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Who Captures Value in Global Supply Chains?

Case Nokia N95 Smartphone

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Abstract

Available statistics tell us little about the economic consequences of increasing global dispersion of production processes. In order to shed light on the issue, we perform grass roots detective work to uncover the geography of value added in the case of a *Nokia N95* smartphone circa 2007. The phone was assembled in Finland and China. In the case when the device was assembled and sold in Europe, the value-added share of Europe (EU-27) rose to 68%. Even in the case when it was assembled in China and sold in the United States, Europe captured as much as 51% of the value added, despite of the fact that it had rather little role in supplying the physical components. Our analysis illustrates that international trade statistics can be misleading; the capture of value added is largely detached from the physical goods flows. It is rather services and other intangible aspects of the supply chain that dominate. While final assembly – commanding 2% of the value added in our case – has increasingly moved offshore, the developed countries continue to capture most of the value added generated by global supply chains.

Key words: Global supply chains, international trade, value capture

JEL: F 14, F 23, L 22, L 23

1 Introduction

Global business networks operate at ever-finer resolutions in terms of where, when, and by whom individual tasks are carried out. While the economic importance of this phenomenon has been likened to that of the industrial revolution (Baldwin, 2006) and its theoretical understanding is mounting (Grossman & Rossi-Hansberg, 2008), its empirics remain ill-understood.

Due to limitations in available statistics, in this paper we resort to grass roots detective work to uncover the geography of value added in the case of a *Nokia N95* smartphone circa 2007. While we study a specific case, it arguably illustrates broader trends in globalization. We find that value capture is increasingly detached from cross-border flows of physical goods. It is rather in-house and market services as well as various forms of intangible assets that command the lion's share of value added (and thus income and profits earned). Even if final assembly has largely moved offshore, the developed countries continue to capture most of the value added generated globally.

Linden, Kraemer, and Dedrick (2009), who study the supply chain of *Apple*'s *iPod* digital music player in 2005, is the most important predecessor of our work. They conclude that, even if the *iPod* was assembled in Asia, *Apple*'s American workers and shareholders predominantly reaped the benefits. They also emphasize, that innovation matters: the greatest value tend to go to companies and locations providing critical differentiated inputs. Finally, they highlight the fact that international trade statistics can mislead as much as inform. In certain ways all of these findings are echoed in this paper.

There are several strands of analysis that relate to our study. First, the value creation of a high-tech product, like smartphone, can be analyzed from *innovation value chain* vantage point (Roper et al., 2008). The basic idea is that the capability to manage and utilize previously produced knowledge determinates to a large extent the company's ability to capture higher amounts of value from their products and services. This implies that value capture is increasingly dependent on intangibles also in the case of manufactures. Our analysis shows that this is, indeed, the case.

Second, one may look at the value creation from the *governance perspective* (Gereffi et al., 2005). It can be argued that the structure of global value chains depends on three variables: the complexity of transactions within the value chain, the ability to codify transactions, and the capabilities in the supply-base (Gereffi et al., 2005, 98). These three variables, again, play a large role in how global value chains are governed. It is likely that in electronics the codification of product and process specifications is important determinant of governance patterns. However, as we will see, increasing modularity characterizes the value chain governance in our case industry.

Third, and in our analysis a much more important, viewpoint is *trade analysis* and the *macro economic implications* of the fragmentation of international production. Recent studies have paid attention to the potentially large bias in official trade statistics due to increasing role of intra-firm trade and global supply chains (e.g. Maurer and Degain, 2010; and EU, 2010). The grass root analysis of a single product contributes to that discussion.

Our approach and method closely resemble those of Linden *et al.* (2009). Besides obvious differences of industry, product, and point in time, our analysis is more detailed on several accounts. Furthermore, our analysis is on value added (rather than gross margin) basis (see also Ali-Yrkkö 2010). Our most important extension concerns the geographical breakdown of value added: we go beyond headquarter locations as well as allow for the generation of each component's value added in multiple locations and functions.[1] To our knowledge this is the first paper to look at global supply chains on value added basis in such detail.

2 Context

The telecommunications industry is typically seen to consist of: network infrastructure equipment and its operation, end-user access (terminals, handsets, and portals), as well as digital content and services. Since the early 1990s, the telecommunications industry has converged with near-by industries, particularly information technology (computers and their data networks, including the Internet) as well as content provision of various types, particularly radio and TV as well as recorded audio and video.

Our case study of the *Nokia N95* smartphone touches upon one aspect of the telecommunications industry; the phone's primary function is to provide a physical end-user access point to wireless voice and data networks and their services. As the phone was introduced at a point in time when the convergence had progressed quite far, it embeds dozens of non-communication functionalities.

Advances in information and communication technology (ICT) have had an important enabling role in the geographic dispersion of production processes. Furthermore, ICT industries are themselves among the globally most dispersed major industries, which especially in the case of personal computers relate to the exceptional modularity of basic designs. While, as compared to PCs, the industry's internal division of labor and geographic dispersion has not gone as far in the case of mobile phones, it should be noted that our case considers an industry that has progressed further in geographic dispersion than many others.

Upon its announcement in 26 September 2006, *N95* was *Nokia*'s flagship product. It was globally one of the early "all-in-one multimedia computers" with size and weight of a standard phone. *N95* supported the latest high-speed mobile telephony protocols; it also had *WiFi* for long-range and *Bluetooth* for short-range data communications. It integrated GPS navigation, MP3 player, FM radio, and two video/still cameras as well as supported multiple email, messaging, and internet protocols. With its cameras, color display, and multiple speakers, *N95* recorded and played back audio, video, and images with ease. Preinstalled software included a calculator, calendar, dictionary etc. and – as with any computer – more could be installed. The phone was actively marketed as an access point to Internet services of *Yahoo!*, *Amazon*, and *Flickr*. The afore-mentioned convergence would have been complete, if only the phone supported viewing of over-the-air television broadcastings. This omission was not, however, due to *Nokia*, but rather related to the (still) lacking standards and unresolved intellectual property rights issues.

[1] For example, *N95*'s main processor was provided by *Texas Instruments* (US). The hardware design was made in Dallas (US) and in Nice (France). Much of the software design and its integration to hardware were of Indian origin. Besides Dallas (US), the processor was also manufactured in Japan.

