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Capturing Value in a Global Innovation Network: A Comparison of Radical and Incremental Innovation

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For advanced industrial nations no longer able to compete on cost, the capacity to innovate is the most critical element in sustaining competitiveness.

Council on Competitiveness, 2003.

Introduction

Innovation is often identified as a key to national competitiveness and prosperity,[1] and is promoted through various policy initiatives in many countries. Yet innovation today is no longer carried out within individual countries, but often crosses national borders in the form of global innovation networks. These can comprise the global branches of multinational corporations (MNCs) and local or regional participants from multiple countries. When innovation is organized in such networks, it is not clear how the economic gains from innovation are distributed among the firms and countries involved. These gains can be measured various ways such as financial value-added, jobs and wages,[2] and trade flows, and at various levels of analysis from the product to the firm to the country.

This paper reports on a study that addresses the question of who benefits financially from innovation in the global networks for a specific set of products, including three members of Apple's iPod family and notebook PC models from Lenovo and HP. These are all examples of globally innovated products, combining technologies from the U.S., Japan and a number of Asian countries.

A product-level study allows us to break out the financial value embedded in an innovative product and clarify how it is distributed across the many participants in the supply chain. Aggregating this firm-level data, we are able to estimate the distribution of value by country as well. The result will be of interest to managers, academics, and policy makers concerned about the value captured by innovators.

A product-level financial focus also serves as a counterweight to other lenses used to view globalization. Bilateral and multilateral trade statistics are important measures of one economy's interaction with others, but they can also be misused. For example, the bilateral trade deficit of the U.S. with China has received considerable attention, but our study makes clear that Chinese firms and workers capture a small share of the trade price of an iPod or notebook PC because China's primary role in the value chain is still that of a low-cost assembly platform. The bilateral trade data obscure how the high-value inputs to the iPod and notebooks come from Japan, Korea, and Taiwan, and even the multilateral trade data are not fine-grained enough to clarify these flows.

The choice of iPods and notebook PCs allows us to examine two general types of innovation, radical and incremental, which are discussed in the next section. The second section describes how innovation is carried out in the context of global innovation networks. The subsequent sections describe and apply a framework for measuring and

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[1] See for example Solow (1956), Mokyr (1990), Grossman and Helpman (1991) and Porter (1998).

[2] These alternate measures will be considered in our future research.

mapping the financial value created along a supply chain (Linden et al., 2007a). Finally, comparative results for the five products are analyzed at the firm and national levels.

Radical and incremental innovation

Radical product innovation (Utterback, 1990) has important differences from the incremental model of development as illustrated in Table 1. Radical innovation either involves introduction of new core technologies, such as digital cameras, or involves a new way of integrating core technologies to develop a product with different capabilities (the latter is referred to by Henderson and Clark, 1990, as architectural innovation). By contrast, incremental innovation, as the term suggests, involves steady evolutionary improvements in products without fundamental changes in technology or architecture.

Table 1. Features of Incremental and Radical Innovation

	Radical innovation	**Incremental innovation**
Opportunity	- New product category - New technology creates opportunity to redefine a product category	- Early introduction of new technologies provides short-term market advantage - Minor design features can be used to differentiate products within an established category
Standards	- No existing dominant design or standard - Few limits on how new architecture is defined, i.e., how hardware and software components work together	- Dominant standard defines and limits innovation opportunities - Need to maintain compatibility with complementary assets and earlier generations - More modular, open architectures, with proprietary control of key standards - Standards owners try to maintain control over technology trajectory
Strategy	- Develop complete platform of hardware, software, content, services -Work with key partners for core technologies - Control key standards within the product architecture - Create an ecosystem of co-specialized asset providers around the standard - May be necessary to create new distribution channels	-Innovate within dominant design - Where standards are in flux, influence development through design choices (e.g., Blu-Ray or HD DVD) -Control product planning, brand image, marketing, concept design -Leverage existing complementary resources and distribution
Value capture	- Lead firm captures economic rents through high margins - Core technology suppliers may also enjoy high margins but can be replaced - Valuable unique intellectual property is a requirement to capture value	- Competition drives down margins - Consumers capture most value created - Firms controlling key standards may earn monopoly profits (e.g., MS and Intel) - Low cost suppliers can capture value through economies of scale

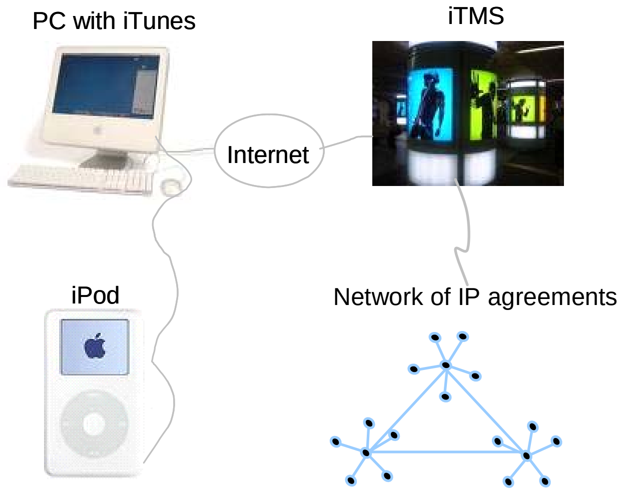
The iPod provides an example of radical innovation carried out in a global innovation network.[3] Introduced in 2001, the iPod was not the first integrated portable music player, but it entered a fledgling market with limited adoption and no strong incumbents. The new industry was enabled by a combination of new technologies (e.g., audio compression software such as MP3), and advances in others such as very small hard drives and low cost flash memory which allowed storing music inside the device rather than carrying CDs or tapes. This situation created an opportunity for someone to create a new product with no need to be compatible with existing products or complementary assets (except the millions of digital music tracks available for ripping from CDs or downloading from Napster or other sites). Apple took advantage by combining existing technologies in a unique way that captured consumers' imagination and became a hit product (Linden et al., 2007a, 2007b).

