facilitated a geographical shift in the global innovation networks of the semiconductor industry towards this region (Pawlicki 2014). With the automotive and telecommunications industry Europe still has some outlets and manufacturing operations that are important for the electronics industry. However, there is an imminent danger that major parts of R&D in the electronics industry will move out of Europe. Innovation initiatives at the EU level too often focus only on pure research and development activities, forgetting almost completely the importance of manufacturing in the innovation process. The call for a real industrial policy that focuses on the entire value chain of an industry should not be perceived as a traditionalist cry for more state influence, but the result of a realistic assessment of how innovation is driven by both manufacturing and research.

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