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Abstract

The supply chains of the mobile phone industry span national and firm boundaries. To analyze how value is distributed among the participants, we apply a novel framework for analysis based on financial measures of value capture to three phone models introduced from 2004 to 2008. We find that carriers capture the greatest value (in terms of gross profit) from each handset, followed closely by handset makers, with suppliers a distant third. However, the situation is reversed in terms of operating profit. Carriers shoulder the burden of network installation, maintenance, and upgrading, which absorbs much of the value from their subscription fees. Handset maker nationality, which may also influence supplier choice, is a key determinant of the geographic distribution of value capture. We also use our results to estimate the relationship of handset subsidies to carrier profits, which has received attention from antitrust authorities in several countries. We show how our framework can be used to calculate how much service charges might be inflated to cover the subsidies.

Key words: mobile phone industry; supply chain; financial value capture; phone subsidies; balance of power; value of innovation.

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1. Introduction

Over the past decade, the firms working around the world on the convergence of computing, communications and consumer electronics have gradually achieved a combination of modest price and high capability that enabled mass uptake, particularly in the developed economies. One of the most visible manifestations is the multi-function “smartphone”, a mobile phone that can perform computing functions such as accessing the Internet and storing data as well as consumer applications such as playing music and video. Nokia’s N Series, Research in Motion’s (RIM) BlackBerry product line, and Apple’s iPhone are the top-selling smartphones worldwide as of early 2010.

Smartphone makers have created tremendous value, as have the innovative components on which they rely. Value also comes from the sophisticated telecommunications systems via which they communicate and from a distributed global network of software and service providers that may include dozens of countries and hundreds of firms (Li & Whalley, 2002).

In order for a good or service to benefit a particular nation or firm, value must not only be created but also captured. Because of the strong complementarities among many of the innovations in the mobile telephony supply chain, the capture of value is a function of firm strategies (Teece, 1986).

It is an empirical question who profits most when innovation, production, and distribution activities that span national and firm boundaries. The answer is especially difficult to observe when prices are obscured by various subsidies or by bundling of products and services by mobile carriers, as is often the case in the U.S. market.

From a public policy perspective, the embeddedness of the smartphone in a global value network raises the question of how countries can capture the greatest social benefit from innovation. Would policies to support domestic handset producers create benefits that end up mostly overseas if those producers rely on foreign suppliers of components and manufacturing services?

Another important public policy issue concerns the competitive rules for carriers. How do these affect carrier profits, subscriber fees, and the rate of technology uptake by consumers? The relatively slow adoption of mobile communication technologies in the U.S. compared to European and Asian economies has been noted frequently and is sometimes blamed on the institutional structure of the U.S. mobile sector, with strong carriers effectively limiting the innovation of manufacturers (Funk, 2006; Wu, 2007). However, later adoption can bring advantages (such as a lower equipment cost and learning from the experiences of other countries) that may exceed the potential competitive benefits of early adoption.

The aspect of carrier competition that concerns us here is the use of carrier subsidies for phones in exchange for fixed-term contracts with subscribers. The costs and benefits of these subsidies have been debated in the academic literature, and. they have been the object of bans in various countries, including South Korea and Finland (Albon & York, 2008; Tallberg et al., 2007; Kim et al., 2004). United States policymakers have also taken an interest. Congress and the Federal Communications Commission are reportedly investigating exclusive deals made between wireless carriers and handset makers as possibly stifling consumer choice and raising prices (Reardon, 2009; Puzzanghera, 2009). There have also been reports that the Justice Department is looking at possible anti-trust issues in the telecommunications sector, including whether mobile carriers are abusing their market power (Sharma, 2009). At the same time, the success of the iPhone and its associated applications store suggest that the balance of power might shift towards equipment suppliers such as Apple and RIM as consumer loyalty is attached to a particular product platform rather than to a carrier.

One thing lacking in most discussions about these issues is solid data on who is capturing value in the current industry structure. Such data is needed to undertake an informed analysis of firms' incentives to innovate, the market power of different firms in the supply chain, and the distribution of value among the nations involved.

In this article, we analyze the supply chains of three high-end mobile phone models, including two smartphones, that each benefitted from carrier subsidies. These phones are representative of the high-end phones that are offered by carriers in exclusive, heavily-subsidized arrangements with handset makers.

We apply a framework for analysis based on financial measures of value capture, including various measures of profitability.[1] This analysis answers the following questions: (1) How are the financial benefits of innovation distributed among firms in a global value chain for advanced mobile technologies? (2) How much value is created and captured in the home countries of innovative firms, versus countries where the products are manufactured, or where they are distributed and used? (3) How do handset subsidies affect the profitability of carriers and handset makers, and the consumer cost of services?

Looking at individual handset models, we find that the carriers capture the greatest share of value from each phone, followed closely by the handset makers who in turn capture far greater value than any of their component suppliers. Considering the companies more holistically, the handset makers are able to retain more of that profit than the carriers, who must maintain their

[1] The concept of "value" could be defined in various ways, including the number of jobs or the wages generated by an activity as well as the financial measures (gross profit, value capture) that we use here.

costly infrastructure. In terms of national outcomes, we find that handset maker nationality matters most because these firms still retain a significant share of the profits from each unit sold. High-value jobs such as R&D, market analysis, and product management also tend to cluster near the headquarters of companies, underscoring the importance of competitive firms for national economies.

We begin with brief description of supply chains in the mobile phone industry, followed by an introduction to our analytical approach. We then provide a functional analysis of the components within the phones in our sample and a detailed estimate of the profits accruing to firms along their respective supply chains. We expand on these results to analyze the relation of handset subsidies to service charges and to consider a wider selection of profit measures for selected firms in the supply chain. Finally, we discuss the results and consider their policy implications.

2. The mobile phone industry and its supply chain

Mobile telephony technology has shifted through recent decades from a plethora of nation-based technologies commercialized by vertically integrated firms to a few global standards supported by globe-spanning supply chains. Beginning in the 1950s, bulky portable phones with limited capabilities became available for a select user base. These have given way to slim handsets at prices that have spurred mass acceptance. In 2010, telecom equipment maker Ericsson estimated that over five billion mobile phones were in use, up from just 720 million a decade before (Ericsson, 2010).

While handset hardware has been integrating more functions over the past twenty years, industry supply chains in telecommunications, as in the broader electronics industry, have been steadily disintegrating/disaggregating across corporate and national boundaries (Sturgeon, 2002; Dedrick & Kraemer, 1998). Where once large integrated companies such as AT&T built their own infrastructure, made the key components, and designed, manufactured and distributed their own products, today these activities are more often carried out by independent companies in a vast global network spanning the semiconductor, computer, communications and consumer electronics markets.