Apple designed the system architecture that affected critical features such as sound quality and power consumption and developed the distinctive industrial design of the iPod; it developed most of the iPod and iTunes software in-house or adapted others' software. Apple tightly managed the whole process, coordinating closely with outside partners so that it could design the iPod, and its manufacturer and suppliers could concurrently prepare the tooling and supply chain for volume manufacturing, and bring it to market in eight months. While many standard parts and components were involved, Apple worked closely with outside partners to design or adapt many custom inputs, such as integrated circuits, hard drives, and the iPod's distinctive plastic and metal casing, screen and control wheel.

The radical innovation of the iPod was not a dramatic technological advance, but rather a unique integration of hardware, software, content and services in a way that was more user-friendly and comprehensive than existing music players. Apple developed the iTunes software application to collect and manage content on a PC or Mac and easily transfer that content to the iPod. It also developed the online iTunes Music Store and tightly integrated that with the iTunes application. Apple licensed content from all the major music labels and, subsequently, from the audio book, movie and television industries, and established pricing and digital rights models that were attractive to consumers (Figure 1).

[3] Using a related terminology, the iPod and its associated business model also constitute a "disruptive innovation" (Christensen and Raynor, 2003) that provided a set of functionality and infrastructure to mainstream users who were not attracted by then-existing combinations of portable music players and digital music sources.

Figure 1. iPod Value Network



By contrast, notebook PCs today represent incremental innovation. While a portable PC was originally a radical departure from desktop PCs, requiring innovation in batteries, flat-panel displays, and miniaturization, today's notebook PCs are basically refinements and extensions of the original "clamshell" laptop designs of the mid-1980s. The architecture has not changed much, and the keyboard, display, CPU etc. are in the same place (by contrast, consider the layout of a tablet PC). The majority of laptops, including those analyzed here, include an operating system from Microsoft and an Intel (or at least Intel-compatible) processor.

In the case of notebook PCs, innovation is shaped by the need for compatibility with a vast array of complementary assets, from software to peripherals to components, and by the need for backward compatibility (and perceived future compatibility) with other systems. The key architectural decisions are driven by Microsoft and Intel, along with a few key players in other components (e.g., Nvidia, AMD/ATI, creative in graphics and sound; TI and Broadcom in communications and Adobe in software). PC makers at best can influence the technology directions by their own design choices, such as what set of wireless interfaces or next-generation DVD standards to incorporate. But this influence is limited by the fact that no PC maker has even 20 percent of the global market.

The mature PC industry consists of thousands of firms, producing mostly interchangeable inputs and complementary assets, as well as industry-standard systems. Barriers to entry are low in many segments such as desktop systems, commodity parts and software. The industry is highly global, with manufacturers, assemblers and developers around the world, although there is a strong concentration in the U.S. and the Asia-Pacific region. The notebook industry, discussed below, is dominated by a small number of PC vendors (HP, Dell, Acer, Lenovo, Toshiba and a few others) who rely on a similar number of Taiwanese manufacturers to produce about 80 percent of their products. PC vendors concentrate on design, branding, marketing and distribution, leveraging the innovation of others to enhance their product (Dedrick and Kraemer, 2007).

Competition in almost every segment of the industry drives prices down steadily, so that much of the value of innovation is passed on to consumers in the form of cheaper and more powerful computers. The exceptions are Microsoft and Intel, who enjoy net margins of about 30 percent and 20 percent respectively, thanks to their control over key standards and lack of competition. Other component makers must constantly innovate to keep up, and yet must also control costs to survive in highly competitive markets.

Globalization of innovation

In the past, large electronics companies designed and developed their own products, often using internally-produced components. Such highly integrated companies created and captured a large share of the value of innovation, mostly in their home countries. Since then, supply chains in the global electronics industry have steadily disaggregated across corporate and national boundaries (Sturgeon, 2002; Dedrick and Kraemer, 1998). Companies that formerly manufactured most products in-house, such as IBM and HP, as well as start-ups that never had manufacturing capabilities, have outsourced production and even product development to global networks of contract manufacturers (CMs) and original design manufacturers (ODMs). Even vertically integrated Japanese and Korean companies rely on outside suppliers for key parts, equipment and some final assembly.

Today, the creation of a successful product in the global electronics industry spreads wealth far beyond the lead firm, i.e. the company whose brand appears on the product, and who bears primary responsibility for conceiving, coordinating, and marketing new products. While the lead firm and its shareholders are the main intended beneficiaries of the firm’s strategic planning, other beneficiaries include partners in the firm’s supply chain. Firms that offer complementary products or services may also benefit.