While there were some initial difficulties with the phone's two-way sliding design, both technically and commercially *N95* was a success: some ten million highly profitable copies were sold worldwide. Several "face lift" versions were introduced and aspects of its basic design are being employed in models currently in production. In terms of basic functionality, later models launched in 2007–09 have added relatively little to what *N95* had to offer, even though all features continue to be refined.

3 Sources

Our analysis is based on five sources. *First*, in August 2008 we physically broke down a fully-functioning *N95* and examined each of its approximately 600 individual components with two engineering experts.[2] *Second*, we accessed public (particularly Internet searches) and private (direct contacts to various companies and individuals across the supply chain) information to get an idea of direct (primarily coding in the case of software and manufacturing/assembly in the case of hardware) and indirect (R&D, design, and various supporting functions) value added of each component. *Third*, we purchased a standard "teardown" report of the component composition of N95 (Portelligent, 2007), which also included estimates of factory prices and vendors by component.[3] *Fourth* – armed with the knowledge gathered in the previous steps –, we collected further qualitative and quantitative information (as well as confirmed what we had gathered so far) via interviews of sixteen industry experts working currently or previously in various roles in the mobile handsets' supply chain.[4] *Fifth*, we examined financial reports and press releases of the companies involved as well as those of their direct competitors. We particularly exploited the differences in reporting in various geographies as well as officially required further information such as 20-F reports in the United States.

4 The supply chain

In our terminology a supply chain refers to the global flows of intermediate goods and services (both those provided in-house and purchased form outside vendors) involved in providing goods and services for final consumption. In each step, the vendor employs inputs, conducts its own value adding activities, and transfers its output to the other participants in the supply chain. The sum of all value-adding activities equals the final retail price of the phone before any applicable taxes.

Figure 1 represents a stylized supply chain of *Nokia N95*. In the case of tangible components, there are typically four to eight layers between Nokia and the extraction of metals and minerals for the earth's crust (Nokia, 2009). All components embed intangible assets in some form and confirm to one or more industry standards. In the case licensed or purchased embedded and standalone software, the flows cannot be readily mapped in a similar manner, but typically there are fewer intermediate layers.

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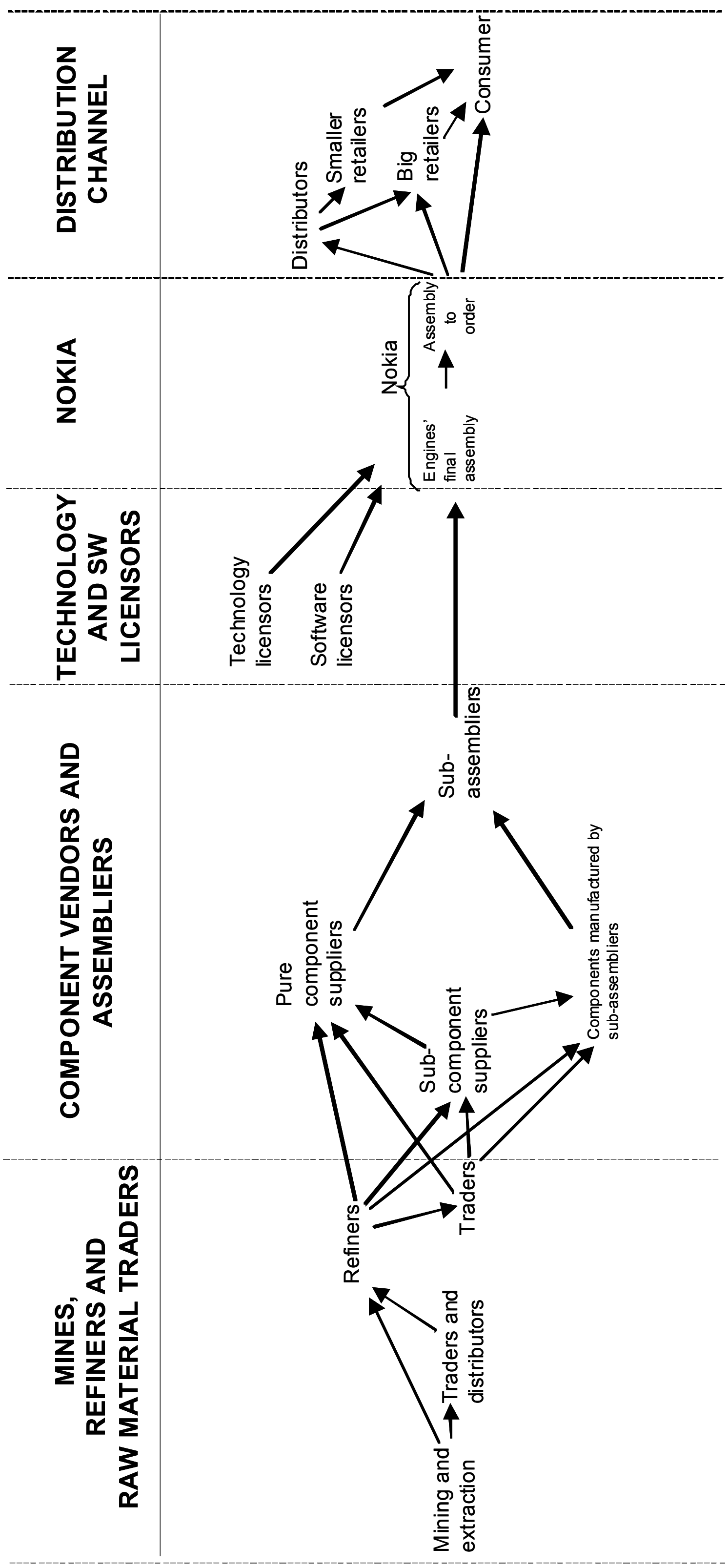
[2] The phone was purchased at the *Nokia Flagship Store* Helsinki in the Spring of 2007 and it served as a "company phone" of one of *ETLA*'s employees before its dismantling.

[3] The teardown report of *Portelligent* was acquired in September, 2008. We have also reviewed teardowns of other companies such as *iSuppli*.

[4] Due to the sensitivity of the topic, we had to assure full anonymity to our interviewees. The interviews were conducted between January 2009 and March 2010. The interviews were semi-structured and the questions varied between interviewees depending on their position in the supply chain.

Figure 1 A stylized supply chain of Nokia N95



Source: ETLA.