The deconstruction of the telecommunications industry and its increasing recombination with related sectors is described by Li and Whalley (2002:451) as a radical transformation where "value chains are rapidly evolving into value networks, with multiple entry and exit points, creating enormous complexity for all the players involved." They identify the distribution of value capture among the various parties that contribute to a product or service as an important issue for determining the viability and success of new enterprises, and they call for empirical research and new tools for understanding this question.

As a first step toward understanding the distribution of value in these complex networks, we use the supply chain, the series of organizations and processes through which a product passes from raw materials to the consumer's hands, as the unit of analysis. A cell phone, despite its small size, contains hundreds of parts. Most are low-value parts that account for a small share of the value. A few high-value components, such as the display and the main microchips, account for most of the cost. A brand name ("lead") handset maker, who may not even assemble the product in-house, contributes its market knowledge, intellectual property, product design, system integration and cost management skills, and a brand whose value reflects its reputation for quality, innovation, and customer service.

Mobile operators are the final links in the chain to the consumer, and their role is key because they control the customer relationship. In the U.S. and many other countries, carriers subsidize the cost of high-end handsets in exchange for a period of exclusivity from the manufacturer. They make up this cost by requiring customers to commit to lengthy service contracts (usually two years). While there are a variety of wholesale and retail channels in the mobile phone market, particularly in Europe and Asia where "unlocked" phones are often sold by retailers without service contracts, for the purposes of this study of high-end phones, we focus primarily on the U.S. case.

3. Data sources and analytical approach

The supply chain analysis method used in this paper has previously been applied in studies of notebook computers and the iPod (Linden et al., 2008; Dedrick et al., 2009) where it is explained in detail. Its application here to high-end cellular handsets is important for what it reveals about the relation between phone makers and carriers, who play a more active role in sales and in the creation of a customer experience than do the retailers in the PC and iPod supply chains. We therefore analyze the value captured by carriers as well handset firms; however, we only analyze the supply chain for the phones and not for the carrier networks.

The analysis here is based on product-level data, which are extremely hard to obtain directly from electronics industry firms, who jealously guard information about the pricing deals they have negotiated and often compel the silence of their suppliers and contractors through non-disclosure agreements. However, for some electronic products, lists of components and their estimated factory prices are available from industry analysts. These “teardown” reports are often cited in the press, but the retail price of the product is used as a baseline instead of the wholesale price we estimate here. Our analysis leads to an estimate of the handset maker's product-level gross profit, or, when expressed in percentage terms, gross margin.

Gross profit is just one measure of financial value captured by a firm. It is related to the more-familiar concept of net profit as follows:

Wholesale price

- Cost of Goods Sold (purchased inputs and direct labor)

= Gross profit

- Overhead costs (R&D, depreciation, marketing, and administrative expenses)

= Operating profit

- Interest expenses, taxes, and one-time adjustments

= Net profit

Gross profit shows what share of a firm's sales price is retained after the direct costs of producing a product are deducted. Those funds can then be used to invest in future growth (R&D), cover the cost of capital depreciation, pay overhead expenses (marketing and administration), and reward shareholders (dividends). It is an appropriate concept for the product-specific level of analysis that we use in most of this paper because it abstracts from the company's administrative efficiency (reflected in operating profit) and from non-production factors such as the firm's leverage and its investments in other firms (reflected in net profit). Operating profit also reflects R&D, which typically applies to many different product lines in a non-proportional way, and depreciation, which is an accounting number that may have little to do with the actual economic decay of (or flow of services from) plant and equipment.

At the national level of analysis, corporate gross profit comes closest to capturing the national benefit of a firm's headquarters presence because a large share of the expenditure of gross profits on research, marketing, and administration takes place at or near corporate headquarters, as does, in the case of most carriers, infrastructure investment. It is harder to generalize about the locations where operating or net profits are disbursed. We consider operating and net profits at the firm level in Section 6.2.

While we derive the gross profit achieved by the smartphone producers from detailed analysis, it is impractical to do so for each input. As a shortcut, we estimate the gross profit for each component by multiplying company-wide gross margin for the supplier by the reported purchase cost of the component. The gross margin data are readily available from annual reports in the case of public companies. Our results are not sensitive to inaccuracies in our supplier gross profit estimates.

Furthermore, our attention is concentrated on suppliers of high-value components. In cases where the supplier is not identified in the teardown report, we conduct additional research to identify possible sources. For many components, handset makers use multiple sources, and a teardown report will identify only one of these. With the exception of memory chips, this is less likely to affect high-value components, which are often specifically engineered for a particular phone manufacturer. Since the prices of components change over time, our goal is to derive an estimate that reflects values within a few months of the phone's introduction.

As the breakdown of the profit hierarchy, from gross to net, shows, our analysis requires knowing the wholesale price of handsets (what the carrier pays to the handset maker), but this is not generally published. We estimate this value by looking at various sources, such as the prices charged to cellular subscribers, estimates of phone subsidies from carriers, and statements of average value per phone in company annual reports.

4. Inside phones

Using teardown reports (Portelligent 2004, 2005, and iSuppli 2007), we compared the key parts in three cell phone models that bridge the gap from feature phone to smartphone. All three models were initially offered through exclusive arrangements with a U.S. carrier, representing a shift in the relationship between carriers and handset manufacturers. Motorola's V3 RAZR phone was notable for its slim design which led to it being the most purchased handset model in the U.S. until it was unseated by the "iPhone 3G" in late 2008.[2] The Palm Treo 650 combined features of a PDA and mobile phone with touchscreen and keyboard inputs. Research in Motion's Curve 8300 was part of RIM's effort to expand its reach from business users to the consumer market with a slim product that featured a full keyboard.

Although the original Motorola RAZR was not a smartphone in the sense of offering PC-like functionality, it had a Wireless Access Protocol (WAP) browser for viewing some parts of the internet and also a personal information management software package. More importantly, however, it helped set the trend of signature phones being sold at subsidized prices in exclusive arrangements with one or two carriers.

Table 1 shows how the three systems compare in terms of their key inputs as a percentage of factory cost (the total of the inputs). In the Motorola and Palm phones, the most expensive single input–up to a third of the total–is the display module, which must be compact and high-resolution. Display prices have continued to fall due to both manufacturing advances and increased competition, and the display for the Curve 8300, which dates from a few years later than the others, accounts for just 11% of the total factory cost. Microchips, including processors, wireless transceivers, and memory, are another significant expense area, accounting for about a quarter of the factory cost in all three models. Most of the remaining cost is taken up by the

[2] According to NPD data reported in Reardon (2008).

camera module, the license fee for the phone's cellular protocol, the battery, printed circuit boards, the keypad, the casing (called an enclosure), and the assembly of components into the final product. Each of these accounts for between 2% and 8% of the factory cost, with details shown in Table 1.