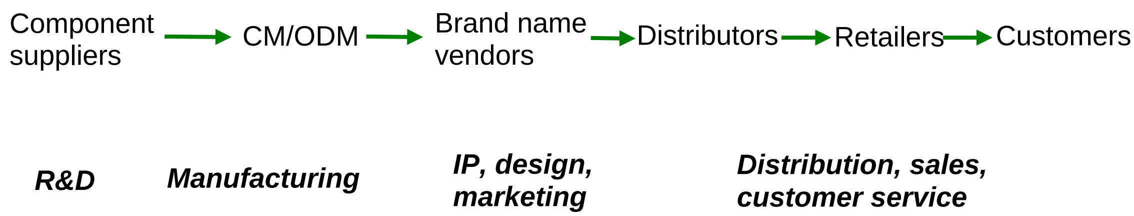
The dependency relationships in these networks run both ways. While innovation in notebook computers is incremental, manufacturers of chips, displays, hard drives and other components must often achieve fundamental scientific advances to advance to ensuing generations of technology. PC makers must work closely with those suppliers to integrate advanced technologies in highly sophisticated designs.

These global networks are flexible. Lead firms and their suppliers are independent organizations that compete, cooperate, shift, and recombine networks from one product generation to the next.

Measuring Value Creation and Capture in Global Networks

Within a supply chain, each producer purchases inputs and then adds value, which then becomes part of the cost of the next stage of production. The sum of the value added by everyone in the chain equals the final product price. The natural starting point for estimating these values is a map of a supply chain showing the activities (R&D, manufacturing, design and branding, and distribution, sales and service) involved in passing from component suppliers to final customers (Figure 2).

Figure 2: Generic Electronics Supply Chain



Moving from left to right in the figure, most R&D is done by a few key component suppliers, although each product incorporates a large number of components (in the case of a notebook computer, hundreds). Some components are low-value, such as capacitors and resistors that cost less than a penny each. Although the suppliers of these components earn profits, they account for a small share of the total value added along the supply chain, and contribute relatively little innovation. We expect suppliers of these generic inputs to earn thin profit margins because they compete with close substitutes.

Most electronics products also contain a few high-value components, such as a visual display, hard drive or key integrated circuits. These components, which are themselves complicated systems, are the most likely to embody proprietary knowledge that helps to differentiate the final product and to command a commensurately high margin. By virtue of their high cost, these few inputs will usually account for a relatively large share of total value added. Innovation is rapid in these components, and accounts for much of the steady technological improvement in final products such as the iPod or notebook PCs.

These complex components may have their own multinational supply chains. For example, an integrated circuit might be sold by a U.S. company but fabricated by a contractor in Taiwan and encased in its final package in Korea before being shipped to a product assembly plant.

The manufacture of these components into the final product is done by a number of large multinational contract manufacturers (CMs) or original design manufacturers (ODMs) such as Flextronics, Solectron, Foxconn, Quanta, and Compal who provide assembly services. These assemblers compete fiercely for high-volume opportunities, limiting their margins. Even large vertically integrated manufacturers such as Sony and Toshiba now outsource part of their production to these CMs and ODMs.

Product design, branding and marketing is done by brand-name vendors. These lead firms contribute market knowledge, intellectual property, system integration and cost management skills, and a brand name whose value reflects its reputation for quality, innovation, and customer service. Lead firms can create value by transforming the innovations of others into products that consumers find useful and usable.

Distribution is done by a few global wholesalers such as Arrow, TechData and IngramMicro. Sales are by large retail chains such as Best Buy, Circuit City, Fry's, CompUSA and Micro Center. They operate on a fixed margin from the vendor and seek scale and reach, but price competition plus capital and operating costs keep margins low.

Sales are also done increasingly by the branded vendors directly online and in cases such as Apple and Sony, through their own stores. The lower cost of direct sales contributes to the lead firm's margins and own store sales may contribute to cross-selling as well.

The figures below expand this generic value chain for the iPod and notebook PC.