In Figure 1, the actors in supply chain of *N95* are categorized into five groups: mines and refiners, component vendors and sub-assemblers, software and technology providers and licensors, final assembly by *Nokia*,[5] as well as wholesale and retail distribution by telecommunication network operators and/or by general traders.

The flow in Figure 1 is as follows: The (still raw but now purified) outputs of miners/refiners are turned to sheets of metal and other elementary processed goods that are traded to parts and components vendors. They in turn deliver to sub-assemblers (which may in turn deliver to other sub-assemblers) feeding the final assembler.[6] Some of the intangibles – to the extent they are not embedded to and bundled with physical components – are licensed in a "pooled" form as parts of industry standards. Standalone software is acquired as necessary. Much of the intangibles are provided in-house or by vendors compensated by billable hour, which have to be considered separately. Depending on the market, *Nokia*'s direct customers are typically distributors – who in turn supply wholesalers and retailers – or operators. In both cases the co-operation and support of the operators is often vitally important in reaching the end-user.

5 Value added by actor

Let us first consider the direct components, parts, sub-assemblies, software, and licenses of *N95* – the bill-of-materials in the industry jargon. We first consider the actual sales prices (the gross value);[7] in later sections we consider the first-tier suppliers on value-added basis.

As shown in Table 1, the direct *bill-of-materials* amounts to about €200. One should note, however, that *Nokia* is a major holder of intellectual property rights (IPRs) in the GSM/WCDMA cellular communication standards and it does not pay licensing fees to itself (see Ali-Yrkkö 2010). Furthermore, cross-licensing is quite common within the industry, in which case fees paid do not reflect the full value of the employed IPRs. For a company without own employable/tradable IPRs, licensing fees could, in our view, more than double from those presented in Table 1.[8] Licensing fees aside, the most costly components of the phone were processors and other integrated circuits as well as the large color display.

The main integrated circuits of N95 were provided by Nokia's long-time ally *Texas Instruments* (US). The display and the most expensive memory chips came from *Samsung* (South Korea).

[5] Unlike some of its competitors, *Nokia* maintains significant in-house manufacturing and assembly capacity; in 2007, *Nokia* outsourced 20% of the total assembly of its phones (SEC, 2007, p. 36). In the case of *N95*, all final assembly was done by *Nokia* itself, *i.e.*, it did not use providers of electronic manufacturing/assembly services (EMSs) or original equipment manufacturers (OEMs).

[6] While we do not elaborate on the issue here, it should be noted that the final assembly consists of two parts: The first bit involves all aspects of the phone that do not vary by order – within the industry the physical outcome of this phase is commonly called an *engine* (hardware and software performing core functions of a phone but lacking aspects that vary from customer to customer). The second bit adds varying elements ranging from the choice of languages to adding a retailer's sticker; in the industry jargon this stage is called *assembly-to-order* (the engine obtains its final configuration per the customer's requests). *Nokia* considered this two-stage assembly process as one of its key differentiators within the industry; its customer promise is to deliver a desired variation from initial order to final delivery within 48 hours. *N95* was delivered in some 170 variations of the physical handset and in some 250 variations of the sales packaging (including the outer packaging, printed manuals, CD-ROMs, as well as a charger and other accessories).

[7] Throughout the paper we refer to the unbundled and unsubsidized official retail price without any applicable taxes, excluding any additional products and services purchased. Depending on the details in each particular case, the actual sales prices varied considerably. Mobile phones' sales margins vary considerably and in many markets they are difficult to estimate due to various types of tie-ins and bundlings with subscriptions and/or other services, in which case the immediate transaction is often made at a loss.

[8] The *Economist* (28 Apr. 2007, p. 8) notes that "ABI research estimates that just four firms own almost 60% of the patents in 3G technology, pushing licensing rates as high as 28.5% of the cost of equipment." In this quote it is a bit unclear what is included in the licensing fees and what is the denominator, but even a conservative interpretation of this would suggest that for an *a priori* industry outsider licensing fees might have been manifold as compared to those in Table 1. In our view the figure suggested in the *Economist* is somewhat exaggerated.

Table 1 The bill of materials (BOM) of *Nokia N95* in 2007

Description	€	%
Processors	34.3	17.3 %
Display	21.6	10.9 %
Main camera module (5 million pixels)	16.5	8.3 %
Memories	14.5	7.3 %
Battery pack	3.0	1.5 %
Video conference camera (VGA)	1.2	0.6 %
Other integrated circuits (excl. processors and memories)	31.5	15.9 %
Mechanics	18.7	9.4 %
All other hardware inputs	21.1	10.6 %
BOM (excl. supporting material, license fees and final assembly)	***162.4***	***81.8 %***
Supporting material	15.5	7.8 %
BOM (excl. license fees and final assembly)	***177.9***	***89.6 %***
GSM/WCDMA license fees	13.5	6.8%
Symbian OS	3.0	1.5%
Other license fees	4.2	2.1%
BOM (excluding final assembly)	***198.6***	***100.0 %***

Source: ETLA.

On the semiconductor side, main European companies were *NXP Semiconductor* (the Netherlands), *STMicroelectronics* (Switzerland) and *Cambridge Silicon Radio* (the UK).

As shown in Table 1, the licensing fee for the *Symbian* operating system was about €3. According to *Nokia*, it paid less than 3% aggregate license fees on its WCDMA handset sales (Nokia's 12 April 2007 press release). On the basis of our interviews, we use 2.9% of *Nokia*'s €467 factory price of N95, which amounts to €13.5. Besides *Nokia*, *Qualcomm* (US), *Motorola* (US), and *Ericsson* (Sweden) are among the major WCDMA IPR holders. Besides the operating system and the telecommunication air interface, *Nokia* paid fees for, *e.g.*, the inclusion of *Adobe Acrobat Reader*, *RealPlayer*, and *Zip Manager*. We estimate that in total they were 0.9% of *Nokia*'s sales price, i.e., €4.2. All-in-all, the total cost of separately licensed intangibles and software was thus €21.

The about €200 in the bill-of-materials is what *Nokia* purchased from upstream vendors as inputs for the final assembly of *N95*. It reflects the total value added of all the first-tier vendors and their suppliers (second- and subsequent-tier vendors). Below we proceed with the analysis of value added by *Nokia* and the distribution channel.