The operating systems for the computing functions were managed under different business models. Motorola's RAZR and RIM's Curve used internally-developed software. We do not count this software as a cost since Motorola (or RIM) would just have paid the software fee to itself. Palm's operating system was originally developed internally, but the software business was spun off to shareholders in 2003 and acquired in late 2005 by Access, a Japanese software company that produced the world's first mobile browser.[3] Based on Palm's reported payments to its software spin-off, PalmSource, the licensing fee per unit was about $10.

<Insert Table 1 here.>

A more detailed accounting of the key inputs in each phone is given in Appendix tables A-1 to A-3.

As suggested by the differences between the columns in Table 1, smartphone architectures (e.g. touchscreens versus keyboards) have not yet come together around a dominant design (Abernathy & Utterback, 1978; Anderson & Tushman, 1990). This remains true, with leading models such as the iPhone, Droid phones from HTC and Motorola, and Nokia's N-Series featuring different physical user interfaces, in addition to their different operating systems. Some leading smartphone brands, including RIM and Nokia, offer both touchscreen and keyboard models.

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[3] Pointed out to us by an anonymous reviewer.

One consequence of this lack of uniformity is that competition continues to be based more on feature differences than on price. This explains in part the attractive margins (i.e. ratios of profit to sales) we will see later and marks a key difference between the markets for smartphones and for PCs. In the latter, the scope for lead firms to distinguish their products is extremely limited, which results in more modest margins (Dedrick et al., 2009).

5. Value capture along the supply chain

Next we turn to a consideration of profitability along the supply chain. We start by looking at component suppliers and the handset maker, with the results for suppliers broken down into regions as follows: U.S.-based, Japan, Other Asia, Europe (including, in one case, a chip from Israel), and Location Unidentified. After that, we introduce the value capture of the carriers.

5.1. Supplier value capture

Supplier value capture is estimated by applying each supplier's 2005 gross margin (2007 in the case of the Curve 8300) to the value of the input it supplied to the phone, as detailed in the appendix tables. Where the supplier is unknown, we applied 33%, the average gross margin for 270 of the leading global electronics firms for 2004 as reported in *Electronic Business*' EB 300 listing.[4]

Table 2 shows the results of these calculations, aggregated for suppliers by the location of their headquarters. For the purpose of this section, we have also included the results from a

[4] As calculated from "EB300: The Rankings," Electronic Business, August 2005. Accessed online at http://www.edn.com/article/CA630171.html?partner=eb on February 9, 2009. The results are not sensitive to changes in this industry-average gross margin.

comparable analysis that we performed on a Nokia 7710 (Appendix Table A-4), a touchscreen-based phone that wasn't sold in the United States. Each cell of the table represents our estimate of the gross profits earned by suppliers in a particular region as a share of all supplier profits, not including the gross profit of the handset maker.

More than a quarter of the aggregate supplier profits in each phone could not be tied to a firm or a region, with a high of 36% for the Nokia phone.

Of the suppliers we have identified, U.S.-based suppliers dominate, primarily based on their strength in integrated circuits. Japanese suppliers played a key role, especially in the very-thin RAZR design, but Japanese suppliers of displays and batteries have faced severe competition in recent years from rivals in Korea, Taiwan, and mainland China. For example Japanese suppliers once dominated the market for handset displays, a high-value component. B, but by 2009, Sharp Corp. ranked just third among a top five dominated by Samsung and populated by firms from Taiwan and Hong Kong.[5]

<Insert Table 2 here>

The geographical data in Table 2, although incomplete because of the unidentified components, raise the question of a possible relationship between handset maker nationality and supplier choice. The role of US-based suppliers ranges from 36% to 41% for the handsets from North American firms, but is only 17% in the Nokia phone. Europe-based suppliers are most important (11% and 12% versus 0% and 3%) in the handsets from the European and Canadian companies in the sample.

[5] Data for the fourth quarter of 2009, reported in DisplaySearch (2010).

If there is a causal relationship between the nationalities of the handset maker and its suppliers, the correlation is constrained by the fact that suppliers of each type of input are not distributed evenly among the world's regions. For example, flat panel displays are produced primarily in Japan, Taiwan, and Korea. Chips, however, are important components for which production is dispersed, giving handset makers a meaningful choice so that a preference might be detected. For example, a published teardown of a smartphone from Japan's Sharp Corp. showed that it used a Toshiba application processor when Toshiba was a relatively minor supplier of these parts, suggesting that transaction costs or other hard-to-observe forces may be driving supplier choice.[6]

Such a relationship, if confirmed by further research, might be explainable by any of several processes. These include cultural affinity and a corresponding increase in trust, efficiencies from the regional co-location of the relevant engineering groups, or path dependence based on historical ties. Field work will most likely be needed to differentiate among the various possibilities.

5.2. Handset firm value capture

In previous analyses, we were able to refer to the retail prices of iPods and notebook PCs to drive the analysis of how much value is captured by particular firms and countries. Unfortunately that is far more difficult in the case of high-end mobile phones because their business model is very different. The estimates that follow are rough, but should be of the right orders of magnitude. As such, they are still useful for analyzing value capture along the industry supply chain.

[6] "Tearing Down SoftBank's Handset w/ Touch Sensor," Tech-On, April 22, 2008; application processor market data for 2008 are from Forward Concepts, reported in Clark (2009).

High-end phones such as those analyzed here are generally sold through carriers, who bundle them with service contracts and subsidize the cost of the phone in anticipation of the carrier's future subscriber revenues. The actual wholesale price received by the phone manufacturer is not observed and is treated by seller and buyer as a closely guarded secret. Moreover, the low prices paid by consumers reflect not only subsidies but also "finder's fees" paid by carriers to third parties, frequent promotional rebates borne by some combination of the carrier and the manufacturer, and the steeply declining price of rapidly aging technology. In the case of the RAZR, which proved to be very popular, the initial price with contract in November 2004 was $500. By May 2005 that dropped to $400 through Cingular (now AT&T), the exclusive network partner, but promotional offers from Amazon and other retailers at the time were as low as $50. In July 2005, the official price through Cingular and T-Mobile (which was added as a second carrier) dropped to $200.

The price received by the handset maker is the sum of the price paid by the consumer and the subsidy paid by the carrier. Based on Motorola's quarterly unit sales figures during 2005 and the changes in price over the year, we estimated a volume-weighted average consumer price for the RAZR to be $250. An industry analyst informed us that the subsidy for this phone was probably $100, for an average price of $350 received by Motorola.[7] Subtracting the estimated factory cost of $144 (Table A-1) gives an estimate of $206 for Motorola's gross profit. As a percentage of the sales price, that's a gross margin of 82%, much higher than Motorola's overall gross margin of 32% in calendar year 2005, but it is likely that the hit RAZR phone was at the high end of Motorola's relatively wide range of business lines and the broad range of handsets that it sells.