Figure 3. Value Chain for an iPod

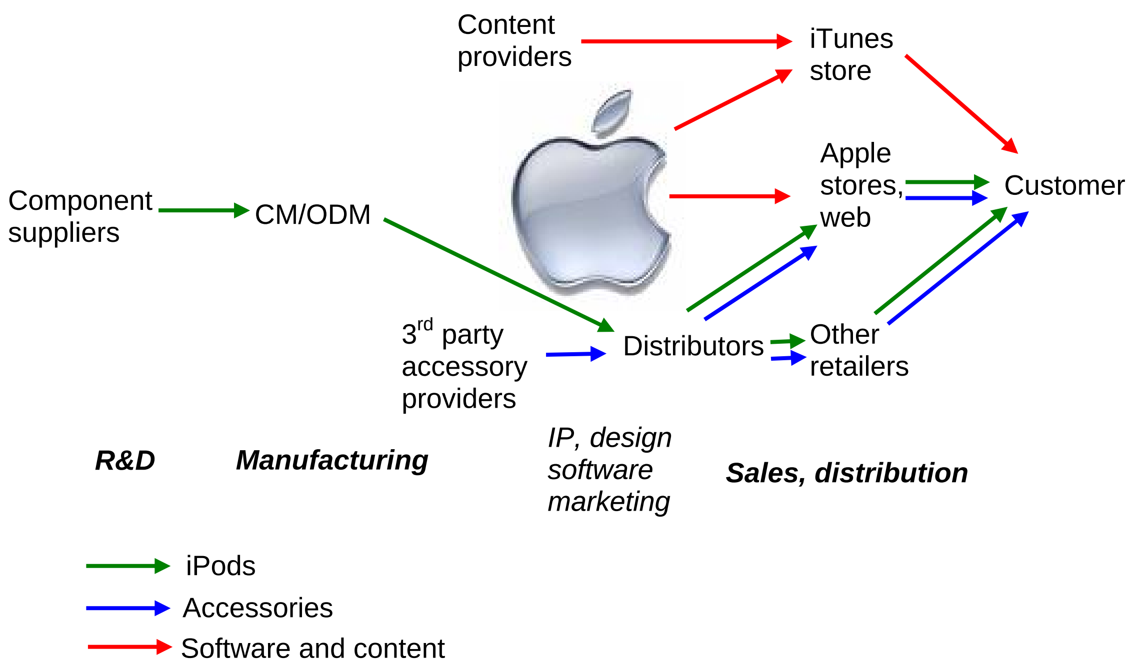


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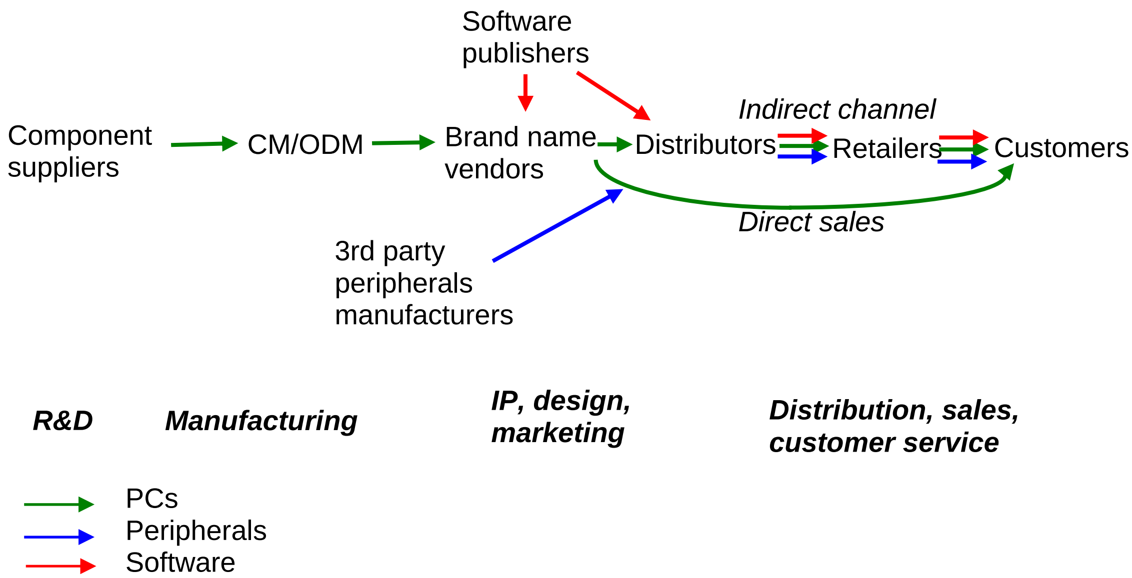
Figure 4. Value Chain for Notebook PC



Using these maps as a guide, we calculate the value added at various stages of the supply chain by estimating the selling price of that stage's output and subtracting the cost of all purchased inputs. The data and method are described fully in another report (Linden et al., 2007a) and briefly described next.

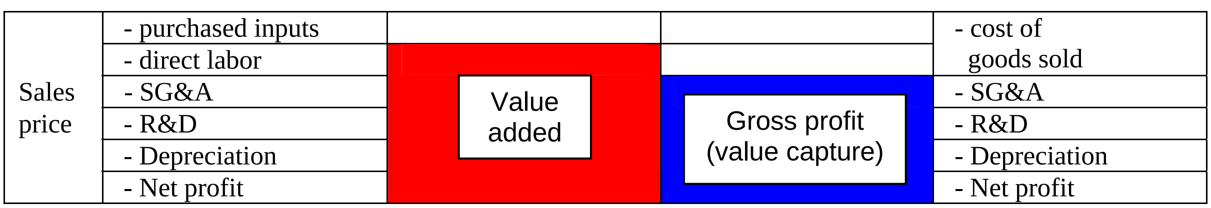
Data sources and analytical approach

Product-level data are extremely hard to obtain directly from electronics industry firms, who jealously protect information about the pricing deals they have negotiated, and often require the silence of their suppliers and contractors through non-disclosure agreements.

For many electronic products, lists of components and their factory prices are available from industry analysts. These "teardown" reports capture the composition of the product at a specific point in time. A teardown report can be used to estimate a product's value added by subtracting the input prices from the wholesale price.

Firm-level information about pure value added isn't readily available because publicly-listed companies do not generally reveal the amount of their wages for "direct labor" (workers who are involved in converting inputs to a salable product). Instead, the wage bill is hidden within "cost of goods sold" or "cost of sales." Therefore, the number we will use to estimate the value captured by suppliers is "gross profit," also called "gross margin," the difference between "net sales" and "cost of goods sold." Gross profit data are readily available from annual reports in the case of public companies. Figure 5 shows the difference between value added and gross profit. The red area includes the components of value added and the blue area includes the components of gross profit, or value captured by the firm.