For each company in the supply chain of *N95*, we derive the ratio of value added to net sales or the *value added margin* at the firm level. For the most part, we then equate this with the component-level value added margin.[9]

[9] A company's value added is equal to the sum of its operating profit, depreciation, and labor costs. For the few companies that only confirm to the US GAAP accounting principles, labor costs are unavailable. For these firms we assume the margin to be the same as it is for its nearest competitor(s). Thus, for example in the case of the charger included in the sales package of N95: the factory price of the charger is €1.1 and it is supplied by *Astec* (US), which is a part of the *Emerson Network Power* group using US GAAP. Its direct competitor *Salcomp Oy* (Finland) – globally the leading mobile phones' charger vendor – follows IFRS. In its 2007 financial statement, *Salcomp*'s value added margin was 23.3%. Thus, we estimate *Astec's* value added to be about €0.3. Similarly in the case of *Texas Instruments* (US), we employ the average of the value added margins of three competitors it identified in its 2007 Form 10-K report (pp. 3–4) required by the US Securities and Exchange Commission, *i.e.*, *NXP* (the Netherlands), *Infineon Technologies AG* (Germany) and *STMicroelectronics* (Switzerland).

For the distributors, wholesalers, and retailers, the value added margin and the sales margin are almost identical. Retailers' sales margins on a high-end mobile phone are somewhat lower than generally in electronics, 10–12% of the final sale price, leading to an estimated value added of €60.1 by the retailer. The distributors'/wholesalers' margins are 3.3–4.5% suggesting an estimated value added of €19.1.

Subtracting all downstream costs from the price *Nokia* sells the phone to the distribution channel yields its own value added, which amounts to €269. It is allocated to direct and indirect in-house labor costs – e.g., in its manufacturing/assembly, innovation, advertising, design, marketing, financial, legal, and management functions –, depreciation of tangible and intangible assets, investments, and operating profit. It also includes some aspects of outsourcing, which we are unable to separate from Nokia's internal functions: purchases of "billable hours", some R&D and software sub-contracting, outbound logistics, and certain externally provided warranty and other services.

Careful studies of industry sources as well as our interviews suggest that the final assembly/manufacturing cost of *N95* is €11.5, i.e., 2% of the pre-tax final sales price.[10] Thus, even if the final assembly is the essential part of the supply chain and it is what meets the eyes of laymen (not least because of the *"Made in …"* labeling found in manufactured goods), the value added it commands is quite low.

Table 2 shows a value-added breakdown of *N95*'s pre-tax retail price of €546: *Nokia* captures 50% of the value, first-tier hardware vendors 11%, first-tier (external, non-cross-licensed) software/intangible vendors 3%, second- and higher-tier vendors (vendors-of-vendors) in both categories 19%, distribution/wholesale 3.5%, and retail 11%.

Table 2 The value added breakdown of *Nokia N95* by supply chain participant, %

Suppliers of material inputs	11 %
Software and other companies selling licenses	3 %
Nokia	50 %
Distributor	3 %
Retailer	11 %
Unaccountable inputs	3 %
Vendors of vendors	19 %

Source: ETLA.

6 Value added by location

Table 2 gives a global breakdown of value added by actors' major categories. Since the gross domestic product can be measured as the sum of the values added by all activities in a given country, national interest is on where the value capturing takes place. Determining this is somewhat difficult, as companies are reluctant to reveal the geography of their operations even at the firm level (let alone at the level of a specific commercial offering). With some de

[10] As compared to some other studies, the final assembly cost may seem high. Besides direct labor costs, our estimate includes factory management and other indirect labor as well as capital costs. Furthermore, from an assembly standpoint, the good in question is rather complicated and thus costly to assemble.

tective work we can nevertheless make estimates that are fairly accurate at least as far as broader geographical regions are concerned.

The value capture of in-house indirect inputs, such as the role of general management and corporate brand/image, as well as re-usable tangible and intangible assets, such as design/technical aspects copied from previous and/or contributing to future models, are particularly tricky to allocate in general and particularly across geographies. Furthermore, we do not observe all aspects/actors involved. Thus, In Table 3 we consider five alternatives in making the geographical breakdown:

- Our baseline method in Column A allocates the value added to the headquarter location of each participant in the supply chain. This tends to over-estimate the role of the developed countries and regions.

- Our second method in Column B (see Equation 4 in Appendix 1) assigns the value capture just on the basis of the locations of production factors (physical capital, labor, and knowledge capital or R&D). This does, for instance, implicitly assume that the general management or corporate brand has no specific role in the value capture, which tends to under-estimate the role of the developed countries and regions.

- The third alternative in Column C is an intermediate case between A and B: it is assumed that, in the case of each participant, 10% of the value capture takes place at the headquarter location and 90% is attributed according to the actual location(s) of participant's production factors.

- Individuals and organizations in various locations have different productivities. Thus, their ability to capture value may vary. Column D is a replication of B but with an attempt to correct for this fact using multifactor productivity differences between regions (see Equation 6 in Appendix 1).

- Our preferred estimation method in Column E combines C and D. Thus, in the case of each participant, 10% of the productivity-adjusted value capture takes place at the headquarter location and 90% in the actual location of the production factors.

In a sense A and B constitute the lower and upper bounds for Europe; C and D refine certain aspects; E provides our preferred estimate of the geography of the value capture.

It should be noted that the first five rows in Table 3 (*Finland …Other countries*) do *not* fully reflect the value captured by each location, simply because the next four rows (*Other countries … The country of final assembly*) have not been allocated accordingly. While we have a sense of the geography of vendors-of-vendors and we can make educated guesses on the small amount of inputs we cannot allocate to specific vendors (*Unaccounted inputs*), the level of detail in our data is not comparable to what we know of Nokia and its first-tier suppliers. With these caveats, we take our "rock-bottom" estimate E from Table 3 and split the value added of unaccounted inputs and vendors-of-vendors to geographies with the assumptions discussed below (see also the notes of Table 3).