[7] See also Carson (2006).

Sales information about the Treo 650 is harder to come by, but Palm is less diversified than Motorola so we can be guided more by Palm's financial statements. Sprint started the price at $450 with a two-year contract and lowered it to $350 over the next 18 months before the next-generation Treo was introduced. We also found a report of a no-contract price of $350 at an electronics retailer in early 2006, suggesting that there may have been rebates offered in 2005 of which we were unable to find documentation. Palm's self-reported average handset price in the fiscal year ended in May 2006 was $316. Based on the limited evidence, we set the Treo 650 wholesale price received by Palm at $425, including a carrier subsidy of $100. Subtracting the $197 estimated factory cost (Table A-2) leaves Palm a gross profit of $228, or a gross margin of 54% (compared with Palm's overall gross margin of 33% for FYE May 2006). This disparity seems reasonable because the Treo 650 would be at the high end of Palm's offerings, which included non-phone handheld computers.

The Curve 8300 was launched in the U.S. in mid-2007 by Cingular/AT&T at a no-contract price of $450, or a $200 price with a 2-year contract (and a subsidy of undisclosed size paid by the carrier to RIM). In the year ended March 1, 2008, 59% of RIM's revenues came from the United States, with 8% from the United Kingdom and 7% from Canada, so the United States price is the most relevant.

Based on our previous research on small, portable electronics (Dedrick et al, 2009), a reasonable wholesale discount for distribution and retail is 25%. Against the $450 unlocked price, that equates to a wholesale price to RIM of $337.50. RIM's self-reported average selling price for the year ending March 1, 2008 was $346, which we will use as the wholesale price for the present analysis.

RIM's per-unit gross profit is the difference between the $346 wholesale price and the $108 estimated factory cost (Table A-3), or $238. That equals a gross margin of 69%, larger than RIM's overall hardware gross margin for FYE March 2008 of 44%.[8]

The disparity in profits among the three handsets seems to reflect firm positioning, although the margins of error on our estimates make such analysis tentative. Motorola's 82% can be attributed to the popularity of the sleek RAZR design in the period right after its introduction. As detailed above, Motorola rapidly lowered its price to expand market share, sacrificing some of its gross margin in favor of higher volume. Palm, a mobile computing firm with limited traction in the phone market, has the lowest gross margin (54%). Research in Motion also came from a mobile computing background, but enjoyed some customer lock-in thanks to the adoption of its pioneering "push e-mail" system by many corporate users. RIM was able to command 69% even on a unit targeting consumers.

Table 3 shows these handset maker gross profits in dollar terms and compares them with the total gross profits of all suppliers. In all three cases, the gross profit of the handset maker is far more than the combined estimated gross profits of all the suppliers.

<Insert Table 3 here>

These results matter not just for profits, but also for high-value jobs such as administration and research that the profits support. For example, Cohen et al. (2009) found that

[8] RIM also earns money from fees for the network services that it provides to carriers and their subscribers via RIM's Network Operations Center, on the order of $5 per user per month, as calculated from their Annual Reports. This would add $120 in revenue over the life of a 2-year contract. Applying RIM's FYE 3/08 gross margin for software and services, 84%, yields an additional gross profit of $101 over the 2-year life of a contract, which yields a total gross profit per phone of $329. However we will not use this higher figure in the body of this paper in order to keep all gross profit conceptually related to the wholesale price.

all the inventors listed on the majority of patents issued to Nokia, Ericsson, Motorola, and Qualcomm between 1985 and 2001 were located in the home region. The explanations they advance are a combination of organizational inertia and the slow maturation of offshore R&D centers. A study of the global iPod supply chain (Linden et al., 2008) estimated that twice as many jobs in 2006 (including distribution, retail, and a share of Apple overhead as well as the supply chain) were located outside the U.S. as in it, but the U.S.-based workers earned twice as much in total wages. Based on the information available to us about the iPhone's supply chain, we believe the distribution of jobs and wages is probably similar, and that this relationship holds for other smartphones as well.

5.3. Carrier value capture

Another element of the smartphone supply chain that we analyze is distribution and usage. The landscape for handset distribution is very complex. The smartphone companies sell directly in some cases, ship via distribution partners in others, and ship directly to carrier warehouses in others. Smartphones in the U.S. are typically sold through a close arrangement between phone maker and carrier, so direct shipment (i.e., no distributor apart from a logistics company) is a common route, with a third-party freight or logistics firm generally handling the physical movement of goods.

Here we will restrict our attention to this distributor-free, carrier-direct case in order to extend our supply chain discussion to include the carrier's value capture. As mentioned above, the RAZR was initially sold exclusively through Cingular, with T-Mobile added after about 6 months. The Curve 8300 was also launched in the U.S. as a Cingular/AT&T exclusive.[9] The

[9] Cingular was rebranded as AT&T in 2007, the year of the Curve 8300 introduction.

Treo 650 for CDMA was initially sold exclusively through Sprint PCS, with Verizon added after about 6 months.

For this estimate of the carrier's per-phone profit, we focus on Cingular and the RAZR. On average, Cingular, like other carriers, incurs a loss on handset sales. In Cingular's financial reports for the period, its reported "cost of equipment" (primarily phones) exceeded "equipment revenues" by 25% across all the handset models that they were offering.[10]

Carrier profits come from subscriber fees, reported by the companies as average revenue per user (ARPU), from which we will subtract the $100 RAZR subsidy discussed in the previous section. Subsidized smartphones are typically sold with a two-year contract. We discounted the second year by 5% to estimate its net present value.

For Cingular/AT&T in 2005/2006, total ARPU, adjusted to reflect the net present value of the second year, was $1,155. The company's gross margin for services (the excess of "services revenue" over "cost of services excluding depreciation") during that time was 70%. Combining these numbers yields an estimate of $804 gross profit per user. Subtracting the $100 subsidy leaves an estimated gross profit per phone of $704 for Cingular. The same calculations for Sprint and the Treo 650 produced a carrier gross profit per user of $975. These estimates, which are more than twice the per-phone profit estimated for Motorola and Palm in Table 4, make clear why the carriers are willing to subsidize handsets.