Figure 5. Components of Value Added and Gross Profit



Gross profit does not equal the full value added, since it excludes direct labor. Instead, it measures the value the company (excluding its direct workers) captures from its role in the value chain, which it then can use to reward shareholders (dividends), invest in future growth (R&D), cover the cost of capital depreciation, and pay its overhead expenses (marketing and administration). In cases such as the iPod or Hewlett-Packard (HP) notebook, where the lead company outsources all of its manufacturing, the value added calculated from the teardown report will be more or less identical to the gross profit.

Since gross profit excludes wages for direct labor, it avoids the geographical ambiguity about where a product was assembled versus where the company is headquartered. The offshore assembly aspect of value distribution needs to be captured in other ways, such as an analysis of the location, quantity, and salary of jobs.

Inside Portable Electronics

Apple's iPod is essentially a portable computer dedicated to media processing. As such, it shares general features with a range of related products, including notebook computers, cell phones, and PDAs. These features include a display, a storage medium, microprocessors, system memory, an input interface, a battery, printed circuit boards (PCBs), a physical enclosure, and software. They all also require assembly services, which are today mostly outsourced.

Using Portelligent teardown reports, we compared the key parts in one model of Apple's iPod (30GB Video iPod from 2005) and a Hewlett-Packard notebook computer (nc6230, also from 2005). Table 2 shows how the two systems compare in terms of each of their features as a percentage of factory cost (the cost of the inputs plus assembly services).

Table 2. Comparison of Inputs as Percentage of Factory Cost: 30GB Video iPod and HP nc6230 notebook

	Video iPod	HP nc6230
Software	Not Applicable	11%
Storage	50%	12%
Display	16%	16%
Processors	9%	27%
Assembly	5%	5%
Battery	2%	5%
Memory	2%	4%
PCBs	2%	2%
Enclosure	2%	1%
Input Device(s)[4]	1%	2%
Subtotal for key components	11%	15%
Hundreds of other components	89%	85%
TOTAL	100%	100%
Total Parts	451	2,196

Note: iPod software was developed in-house by Apple so there is no software license fee in the bill of materials.
Source: Authors' calculations

One major difference is that software does not figure in Apple's bill of materials. The iPod's software was developed in-house, which spares Apple from paying license or royalty fees on each unit sold. In contrast, software licenses for the operating system and applications are a major part (11 percent for the nc6230) of the bill of materials for

[4] "Input Device(s)" vary by product. For a notebook computer, it is the keyboard and trackpad (or other pointing device). For the iPod, it is the scroll wheel.

notebooks, which means that this portion of the value is captured by another firm (i.e., Microsoft).

Another key difference is that the iPod's limited-purpose microprocessors are relatively inexpensive as a share of costs (9 percent) compared to the notebook's general-purpose processor chipset (27 percent). By contrast, the iPod's storage system, a hard-disk drive, accounts for half of the factory cost compared to just 12 percent in the notebook for both the hard disk and DVD drives.

Interestingly, the display module in each system worked out to 16 percent, and the assembly services (including component insertion, board test, and final assembly) to 5 percent of the total.[5] The circuit board, enclosures, and means of input account for a relatively small share in each case. The hundreds of components that occupy supporting roles in the two devices only amount to 11 to 15 percent of the total input cost.

The details for these and three similar products (an earlier-model iPod, an iPod Nano, and a Lenovo ThinkPad) are presented in five tables in the Appendix. These tables show specific parts detail for the hard drive and other storage devices, the display assembly, the processor chips, the battery, and short-term memory chips.

The tables omit details for the PCBs, case, and input devices, as well as a host of smaller parts. Functionally, these parts might be very important for a particular product,[6] but their cost is relatively low. Their inclusion would not materially affect the results we report below.

Cross-model comparisons

To better understand the composition of the iPod, we compared three different models for which information was available: the third-generation hard drive-based iPod, which went on sale in early 2003 at $399; the fifth-generation hard drive based Video iPod, which went on sale in October 2005 at $299; and the initial model of the flash-based iPod Nano, introduced in September 2005 at $249. The hard drive base units used in the Portelligent teardowns both have a storage capacity of 30 gigabytes (GB), and the Nano a capacity of 4GB. Different capacity models were also available for sale but were not analyzed.

The share of the main inputs in the factory cost is roughly similar, even between the hard drive and flash-based models. Table 3 compares the relative cost of these main functional parts for each model.

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[5] See p.15 for a discussion of how the assembly total was estimated from Portelligent data.
[6] For example, the iPod's case entails design finesse, requires great precision in its manufacture, and is a key part of the Apple brand image, but it's a small proportion (2%) of the bill of materials.

Table 3. Cost of Parts and Services for iPod Models

	30GB iPod, 2003	30GB Video iPod, 2005	4GB Nano, 2005
	Price of key functional parts as percentage of factory cost		
Storage	61%	50%	67%
Display	3%	16%	9%
Chips*	6%	12%	7%
Battery	2%	2%	1%
Assembly Services	5%	5%	4%
Estimated factory cost	$184.92	$148.10	$156.28
Total number of parts	424	451	359

*Includes processors and memory chips; some chips not included here.
Note: Software not shown because developed in-house by Apple so there is no software license fee in the bill of materials.
Source: see Appendix tables A-1 to A-3.