The geographical allocations of the country of final sales and final assembly depend on the specific case. For instance in the case of a *N95* assembled in Finland (Salo) for the German

Table 3 The value added breakdown of *Nokia N95* by major region

	(a) Based on headquarters	*(b) Based on locations of production factors*	*(c) 10% to head-quarters coun-try and 90 % based on locations of production factors*	*(d) Based on locations of production factors, productivity corrected*	*(e) 10% to head-quarters coun-try and 90 % based on locations of production factors, productivity corrected*
Finland	47.2 %	34.0 %	35.3 %	37.9 %	38.8 %
Other EU-27	1.9 %	9.3 %	8.6 %	7.7 %	7.1 %
North America	6.6 %	9.1 %	8.9 %	9.1 %	8.9 %
Asia	4.7 %	8.3 %	8.0 %	6.6 %	6.4 %
Other countries	1.3 %	0.8 %	0.9 %	0.3 %	0.4 %
Unaccounted inputs	3.1 %	3.1 %	3.1 %	3.1 %	3.1 %
Vendors of vendors	18.7 %	18.7 %	18.7 %	18.7 %	18.7 %
The country of final sales	14.5 %	14.5 %	14.5 %	14.5 %	14.5 %
The country of final assembly (Finland or China)*	2.1 %	2.1 %	2.1 %	2.1 %	2.1 %
	100 %	100 %	100 %	100 %	100 %

Source: ETLA.

Note: * *N95* was only assembled in Finland (Salo) and China (Beijing). Notes: The majority of *unaccounted inputs* are low cost inputs such as resistors, capacitors and screws mostly manufactured and designed in Asia; in the geographical breakdown we assume that 80% of the total value added of these inputs is created in Asia, 10% in EU-27 and 10% in the United States. *Other countries*: Based on our firm-level data, roughly 1/3 of this value is created in the new member states of EU. Thus, we attribute this amount to EU-27 and leave the rest 2/3 to other countries (*i.e.*, countries outside EU-27, Asia and North-America. *Vendors of vendors*: We consider separately the vendors of material suppliers and immaterial suppliers. Dividing value added created by material suppliers' vendors to different regions is a difficult task as the following examples show. On the one hand, the majority of components that, for instance, charger includes are designed and manufactured in Asia. On the other hand, for instance, semiconductors include silicon wafers, lead frames, mold compounds, ceramic packages and chemicals that can be purchased from all continents. Due to this complexity, we divide the value added created by vendors of material suppliers equally to all regions (EU-27, North America, Asia and other countries). In terms of value added created by immaterial suppliers' vendors, we proceed as follows. First, we know that the great majority of first tier immaterial suppliers are mainly the US, European, or Japanese companies and we assume that also their vendors operate in these areas. Hence, we assume that 90% of value added created by vendors of immaterial suppliers has been created in these three regions and we divide this 90% equally to EU-27, North America and Asia. The rest 10% is attributed to other countries.

market, an extra 2.1% would go to Finland and an extra 14.5% to Germany (Other EU-27); in the case of an assembly in China (Beijing) for final sale in the United States, the outcome would be different. We considered how the two cases (from Finland to Germany and from China to the United States) are recorded in international goods trade statistics on the basis of gross value, as well as how the geography on value added basis differs from that (Table 4a and 4b).[11]

[11] In 2007, the basic principle of Nokia was that smartphones for the European market were assembled in Europe and the ones for the Asian market were assembled in Asia. To our knowledge smartphones for the US market were mainly assembled in Asia. Thus, using these three principles as our guidelines, potential combinations are: (assembled in EU and sold in EU; assembled in EU and sold in other countries; assembled in Asia and sold in Asia; assembled in Asia and sold in North America; assembled in Asia and sold in other countries). As a robustness check (Appendix 2), we changed the assumptions and re-calculated the geographical allocations.

Table 4a N95's geography of gross value in two cases as recorded in international goods trade statistics

	Exports from Finland to Germany	*Exports from China to the US*
Assembly in Finland, final sale in Germany	EUR 467	
Assembly in China, final sale in the US		EUR 467

Table 4b In two cases as recorded in international goods trade statistics (top), as well as the actual N95's geography of of value added in the two cases and across the product's life cycle (accounting for both assembly locations and all final sales markets)

	Finland	*Other EU-27*	*Asia*	*North-America*	*Rest of world*
Assembly in Finland, final sale in Germany	41 %	27 %	13 %	14 %	5 %
Assembly in China, final sale in the US	39 %	12 %	16 %	28 %	5 %
The average of all potential combinations*	38 %	16 %	18 %	17 %	11 %

Source: ETLA.

Note: * In 2007, the basic principle of Nokia was that smartphones for the European market were manufactured in Europe and correspondingly smartphones for the Asian market were manufactured in Asia. And to our knowledge, smartphones for the U.S market are mainly manufactured in Asia. Thus using these three as our guidelines, potential combinations are: (assembled in EU and sold in EU; assembled in EU and sold in other countries; assembled in Asia and sold in Asia; assembled in Asia and sold in North America; assembled in Asia and sold in other countries).

7 Discussion

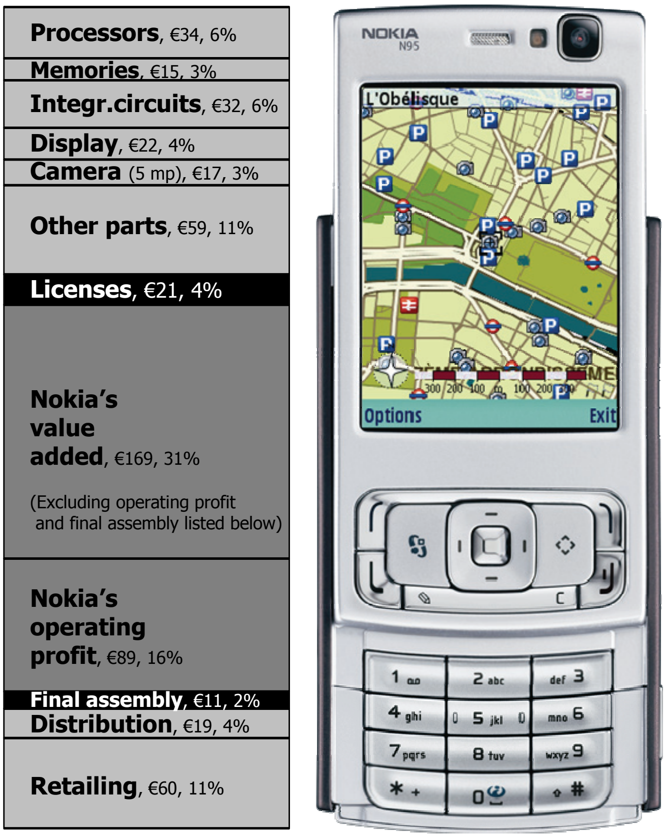
Our best estimate is that, taking into account both assembly locations and all countries of final sale, over *N95*'s life cycle 54% of the value added was captured by EU-27. Even in the case of the final assembly in China and final sales in the United States, EU-27 captured 51% of the value added – despite of the fact that the phone was *Made in China*.