Figure 1 combines all the data described so far for Motorola's original V3 RAZR phone to show the breakdown of our value capture estimates. The dominant profit position of the carrier, with three quarters of the total gross profit from the phone, is evident, followed by that of Motorola, with about one fifth. Supplier value capture is shown by region, with the U.S. share

[10] Applying this average handset subsidy rate to the V3 RAZR wholesale price calculated above leads to estimated handset subsidies of $87 versus the $100 each that we use in our analysis.

just slightly larger than that of Japan. Of the slice of value capture labeled “Location Unidentified,” at least some of it would also belong to firms based in the U.S. or Japan.

<Insert Figure 1 here>

Figure 2 shows our rough estimate of what these values look like if they were adjusted for marketing and depreciation to reflect the companies’ operating profits. The most notable feature about the figure is that it reverses the ranking of Motorola and the carrier because the latter carries the financial burden of installing and maintaining a nationwide network infrastructure. The contrast of gross and operating margins would be somewhat less drastic had we made it using Palm and Sprint because Sprint’s operating margin was healthier than Cingular’s at the time (see Table 4, below).

<Insert Figure 2 here>

6. Cooperation and competition along the supply chain

We have shown that carriers capture the most value (measured as gross profits) in the smartphone supply chain, followed by handset makers, with component suppliers a distant third. We next discuss the economics of handset subsidies and market power in the supply chain in light of our value analysis. Then we return to the supply chain to consider a broader selection of profit measures for selected firms.

6.1. The economics of handset subsidies

With respect to the debate on bundling of handsets and service contracts, we can use our value analysis to think about how these numbers might differ had subsidies been forbidden at the time the phone was released. In a study of the Korean market, the elimination of subsidies in 2000 led to a drop in service charges of about 15% at the two biggest carriers (Kim et al., 2004, Table 6). In the RAZR example, the end of the $100 handset subsidy could support a reduction in service charges by the carrier of about 10% and still leave the carrier with the same gross profit. And subsidies have gotten steeper since then as smartphones allow carriers to add data subscriptions to their voice contracts. Estimates of the subsidy on the 3G iPhone ranged as high as $500 (Wingfield, 2008). This leaves much greater scope for carrier service charge reductions if subsidies were banned, calling into question the argument that phone subsidies are "pro-consumer" (Hazlett, 2010: 9).

The picture is different for the handset maker. If the full unsubsidized price ($350 in the case of the RAZR) had been charged on all units sold, the per-unit profit would be the same as calculated above. However it is likely that fewer units would be sold at the unsubsidized price because consumers would shift to lower-priced phones, so that Motorola's total gross profit from RAZR sales would have been lower. There is also a negative dynamic effect, because lower sales volume makes it harder for the handset maker to cover its fixed development costs and to extract price reductions from its suppliers over time. In short, the absence of subsidies would have meant lower total profits for all the firms along the supply chain: carriers, handset makers and component suppliers.

The end of subsidies could also negatively affect an innovative handset maker's ability to enter the market by slowing diffusion. Smartphones that run independently developed software applications, like those from the iPhone's "App Store," benefit from network effects; the more people that are using smartphones that run on a given platform, the greater the incentive for independent software vendors to write applications for that platform. If the end of subsidies leads to the slower uptake of a new smartphone platform, then it's harder for a novel platform such as the iPhone to reach a self-sustaining critical mass of users. This type of reasoning was behind one study's endorsement of the Finnish government's permission for otherwise-forbidden subsidies to be used in the years following the introduction of 3G handsets (Tallberg, et al., 2007).

6.2. Market power in the supply chain

Handset makers and carriers compete for market power, but carrier dominance of the gross profit pie does not appear to have eroded since these early smartphones. We made comparable calculations for Apple's first-generation iPhone in late 2007 and early 2008 assuming a $200 subsidy. Our estimate of Apple's gross profit per phone was $284, and our corresponding estimate of AT&T's profit per iPhone user was $1,248.[11]

In the smartphone market, carriers and handset makers will each try to increase their leverage. Handset makers can accomplish this in part by building brand image with consumers. An excellent recent example of this is Apple's iPhone. Well regarded by consumers based on its hit line of iPod music players, Apple was reportedly able to negotiate a share of monthly iPhone subscriber revenue from AT&T (Sharma et al., 2007).

[11] The AT&T estimate reflects the fact, disclosed by AT&T, that iPhone user ARPU is 1.6 that of other AT&T Wireless subscribers (Sharma & Cheng, 2008).

Carriers, for their part, have worked to build their own brands while diminishing the prominence of the handset makers. This movement is most pronounced in Europe, where a lesser reliance on carrier subsidies (and the associated lock-in) meant that phone buyers were used to shopping for carriers. European carriers like Vodafone and Orange turned to small phone makers or independent design houses to build custom phones using software that helped keep customers visiting carrier web sites for added-value services such as ringtones (Pringle 2001; Pringle, 2002). Beyond this, carriers have been increasingly successful at negotiating customization deals that placed their names on the phones they sold, even from large, well-known companies like Nokia (Faucon, 2003; Pringle, 2004). Palm’s Treo 650 was branded with Sprint’s logo.

But we must view this struggle for market power in perspective by taking a broader view of the profitability of these companies, as suggested by the major difference between Figure 1 and Figure 2, above. Here, we consider four measures: gross margin (GM), operating margin (OM), Net Margin (NM), and return on assets (ROA). The margins are the same as the profit concepts introduced in Section 3, but expressed as a ratio to sales. GM, gross profit over net sales, shows what share of a firm’s sales price is retained after the direct costs of producing its goods or services are deducted. OM, operating profit over net sales, shows the success of a firm’s overall productive and innovative activity. NM, the ratio of net profit (or loss) to sales, is included for reference; it is often misleading because of large one time charges or receipts. ROA, the ratio of net profit (or loss) to Total Assets (an accounting value reported on a firm’s balance sheet), shows the firm’s economic efficiency in the use of capital from its shareholders and creditors.

Table 4 shows these data for two handset makers, Motorola and Palm, and for two carriers, Cingular and Sprint Nextel’s wireless division. The carrier gross margins are significantly higher than the handset maker GMs, confirming the impression of Figure 1. The two sets of firms are much more similar in terms of OM, that is after overhead costs such as marketing and R&D have been subtracted out of income. Finally, the handset makers look far better than the carriers in terms of ROA, which reflects the huge capital investments by the carriers to build and upgrade their cellular networks as well as the asset-light business models of these handset makers, who outsource much of their manufacturing.

<Insert Table 4 here>

The more complete picture of profitability in Table 4 suggests that there is a limit to how much handset makers will be able to raise their margins by negotiating a transfer from their carrier partners. The carriers already have relatively low returns on assets and cannot afford to give up much more profit to the handset makers.