Appendix tables A-1 to A-3 provide a detailed breakdown of these key inputs, which account for about 77 and 88 percent of the cost of parts for the models studied. The balance is accounted for by hundreds of parts, mostly small in value, including dozens of resistors and capacitors worth less than a penny each.

The costliest input in each of the three iPod models is storage (hard drive or flash memory). In the 2003 iPod, the 30GB hard drive from Japan's Toshiba has an estimated cost of $112, which alone amounts to more than 60 percent of total input cost. The same is true in the Video iPod, although by 2005, Portelligent's cost estimate for the Toshiba drive has dropped to $73 (50 percent of total input cost), which reflects the typical price reductions (in this case approximately 20 percent per year) of electronics components over time.

In the 2005 Nano, the costliest input is the 4GB of flash memory from Korea's Samsung. In the 4GB model analyzed here, this solid-state storage accounts for 67 percent of the input costs, although this would have been approximately 51 percent if we had looked at the 2GB model that was available at the same time.

Table 3 shows that, unlike the hard drive, the display becomes a larger part of the bill of materials between 2003 and 2005 as the iPod evolves from a music to a multimedia player. The increased complexity also raises the cost share of the microchips, with a video processor from U.S.-based Broadcom added to the main controller from PortalPlayer, a U.S. start-up company. PortalPlayer's chip by itself in 2005 had fallen to $4.94 from the $6.18 estimated cost of the analogous chip in the 2003 model, a decline of about 10 percent per year.

Table 4 shows a similar cost breakdown for two 2005 notebook models, including the Hewlett-Packard nc6230 from Table 1. Details are in Appendix tables A-4 and A-5.

Table 4. Cost of Key Parts and Services for Two Notebook PC Models

	Hewlett-Packard nc6230	Lenovo ThinkPad T43
	Price of key functional parts as percentage of factory cost	
Storage	12%	12%
Display	16%	15%
Chips*	27%	27%
Battery	5%	5%
Software	11%	11%
Assembly Services	5%	5%
Estimated Factory Cost	$877.83	$898.27
Total number of parts	2,196	2,477

*Includes processors and memory chips; some chips not included here.
Source: see Appendix tables A-4 to A-5.

The breakdown is very similar across the two makes. The bill of materials is dominated by the processors, particularly the central processor, which in both cases is an Intel Pentium M, estimated by Portelligent at $127.[7] Following that is the display in each unit, which in both cases came from a Japanese joint venture company, Toshiba-Matsushita Display, that has also supplied some of the iPod's displays.

Next in magnitude are the storage devices (hard drives from Hitachi and Fujitsu and DVD-ROM drives from Hitachi-LG, a Japan-Korea joint venture, or Matsushita) and the operating system (Windows XP Pro).

Value Capture along the Supply Chain

As the component breakdowns above make clear, many companies contribute to every iPod and notebook personal computer (PC). However, the price of the component a company provides does not correspond directly to the value that it captures from the sale.

The bill of materials

We use the parts lists in Appendix tables A-1 to A-5 to estimate firm-specific value capture for the iPods and notebooks. These estimates are shown in the right-hand column of the Appendix tables.

Our basic procedure for deriving these values uses the gross profit rate of the company that supplies the part for the year the product was manufactured. For a few smaller parts, we have had to make an educated guess about the location of the firm that supplied the part and a representative gross profit rate (marked with asterisks in the tables). These estimates, limited to the batteries in three of the products and the monochrome display in

[7] Volume discounts for components are not disclosed by the companies involved, and Portelligent notes that its estimate for the processor chips "should be scrutinized carefully" (Portelligent, 2005c). While this and other numbers may not be perfectly accurate, they are close enough for the purposes of this analysis.

the 2003 iPod, do not materially affect the patterns of value capture discussed below because of the relatively small amounts involved. These inputs were assigned to Japan because of the dominance of Japanese companies in these technologies.

We illustrate this approach to estimating value capture using the Video iPod.

Storage

We begin with the hard drive, supplied by Toshiba. The use of company-wide gross profit may be inaccurate for a company like Toshiba that makes a wide range of products, from memory chips to power-generating facilities, but it can suffice for a first approximation. According to Toshiba's income statements, its gross margin for the fiscal year ended March 2006, which was 26.5 percent of net sales.[8] As points of comparison, the gross margins for 2005 of the two top firms who produce only hard drives, Seagate and Western Digital, were 23.2 percent and 19.1 percent, respectively.[9] Using Toshiba's overall gross margin, recognizing that it is on the high side for the hard drive industry, the value captured by Toshiba and assigned to Japan for the Video iPod is about $20.