How is it possible that EU-27 captures so much of the value from a seemingly minor role? Simply because Finland and other EU countries were dominant in the branding, development, design, and management.

Figure 2 summarizes some of the above findings. While the final assembly is the main step in the physical incarnation of the product, this stage only commands 2% of the overall value added. On the other hand, the distribution channel, and particularly its very final retail loop, captures a large share of the value added – many times more than the final assembly.

Above we have referred to international goods trade statistics and ignored available service trade statistics. On the basis of N95's supply chain's geography and the assembly volume in

Figure 2 Breakdown of the phone's €546 (+tax) retail price circa 2007



Source: ETLA.

Note: Refers to unbundled and unsubsidized official retail price without any applicable taxes; excludes other possibly purchased products and services at the time of initial sale or afterwards. Licenses include protocols, the operating system, pre-installed software *etc*. *Nokia* is a major intellectual property (IP) holder in this domain and it does not pay fees to itself; thus value of its own IP is not included here. Furthermore, non-monetary payments (e.g., cross-licensing) are not included here. For a firm without own its IP, licensing fees could have be manifold; see text for discussion. Besides operating profit and the final assembly, *Nokia*'s value added covers its innovation, advertising, design, marketing, legal, and management costs as well as depreciation and investments. It also includes some aspects of outsourcing we are unable to separate from *Nokia*'s internal functions: purchases of "billable hours", some R&D and software sub-contracting, outbound logistics, and certain external warranty & other services. In Figure 5 *Nokia*'s operating profit has been estimated on the basis of overall operating profits of *Nokia Multimedia* in 2006 and 2007 by assuming that *N95* was as profitable as a typical phone.

Nokia's Beijing plant, we estimate that there should have been roughly €0.8 billion of service exports from Finland to China in 2007. As recorded by Statistics Finland, however, the total services across all industries from Finland to China were €0.6 billion in 2007. Thus, the recorded figure does not even account for one phone model, which in 2007 accounted for less than 1.5% of all sold *Nokia* phones and less than 7.5% of all *Nokia* phone sales (not to mention service exports of all other actors and industries).

In the above calculations we have assigned *Nokia*'s operating profits to the headquarter location, which is consistent with the prevailing national accounts practices. It does not suggest that Finns would own the value added beyond their ownership of the company. Indeed, over 90% of *Nokia*'s stock is held abroad and ultimately profits earned belong to the shareholders, in this case primarily to US-based institutions. Any dividends paid to foreigners are appropriately recorded in cross-border financial flows. It turns out, however, that purchases of own shares are not, which in the case of Finland inflates its current account surplus. Savolainen and Forsman (2010) note that in 2003–2008 Nokia's purchases of its own shares were €18.6 billion. In 2005 they amounted to 2.3% of the Finnish GDP. If included in the gross national income (GNI) – as was the case – it correspondingly inflated domestic economic growth (Maliranta et al., 2011).

While our N95 analysis is a single case study, in our understanding it is quite a typical one in electronics. Furthermore, automobiles, textiles, and some other traditional industries do not seem too different at the surface. Even in industries that feature less geographical dispersion, it is nevertheless on the raise. Thus, in our opinion it is not unfounded to draw broader conclusions from our analysis.

8 Conclusions

Even if the location of the final assembly earns the "made in …" label and for laymen is synonymous to production, it commands only a few per cent of the supply chain's overall value added in the case of an advanced industrial good. Unlike the cross-border flows of the related physical components and goods would seem to suggest, the developed countries continue to capture the lion's share of value added generated globally. Even in the case of manufactured goods, it is services (both the ones provided in-house as well as those purchased from outside vendors) and various forms of intangibles (including returns earned on various forms of intellectual property) that capture most of the value added.

Our analysis has several broader implications. *First*, it highlights the silliness of the still lingering manufacturing vs. services discussion. The recorded manufacturing value added has a significant service component; most services need supporting physical infrastructure and complementing goods. The distinction between the two is a line drawn in water and should perhaps be laid to rest completely. *Second*, international commodity trade statistics that continue to record the gross values of cross-border goods flows can be highly misleading in economic analysis.[12] Indeed, internationally concerted efforts should be taken to develop value-added based trade statistics. While complementing the goods with service trade statistics and the balance of payments information should in principle help, it practice this does not currently seem to be the case. *Third*, in many countries national policy makers seem to have an obsession towards having certain national capacity of final assembly, which can hardly be justi-

[12] Global flows are often quite complex raising some concerns how well gross-value based trade statistics reflect underlying economic activity – for example: "National Semiconductor manufactures wafers at three fabrication plants, or "fabs": South Portland (Maine), Arlington (Texas), and Greenock (Scotland). Wafers are then shipped to the company's assembly and packaging houses at Melaka (Malaysia) and Suzhou (China) where they are subjected to final testing and from where they are shipped directly to the production lines of customers worldwide. … For a particular project we could have a marketing engineer in Germany and design engineer in Korea, a layout engineer from Santa Clara, a production engineer based in Longmont (Colorado), and test engineers in Melaka and Santa Clara." (Invest Korea, 2010), http://ikjournal.com/InvestKoreaWar/work/ik/eng/bo/bo_01.jsp?no=610230001&bno=707130011&sort_num=18&code=1020105&mode=bbs&url_info=./bbs_read.jsp&l_unit=90202&m_unit=&s_unit=&page=3&sel=title&val=

fied with its role in national employment or value added. This is *not* to say that final assembly would not matter, just that its national importance may relate more to its links to other functions in the supply chain.

Ultimately nations compete for their citizens' high value-adding roles in globally dispersed supply chains; for a given level of effort, the national objective is then to capture as much value and generate as much national wealth as possible. While China is determined *not* to remain a "2%" assembly location and it is rapidly entering higher-value adding functions, Europe and the United States still have many advantages in providing globally differentiating inputs.