Although component suppliers generally have little market power in the mobile telecommunications supply chain, there are important exceptions. Table 4 also includes data for the suppliers of the baseband chip that controls the digital side of a phone's cellular functions (before and after analog chips have converted the signal for transmission and receiving). Freescale Semiconductor, the spin-off of Motorola's chip division, is one of many firms that supply baseband chips for GSM and related standards. In 2005, it ranked second behind the leader, Texas Instruments (Lammers, 2006). The fierce competition in the GSM side of the baseband market has led it to consider the once unthinkable step of selling off its wireless chip business (Ojo, 2008).

This is a sharp contrast with Qualcomm, the supplier of the Treo 650's CDMA baseband and related chips, as well as the principal licensor for the use of CDMA technology. Qualcomm pioneered the CDMA standard and has remained the near-monopoly supplier of the chips, in addition to receiving a royalty for every 3G (CDMA2000, W-CDMA, and TD-SCDMA) phone. Qualcomm's large margins demonstrate the benefits of owning a successful standard.

7. Summary and conclusions

In this paper, we have presented the first quantitative analysis of value capture by firms along the supply chain for high-end phones. Extension of this methodology to more pieces of the telecommunications value network is an area for future research.

We find that a brand-name handset maker stands to capture greater financial value from each phone than any of its suppliers. This analysis reinforces the earlier finding of (Dedrick et al., 2009) with regard to iPods and, to a lesser extent, notebook computers (where Intel and Microsoft capture a large share of the value).

The smartphone supply chain also includes carriers, which have no equivalent in the supply chains of non-subscription devices such as iPods or PCs. The carriers capture a great deal of value (measured as gross profit) from each handset, a slice of value that handset makers are striving to tap into. However the carriers must also shoulder the burden of network installation, maintenance, and upgrades, which absorbs a lot of the gross value from their subscription fees. Even so, the absolute value of their operating profits per phone dwarf those of any upstream suppliers of handset inputs (see Figure 2, above).

Our value capture methodology also allowed us to quantify and analyze some of the microeconomic aspects of handset subsidies. Our quantitative results confirm the qualitative analysis in Tallberg et al. (2007) that argued in favor of subsidies during the introduction of new technologies in order to accelerate adoption, with proper regard for the potential anti-competitive effects of customer lock-in through long-term contract commitments. Our estimates show how much higher service charges might be because of subsidies and the resulting customer commitments. Yet we recognize that the benefits of lower consumer prices due to subsidies benefit the entire supply chain by increasing sales volumes. While subsidies have unquestionably helped the iPhone to be adopted on a sufficient scale to alter the design of other high-end mobile phones, the Federal Communications Commission is reportedly investigating whether consumers are well served by the trade-off of handset subsidies for long-term subscriber contracts (Sharma, 2009).

In the ongoing struggle for value capture in the smartphone supply chain, the business models and managerial attention of component and system suppliers must evolve. Brand building and management of customer relationships are critical to capturing value and growing the market as the end users of networks compare the complete bundle of features and services offered by an array of competing yet overlapping supply chains. Value-adding complementary goods and services such as downloadable third-party applications have successfully increased the value of smartphone ownership for handset makers, carriers, and consumers. They also are shifting the key level of competition toward platforms based on operating systems, including those provided by software makers such as Google and Microsoft or by the handset makers such as Apple.

In terms of national outcomes, our study shows that handset maker nationality matters. Whereas carriers most often compete and invest in their headquarters market only, the leading handset makers compete and invest (or outsource) globally. High-value tasks such as planning and R&D still tend to cluster near the headquarters of companies, so national identity matters for jobs and income as well as for profit. The same is true for successful component suppliers, as demonstrated in the examples above by companies like Qualcomm and Texas Instruments. And, as suggested by Table 2, the choice of some key suppliers may be influenced by the nationality of the handset firm, although a broader sample needs to be studied.

Finally, our analysis also shows that, despite the very different business model followed in the phone industry compared to personal computers and the iPod, supply chain analysis, with suitable adjustments for the relevant business model, can be useful for revealing which participants capture the most value.

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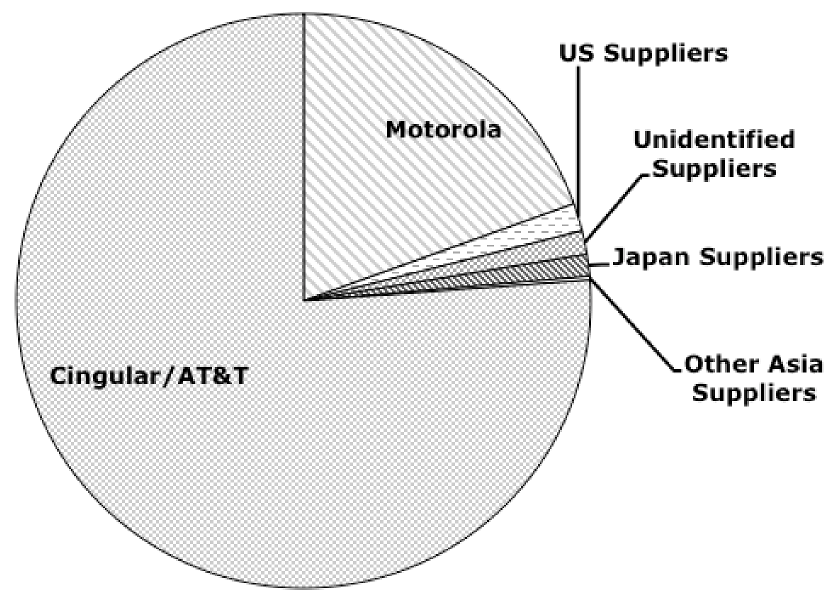
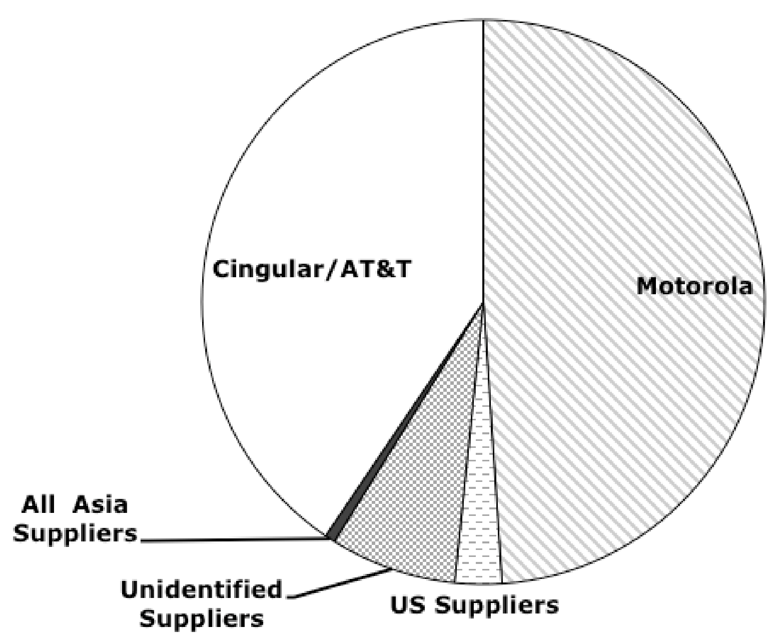
Figure 1. Gross Profit in the Motorola V3 RAZR Supply Chain