Display

The display used in the Video iPod was supplied by Toshiba-Matsushita Display, a joint venture. The estimated factory price was $23.27, and the average gross margin for Toshiba and Matsushita was 28.7 percent, which would translate into an additional $6.68 captured by Japan.[10]

Processors

Next are two microchips from U.S. companies, Broadcom and PortalPlayer, that control video playback and manage the iPod's functions, respectively. Their gross margins in 2005 were 52.5 percent and 44.8 percent, respectively, leading to an estimate of $6.60 in value captured assigned to the U.S.[11]

Battery

In the case of lithium-ion batteries, Portelligent was not able to identify the supplier, nor were we able to do so through our own research. The market for lithium-ion batteries is dominated by three Japanese companies, Sanyo, Sony, and Matsushita, who collectively

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[8] Gross profit rate calculated from data at http://www.toshiba.co.jp/about/ir/en/finance/pl.htm.
[9] Calculated from Edgar Online data accessed at http://finance.yahoo.com.
[10] Matsushita margin of 31% for fiscal year ended March 2006 calculated from data at: http://finance.yahoo.com/q/is?s=mc&annual. Toshiba margin was already discussed in the hard drive analysis.
[11] Gross margins from http://finance.yahoo.com/q/is?s=BRCM&annual and PortalPlayer's 10-K for the year ending December 31, 2005.

account for more than half the market.[12] Their respective gross margins in the fiscal year ending March 2006 were 18 percent, 31 percent, and 31 percent.[13] Because Sanyo's low margin appears to be due to problems in its non-battery lines of business,[14] we assigned a gross margin of 30 percent to the Video iPod battery.

Memory

A similar analysis was performed for the three chips serving as memory from Samsung (main system memory), Spansion (non-volatile flash memory for retaining settings between uses), and Elpida (memory support for the video processor).[15]

Assembly

Our estimate of the value captured by the placing of components on circuit boards, board testing, and final product assembly, required a different approach. A fair amount of component insertion and final product assembly of electronics goods is outsourced to specialist suppliers of manufacturing services, especially by U.S. companies. Since it is not clear from a teardown whether a product was assembled in-house or by a supplier, Portelligent's reports include only an estimate of the direct cost of component insertion, test, and final product assembly, as opposed to the total cost of manufacturing services if supplied by a contract manufacturer.

As best we can determine, all manufacturing except the final assembly of the Lenovo notebook PC was outsourced to Taiwanese companies with factories in mainland China. Apple's initial manufacturing partner for the iPod was Taiwan's Inventec.[16] While Inventec reportedly continues to assemble the hard-drive based iPods, another Taiwanese company, Hon Hai (also known under the brand name Foxconn) was hired to assemble the Nano.[17] In the Lenovo ThinkPad, the main PCB (which accounts for 93 percent of insertion and test cost) was assembled by Universal Scientific Industrial. Although we do not know the specific company that assembled the Hewlett-Packard PC, H-P uses several

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[12] 2002 market data from Institute of Information Technology, Japan, reported in NIST (2006). Subsequent mentions in the press (e.g. Tim Culpan, "Sony Battery Recall to Cause Shortage Until June, Makers Say," Bloomberg.com, October 12, 2006) suggest that this is still the case.

[13] Calculated from data at http://www.hoovers.com/sanyo/--ID__41882,target__financial_information--/free-co-samples-index.xhtml, http://finance.yahoo.com/q/is?s=SNE&annual, and http://finance.yahoo.com/q/is?s=mc&annual.

[14] Based on a review of business segment data in Sanyo Financial Statements: http://www.sanyo.co.jp/ir/e/library/pdf/financialstatements/fs-2006.pdf

[15] 2005 gross margins from: http://samsung.com/AboutSAMSUNG/ELECTRONICSGLOBAL/InvestorRelations/FinancialInformation/AnnualFinancialSummary/Income.htm, http://finance.yahoo.com/q/is?s=SPSN&annual (Spansion), and http://investing.businessweek.com/businessweek/research/stocks/financials/financials.asp?symbol=6665.T&dataset=incomeStatement&period=A&currency=US%20Dollar (Elpida).

[16] Levy (2006), Chapter "Origin."

[17] Daniel Shen, "Sources: Inventec Appliances making video iPod for Apple," DigiTimes.com, October 14, 2005.

contract manufacturers in Taiwan, including Arima, Compal, Hon Hai, Inventec, Quanta, and Wistron.[18]

We have approximated the market price of these assembly and test services by assuming a 100 percent mark-up over Portelligent's labor-only cost estimate. This approach was chosen as a reasonable approximation after assessing the income statements of typical contract manufacturers. The reported gross margins of contract manufacturers tend to be small, but this is misleading because they often carry some or all of the unassembled components in their Cost of Goods Sold. The $1.22 in-house labor cost for Lenovo's final assembly was included in "Other Parts" along with input costs.

Upstream value capture

For the complex, high-value components, we are also researching upstream value captured by the supplier's suppliers, especially where these have cross-border implications.

This can involve extensive research, and the values involved are inherently small. We will use PortalPlayer's controller chip as an example. According to PortalPlayer's last 10-K filing before it was acquired by Nvidia in 2006, PortalPlayer's manufacturing was outsourced to Taiwan Semiconductor Manufacturing Corp. (TSMC) or LSI Logic, a U.S. company.

Chip fabrication typically accounts for about a third of the factory price of a chip, so approximately $1.63 of PortalPlayer's cost of goods sold can be attributed to Taiwan. TSMC's gross margin for 2005 was 44 percent and LSI Logic's was 43 percent, so about $0.70 was captured in this way. However, given that we do not know whether TSMC or LSI Logic did the chip fabrication, it is unclear whether this value capture should be attributed to the U.S. or Taiwan, so we have omitted it from the geographic breakdown, below.