References

Ali-Yrkkö, J. (2001). *Nokia's Network – Gaining Competitiveness from Co-Operation*. Helsinki: Taloustieto (ETLA B 174).

Ali-Yrkkö, J. (2010). The Value Creation of Mobile Phones – The Case of Nokia N95. In Ali-Yrkkö (Ed.): *Nokia and Finland in a Sea of Change*. Taloustieto Oy, Helsinki.

Baldwin, R. (2006). *Globalisation: The Great Unbundling(s)*. Helsinki: The Economic Council of Finland, Prime Minister's Office (http://www.vnk.fi/hankkeet/talousneuvosto/tyo-kokoukset/globalisaatioselvitys-9-2006/artikkelit/Baldwin_06-09-20.pdf).

Capron, H., & Cincera, M. (1998). Exploring the Spillover Impact on Productivity of World-Wide Manufacturing Firms. *Annales d'Economie et de Statistique, January-June*(49-50), 565-587.

Economist. (28 Apr. 2007). A World of Connections. *The Economist (cover story), 383*, 3-16 (a special report on telecoms).

Gereffi, G., Humphrey, J. & Sturgeon, T. (2005), The governance of global value chains. *Review of International Political Economy* 12:1 February 2005:78-104.

Grossman, G. M., & Rossi-Hansberg, E. (2008). Trading Tasks: A Simple Theory of Offshoring. *American Economic Review, 98*(5), 1978-1997.

Hall, B. H. (1993). Industrial Research during the 1980s: Did the Rate of Return Fall? *Brookings Papers on Economic Activity, Microeconomics 2*.

Harhoff, D. (1998). R&D and Productivity in German Manufacturing Firms. *Economics of Innovation & New Technology, 6*(1), 29-49.

Inklaar, R., & Timmer, M. (2008). GGDC Productivity Level Database: International Comparison of Output, Inputs and Productivity at the Industry Level. *EU KLEMS Working Papers, 40*.

Invest Korea. (2010). The National Semiconductor Korea R&D Center. *Invest Korea Journal, 44*(1).

Linden, G., Kraemer, K. L., & Dedrick, J. (2009). Who Captures Value in a Global Innovation Network? The Case of Apple's iPod. *Communications of the ACM, 52*(3), 140-144.

Mairesse, J., & Hall, B. H. (1994). Estimating the Productivity of R&D in French and U.S. Manufacturing Firms: An Exploration of Simultaneity Issues with GMM. In K. Wagner & B. van Ark (Eds.), *International Productivity Comparisons* (pp. 285-315). Amsterdam: North-Holland.

Maliranta, M., Mankinen, R., Suni, P. & Ylä-Anttila, P. (2011). Suhdanne- ja rakennekriisi yhtä aikaa? Toimiala- ja yritysrakenteen muutokset taantumassa. *ETLA Discussion Papers No. 1239*. 17.2.2011

Maurer, A. & Degain, C. (2010), Globalization and trade flows: what you see is not what you get! WTO World Trade Organization Staff Working Paper ERSD-2010-12. June 2010. http://www.wto.org/english/res_e/reser_e/wpaps_e.htm

Motohashi, K. (2007). Assessing Japan's Industrial Competitiveness by International Productivity Level: Comparison with China, Korea, Taiwan and the United States. In D. W. Jorgenson, M. Kuroda & K. Motohashi (Eds.), *Productivity in Asia: Economic Growth and Competitiveness* (pp. 215-238). Cheltenham, UK: Edward Elgar.

Nokia. (2009). Supply chain. from http://www.nokia.com/corporate-responsibility/supply-chain/overview

Portelligent. (2007). *Nokia N95: GSM/EDGE 850/900/1800/1900MHz + WCDMA/HSDPA 2100MHz UMTS Cellular Phone* (No. #11807-070416-TMf).

Roper, S., Du, J. & Love, J. (2008), Modelling the innovation value chain. *Research Policy 37* (2008), 961-977.

Savolainen, E. & Forsman, P. (2010). Osakkeiden takaisinostot kaunistelevat vaihtotasetta. *Tieto & Trendit* 7/2010

Schankerman, M. (1981). The Effects of Double-Counting And Expensing on the Measured Returns to R&D. *Review of Economics & Statistics, 63*(3), 454.

SEC. (2007). *FORM 20-F REPORT – Nokia Corporation*. Washington D.C.: Securities and Exchange Commission.

Seppälä, T. (2010). Transformations of Nokia's Finnish Supplier Network from 2000 to 2008. In J. Ali-Yrkkö (Ed.), *Nokia and Finland in a Sea of Change* (pp. 37–68). Helsinki: Taloustieto (ETLA B 244).

Appendix 1

To estimate the geographical breakdown of the N95's value, we proceed as follows. The total value of the product Y is composed of the value added of all parts of the N95's value chain or

$$Y = \sum_{c=1}^{N} Y_c , \tag{1}$$

where

Y = The total value of the N95

Y_c = The value added of value chain's part c.

The value added of each part (Y_c) can be created globally. We assume that this total value added of each part is created in an area covering home country (Finland), other Europe, North-America and Asia, thus

$$Y_c = Y_{c,D} + Y_{c,E} + Y_{c,N} + Y_{c,A} + Y_{c,O} , \tag{2}$$

where

D = Domestic (Finland)

E = Europe (Other EU-27)

N = North-America

A = Asia

O = Others

Our data includes the value add of each part (Y_c) but we do not have information how this value added is created in different areas. To estimate the value added of part c created in each region ($Y_{c,D}$, $Y_{c,E}$, $Y_{c,N}$, $Y_{c,A}$, $Y_{c,O}$), we have proceed as follows.

We assume that the value added of part c captured in each region is created through factors of production. As usually in the economic literature, we consider three factors of production: physical capital stock (C), the size of labor force (L) and knowledge capital stock (K). We assume the impact of each production factor is the same as their elasticities of output. The previous empirical literature including a number of studies has estimated a Cobb-Douglas style of production function:

$$Q = AC^{\alpha} L^{\beta} K^{\gamma} , \tag{3}$$

where A = multiplicative technology parameter

The equation (3) is typically estimated in logarithm form thus the parameters α, β, and γ are the elasticities of output (Q) with respect to physical capital stock, labor and knowledge, respectively. In the majority of empirical studies, the estimated production function has included only two factors of production: physical capital and labor. Usually, the results of empirical studies show that the physical capital elasticity is about 0.4 and labor elasticity about 0.6.