Source: see text

Figure 2. Operating Profit in the Motorola V3 RAZR Supply Chain



Source: see text

Table 1. Comparison of Inputs as Percentage of Factory Cost: Three Phones

	Motorola V3 "RAZR"	Treo 650 CDMA	RIM Curve 8300
Year of introduction	**2004**	**2004**	**2007**
Display	30%	23%	11%
Processors	10%	16%	13%
Storage	9%	3%	9%
Memory	2%	5%	
Assembly	4%	6%	7%
Camera	5%	3%	8%
Cellular and Bluetooth chips	6%	4%	4%
Cellular license	4%	incl.in chip cost	5%
Battery	3%	5%	4%
PCBs	5%	5%	5%
Enclosure	2%	2%	5%
Keypad	6%	1%	2%
Software	Not Applicable	5%	Not Applicable
Subtotal for key components	86%	82%	72%
Hundreds of other components	14%	18%	28%
TOTAL	100%	100%	100%
Total Parts	640	1,040	585

Source: Authors' calculations

Table 2. Estimated Gross Profit Shares of Suppliers for Four Phones

	US-based Suppliers	Japan-based Suppliers	Other Asia Suppliers	Europe-based Suppliers	Supplier Location Unidentified	Total
Motorola RAZR	36%	28%	6%	0%	30%	100%
Palm Treo 650	39%	19%	8%	3%	31%	100%
RIM BlackBerry Curve 8300	41%	2%	8%	12%	37%	100%
Nokia 7710	17%	35%	2%	11%	36%	100%

Source: Authors' calculations

Table 3. Estimated Profitability of Suppliers for Three Phones

	Handset Maker Gross Profit	Lead Firm HQ Location	Total Gross Profits For all Suppliers	Largest Region of Input Supply
Motorola RAZR	$206.00	US	$46.51	US
Palm Treo 650	$228.00	US	$75.90	US
RIM Curve 8300	$238.00*	Canada	$34.77	US

* Does not include additional gross profit from Network Operations Center services (see text)
Source: Authors' calculations

Table 4. Selected Financial Ratios for the Fiscal Year Covering December 2005

	Gross Margin	Operating Margin	Net Margin	Return on Assets
BASEBAND SUPPLIERS				
Freescale	42%	10%	10%	8%
Qualcomm	71%	36%	33%	16%
HANDSET MAKERS				
Motorola	32%	13%	12%	13%
Palm	33%	7%	21%*	23%*
CARRIERS				
Cingular	58%	5%	1%	1%
Sprint	61%	10%	5%	3%

* - Palm's NM and ROA reflect a large one-time tax benefit, without which ROA would have been close to its operating margin of 7%.
Source: Authors' calculations from company reports; Sprint data are for Sprint Nextel's Wireless segment only.

Appendix

Table A-1. Key Inputs in the Motorola V3 RAZR phone

Type	Component	Supplier	Company HQ Location	Estimated Factory Price	Price as % of Factory Cost	Gross Profit Rate	Estd. Value Capture	Operating Margin
Display module	Display module	Unknown*	Japan?**	$42.74	29.7%	28.6%	$12.22	
Processors	Baseband Processor	Freescale	US	$10.05	7.0%	42.2%	$4.24	10.3%
Processors	Analog ASIC	Texas Instruments	US	$3.92	2.7%	48.8%	$1.91	20.7%
Storage	NOR Flash-32M Bytes	Intel	US	$12.21	8.5%	33.0%	$7.25	
Memory	p-SRAM-8M Bytes	Micron	US	$3.28	2.3%	23.5%	$0.77	4.4%
Camera	Camera module	Altus (Micron)	Taiwan(US)	$6.84	4.8%	23.5%	$1.61	4.4%
PCB	Main board	Unknown		$2.67	1.9%	33.0%	$0.88	
Cellular	GSM Transceiver	Freescale	US	$2.14	1.5%	42.2%	$0.90	10.3%
Cellular	Power Amplifier/Tx & Rx Switch	Skyworks	US	$3.58	2.5%	38.8%	$1.39	6.3%
Bluetooth	Bluetooth transceiver	Broadcom	US	$3.18	2.2%	52.5%	$1.67	10.9%
Battery	Li-Ion Cell	Sanyo	Japan	$4.18	2.9%	17.6%	$0.74	<0
Keypad	Substrate	Unknown	Taiwan?	$2.56	1.8%	33.0%	$0.84	
Keypad	Keypad surface	Unknown	Korea?	$4.15	2.9%	33.0%	$1.37	
Keypad	Keypad enclosure	Unknown	Taiwan?	$2.36	1.6%	33.0%	$0.78	
License	GSM	Various	Various	$5.00	3.5%	33.0%	$1.65	
			Sub-Total	**$108.86**	**75.7%**			
			Other parts	$29.06	20.2%	33%	$9.59	
			Estimated assembly and test	$5.81	4.0%	33%	$1.92	
			Estimated factory cost	$143.73	100.0%		$46.51	

Source: Portelligent (2004) and authors' calculations.
Notes: Blank "Operating Margin" means the actual company was not known (gross margin is industry average), except in the case of Intel's flash memory chips, which are not likely to have been as profitable as its processors; industry-average gross margin was used there as well.
Question marks after a "Company HQ Location" indicates an educated guess based on the structure of the supply market and other sources of information.
* The module supplier's cost of goods includes $14 for a chip from ATI, which was then a Canadian company (now part of AMD).
**Portelligent considered Japan the likely source for the display module and provided the 28.6% gross margin estimate.