In studies, where knowledge capital is approximated by using R&D stock, the estimated knowledge capital elasticity varies typically between 0.05–0.25 (Capron & Cincera, 1998; Hall, 1993; Harhoff, 1998; Mairesse & Hall, 1994). Based on these studies, in our calculations we assume that this elasticity is 0.15. However, most of studies have not taken into account the double counting related to R&D. R&D investment also consists of investment in physical capital and labor and these components are included in the regular production factors (Schankerman, 1981) (Hall & Mairesse 1996). Based on earlier literature, we know that roughly 50 percent of R&D expenditure are labor costs (Hall 2009, NSF 1995). By taking this fact into account, we modify the capital elasticity (0.6) and labor elasticity (0.4) as follows:

$$\hat{\alpha} = \alpha - 0.5\gamma$$

$$\hat{\beta} = \beta - 0.5\gamma$$

Thus, our double counting corrected elasticities for capital, labor and R&D are 0.325, 0.525 and 0.15, respectively. We use these elasticities as the multipliers of production factors.

We continue by calculating what share of each production factor is located in each region R and then multiply each share by the elasticity of output. Then we sum these values by region and obtain each region's share of value added (related to part *c*). Finally, we multiply this share by the value added of part *c* (Y_c). The value added of part c created in region *R*, is calculated as follows

$$Y_{c,R} = \left(\frac{C_R}{C}\hat{\alpha} + \frac{L_R}{L}\hat{\beta} + \frac{K_R}{K}\gamma \right) Y_c \,, \tag{4}$$

where

C_R is firm's physical capital stock in region *R*,

C is the sum of firm's physical capital in all regions,

L_R is firm's employment in region *R*,

L is the sum of firm's employment in all regions,

K_R is firm's knowledge capital in region *R*,

Y_c is the sum of firm's knowledge capital in all regions,

Thus, for instance the domestically created value added is calculated as follows:

$$Y_{c,D} = \left(\frac{C_D}{C}\hat{\alpha} + \frac{L_D}{L}\hat{\beta} + \frac{K_D}{K}\gamma \right) Y_c \,. \tag{5}$$

Equations (4) and (5) implicitly assume that the total productivity is equal in each region. To take into account the regional productivity differences, we calculate the productivity corrected value added of part c created in region *R* as follows:

$$\hat{Y}_{c,R} = \frac{MFP_R\left(\frac{C_R}{C}\hat{\alpha}+\frac{L_R}{L}\hat{\beta}+\frac{K_R}{K}\gamma\right)}{\sum MFP_R\left(\frac{C_R}{C}\hat{\alpha}+\frac{L_R}{L}\hat{\beta}+\frac{K_R}{K}\gamma\right)}Y_c\,, \qquad R\in(D,E,N,A,O) \tag{6}$$

where MFP_R is multi-factor productivity in region *R*.

Thus, for instance the domestically created value added is calculated as follows:

$$\hat{Y}_{c,D} = \frac{MFP_D\left(\frac{C_D}{C}\hat{\alpha}+\frac{L_D}{L}\hat{\beta}+\frac{K_D}{K}\gamma\right)}{\sum MFP_R\left(\frac{C_R}{C}\hat{\alpha}+\frac{L_R}{L}\hat{\beta}+\frac{K_R}{K}\gamma\right)}Y_c \qquad R\in(D,E,N,A,O) \tag{7}$$

Operationalization of production factors

If component-level factors and factor shares are unavailable, we use firm-level information on the location of different factors. Firm-level data is based on the annual reports and web-sites of each vendor. We have operationalized variables as follows:

C = Non-current assets or long-lived assets depending on which one has been reported in 2007.

L = Number of employees (in 2007).

K = R&D expenditure. We are unable to calculate R&D-stock for each region thus we have used R&D expenditure in 2007.

In some cases, the reported regional breakdown of some factor is imperfect. In those cases, we have read carefully the entire annual report and also searched necessary information from the Internet in order to approximate roughly the regional breakdown. For instance, *National Semiconductor* (US) reports the regional breakdown of long-lived assets (Annual Report, p. 104) and employees (Annual Report, p. 12), but do not report exact geographical breakdown of their R&D expenditure. However, on page 21 the company reports that their principal research facilities are located in Santa Clara (US), and that they also operate small design facilities in 13 different locations in the United States and 11 different locations outside the US. Out of those 11 overseas R&D units, roughly half are located in Asia and half in EU-15 area. Based on these facts, we estimate that roughly 70% of R&D is done in the U.S. and we divide the rest of 30% fifty-fifty for Europe (15%) and Asia (15%).

Operationalization of multi-factor productivity (MFP):

We have used value added based *MFP* figures of the Electrical and optical equipment and Post and Telecommunicationss industries reported by Inklaar and Timmer (2008).[13] Based on this database, the regional *MFP*'s used in our estimations are as follows:

MFP_D = 1.24 (Finland)

MFP_E = 0.81 (the average of EU-15 countries excluding Finland)

MFP_N = 1 (United States)

MFP_A = 0.52 (the average of Japan, China, South-Korea and Taiwan). The *MFP*s of China, South-Korea and Taiwan are based on Motohashi (2007) using Japan as a reference country (Japan=1.00).

MFP_O = 0.37 (the average of Australia, Czech Republic, Hungary, Slovenia).

[13] This data is downloadable at www.ggdc.net/databases/levels.htm.

Appendix 2

Robustness test 1:

To test to what extent our results depend on our assumptions related to the value added created by material suppliers' vendors, we recalculate the geo-graphical breakdown of value added by changing these assumptions. One could argue that Asia's role in these upstream activities is bigger than we assumed in our basic calculations. Moreover, Australia, Russia and Africa are important raw material providers, and in this sense our basic assumptions potentially under-estimate the role of these regions. Due to these two reasons, we raise the share of Asia to 50% and Other countries (including, e.g., Australia, Russia and Africa) to 30% of the value added created by vendors of vendors, and respectively lower the share of EU-27 to 10% and the North-America to 10%. Then we re-calculate all potential combinations related to the final assembly location and the country of final sales. The results of this re-calculation show that our basic results hold. On average, overall 52% of the total value added is captured in EU-27, 14% in North America, 22% in Asia and 12% in the rest of the world.

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