Table A-2. Key Inputs in the palmOne Treo 650 phone

Type	Component	Supplier	Company HQ Location	Estimated Factory Price	Price as % of Factory Cost	Gross Profit Rate	Estd. Value Capture	Operating Margin
Display module	Display	Sony	Japan	$46.05	23.4%	31.1%	$14.32	2.6%
Processors	Mobile Station Modem	Qualcomm*	US	$14.30	7.3%	60.0%	$8.58	30.0%
Processors	Analog Baseband	Qualcomm*	US	$2.62	1.3%	60.0%	$1.57	30.0%
Processors	312MHz Application Processor	Intel	US	$14.22	7.2%	59.4%	$8.45	31.1%
Storage	NAND Flash - 32M Bytes	M-Systems	Israel	$4.93	2.5%	24.8%	$1.22	10.3%
Memory	SRAM-1M Byte	Cypress Semi	US	$2.81	1.4%	40.4%	$1.14	-10.4%
Memory	SDRAM -32M Bytes	Infineon Tech	Germany	$3.89	2.0%	30.2%	$1.17	-8.1%
Memory	NOR Flash-4M Bytes	Intel	US	$2.78	1.4%	33.0%	$0.92	
Camera	Image Sensor	Micron	US	$6.05	3.1%	23.5%	$1.42	4.4%
PCB	Main board	Unknown	Taiwan	$6.84	3.5%	33.0%	$2.26	
Cellular	RF-to-Baseband Receiver	Qualcomm*	US	$2.77	1.4%	60.0%	$1.66	30.0%
Cellular	Baseband to RF Transmitter	Qualcomm*	US	$2.27	1.2%	60.0%	$1.36	30.0%
Bluetooth	Bluetooth Transceiver	Broadcom	US	$3.53	1.8%	52.5%	$1.85	10.9%
Battery	Battery	Unknown		$9.28	4.7%	33.0%	$3.06	
Keypad	LED (14)	Unknown		$2.80	1.4%	33.0%	$0.92	
License	CDMA	Qualcomm*	US	Included in chip cost	--	-	-	
			Sub-Total	**$125.14**	**63.7%**			
			Other parts	$59.85	30.4%	33%	$19.75	
			Estimated assembly and test	$11.58	5.9%	33%	$3.82	
			Estimated factory cost	$196.57	100.0%		$75.90	

Source: Portelligent (2005) and authors' calculations.
Note: Blank "Operating Margin" means the actual company was not known (gross margin is industry average)
Industry-average gross margin was also used for Intel's flash memory chips, which are not likely to have been as profitable as its processors.
* Qualcomm margins are estimates based on Qualcomm's segment reporting of Earnings Before Tax

Table A-3. Key Inputs in the RIM Curve 8300

	Component	Most Likely Supplier	Company HQ Location	Estimated Factory Price	Price as % of total factory cost	Gross Margin	Est'd Value Capture	Operating Margin
Display	Display Module	Unknown	Asia	$11.68	11%	16%	$1.87	0%
Processors	Baseband Chip	Marvell	US	$14.60	13%	48%	$7.01	-4%
Processors	Audio processor	Texas Instruments	US	$1.88	2%	53%	$1.00	25%
Storage and memory	Flash and SDRAM multi-chip package	Intel	US	$9.25	9%	52%	$4.81	24%
Camera	Camera module	STMicro	Europe	$8.50	8%	35%	$2.98	-5%
PCB	Main PCB	AT&S	Europe	$5.17	5%	18%	$0.93	9%
Cellular	RF Transceiver	Freescale	US	$2.35	2%	33%	$0.78	<0
Cellular	Power Amplifier	Freescale	US	$1.75	2%	33%	$0.58	<0
Bluetooth	Bluetooth chip	CSR	Europe	$1.90	2%	47%	$0.89	18%
Battery	Battery Pack	Unknown	Japan (cell)	$4.24	4%	16%	$0.68	1%
Keypad	Keypad assembly	Unknown		$1.71	2%	33%	$0.56	
Trackball	Trackball mechanism	Unknown		$0.42	0%	33%	$0.14	
License	EDGE royalties	Various	Various	$5.00	5%	33%	$1.65	
			Sub-Total	**$68.45**	**63%**			
			Other parts	$31.85	29%	33%	$10.51	
			Estimated assembly and test	$7.95	7%	5.0%	$0.40	0%
			Estimated factory cost	$108.25	100%		$34.77	

Source: iSuppli (2007) and authors' calculations.
Note: Blank "Operating Margin" means the actual company was not known (gross margin is industry average)

Table A-4. Key Inputs in the Nokia 7710 phone

Type	Component	Supplier	Company HQ Location	Estimated Factory Price	Price as % of Factory Cost	Gross Profit Rate	Estd. Value Capture	Operating Margin
Display	Display module	Sanyo?	Japan	$56.67	29.8%	17.6%	$9.97	<0
Processors	Baseband	Nokia/TI	US	$7.71	4.1%	48.8%	$3.76	20.7%
Processors	Application Processor	Texas Instruments	US	$9.64	5.1%	48.8%	$4.70	20.7%
Processors	Analog ASIC	Nokia/ST Micro	Europe	$3.38	1.8%	34.2%	$1.16	27.5%
Storage	SD card	Unknown**	Unknown	$12.00	6.3%	42.2%	$5.06	25.0%
Memory	512M NAND Flash EEPROM	Toshiba	Japan	$7.82	4.1%	26.5%	$2.07	3.8%
Memory	64MB SDRAM Memory	Samsung	Korea	$3.21	1.7%	30.1%	$0.97	14.0%
Memory	4 MB NOR Flash	Spansion	US	$1.22	0.6%	9.6%	$0.12	<0
Camera	Camera module	Toshiba	Japan	$11.08	5.8%	26.5%	$2.94	3.8%
PCB	Main substrate	Ibiden	Japan	$7.84	4.1%	26.1%	$2.05	13.7%
Cellular	GSM Transceiver	Nokia/ST Micro	Europe	$2.92	1.5%	34.2%	$1.00	27.5%
Cellular	Power Amplifier	RFMD	US	$1.65	0.9%	34.2%	$0.56	7.8%
Cellular	Tx/Rx Switch	Murata	Japan	$0.63	0.3%	39.7%	$0.25	18.3%
Bluetooth	Bluetooth transceiver	CSR	Europe	$2.79	1.5%	46.9%	$1.31	23.0%
Battery	Li-ion cell	Sony	Japan	$5.77	3.0%	31.1%	$1.79	2.6%
Battery	Battery electronics	Mitsumi*	Japan	$0.42	0.2%	7.9%	$0.03	1.9%
License	GSM/EDGE	Various	Various	$5.00	2.6%	33%	$1.65	
		Sub-Total		**$139.75**	**73.57%**			
		Other parts		$42.59	22.42%	33%	$14.05	
		Estimated assembly and test		$7.61	4.01%	33%	$2.51	
		Estimated factory cost		$189.95	100.0%		$55.96	

* * - used 2005 data for SanDisk, the SD card market leader at the time, but the SD card included with the 7110 could also have been made by Toshiba or another non-US firm

Note: Blank "Operating Margin' means the actual company was not known (gross margin is industry average)

Source: Portelligent, Inc., 2005b and authors' calculations.