PortalPlayer's chip also requires a license for one of its main elements, the processor core, from a British company named ARM. ARM charges anywhere from $0.35 to $2.00 per chip in royalties, which is almost pure gross profit and should be assigned to Great Britain.[19] This amount will not be discussed further since so little value in these products is captured by European firms.

A similar upstream analysis could be conducted for the Video iPod's hard drive, which contains a number of external inputs, including chips, disks, motor, and head assembly, and for the display module, which includes a display panel and an embedded chip.

[18] Celia Lin and Jessie Shen, "HP to strengthen Taiwan R&D facility and partnerships with notebook makers," DigiTimes.com, September 26, 2005.
[19] Royalty rate estimate from Jim Turley, "Embedded Processors, Part One," January 11, 2002, http://www.extremetech.com/print_article/0,3998,a=21014,00.asp

Beyond the bill of materials: distribution and retail

Once the product is manufactured, there is still a great deal of value to be captured. The retail price of the 30GB Video iPod at the time of Portelligent's analysis was $299. Based on our research, we estimate a 25 percent wholesale discount for each unit, with 10 percent for distribution and 15 percent for retail.[20] These amounts were applied to each iPod and notebook PC in our study, although we continue to research the reasonableness of this assumption.

Applying all these estimates to the retail price, we were able to arrive at an estimate of Apple's gross margin on each 30GB Video iPod sold. Apple is the lead firm in the iPod value chain, incurring costs for R&D, marketing, coordination of the entire value chain, and other overhead costs such as warranty.[21] It is the residual claimant for value capture, as detailed in Table 5.

Table 5. Derivation of Apple's Gross Margin on 30GB Video iPod

Retail Price	$299	
Distributor Discount (10%)	($30)	
Retailer Discount (15%)	($45)	
Sub-Total (estimated wholesale price)		$224
Factory Cost	($148)	
Remaining Balance (estimated Apple gross margin)		$76

Source: Authors' calculations; see text.

Apple's estimated gross profit on these units would be $76, which works out to 34 percent of the $224 estimated wholesale price for this model. This is not far from Apple's overall corporate gross margin of 29 percent for the year ending September 30, 2006.[22]

Apple's estimated $76 profit is greater than the price of any single input, so it is definitely greater than the value captured by any of its partners. And for sales through Apple's own web or store outlets, it also captures the retailer discount of $45.

[20] A gross profit margin of "less than 15 percent" for non-Apple sales is claimed in Damon Darlin, "The iPod Ecosystem," New York Times, February 3, 2006, so Apple's wholesale discount would need to be at least this large. The distribution estimate is from an industry interview.

[21] We examined whether warranty expenses were higher for Apple than for the notebook computer companies because of the iPod's full exposure to the consumer market (as opposed to the notebook industry's mix of enterprise and consumer customers). Based on published data (http://www.warrantyweek.com/archive/ww20070508.html), Apple's overall warranty expense as a share of sales is lower than that for the major computer manufacturers for the period 2003-2006. We also interviewed a former Apple employee (February 2007), who indicated that, although warranty costs were considered too high in the iPod's early years, return rates were gradually brought to an acceptable level even as sales volume rose substantially.

[22] Calculated from data at http://finance.yahoo.com/q/is?s=AAPL&annual. Gross margin for the preceding year was also 29%.

Similar estimates of value capture were made for all the products in our study. The results are shown in Table 6.

Table 6. Lead Firm Estimated Gross Margins for Five Products[23]

Product	Retail Price	Estimated Wholesale Price	Estimated Gross Profit	Gross Profit as Percentage of Wholesale Price
30GB 3rd-Generation iPod, 2003	$399	$299	$114	38%
30GB Video iPod, 2005	$299	$224	$76	34%
4GB iPod Nano, 2005	$249	$187	$30	16%
Lenovo ThinkPad T43, 2005	$1,479	$1,109	$212	19%
Hewlett-Packard nc6230, 2005	$1,399	$1,049	$171	16%

Source: Author's calculations; see text.

Apple's iPod gross margins are generally higher than those for the two notebook models. The lower Nano margin may be due partly to its being targeted at the mass market, rather than Apple's usual premium niche, but it may also represent an overestimation of the price that Apple actually paid for the flash storage that accounts for two-thirds of the Nano's factory cost (see Appendix Table A-3). Apple reportedly negotiated deep discounts from flash suppliers in exchange for high volume at the time of the Nano's introduction.[24]

Apple's higher gross margin is partly dissipated by its extra overhead costs.[25] As mentioned above, Apple's in-house software was critical to the iPod's success, but absent from the bill of materials. Apple's internal electrical and mechanical engineering capability, which determine important details like the quality of an audio circuit, the ability to pack components in a limited space, and the materials chosen for the case, add value to the raw components that make an iPod.

Other lead firms vary in the level of internal engineering capability they maintain. For example, HP relies more on ODMs for development engineering (mechanical and electrical engineering, PCB layout, and software engineering), whereas Lenovo relies more on the internal capability acquired with the IBM PC division (although Lenovo also outsources to ODMs). Both have their own design engineering capabilities for the critical task of establishing initial specifications that balance market demands and technology trends.

For the makers of Intel-based computers, it is hard to get around the fundamental economics that siphon off a large share of industry profits to Microsoft and Intel, whose

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[23] The product-specific gross margins in Table 5 are calculated as described in the text. They are different from the gross margins for inputs listed in the Appendix tables, because those are company-wide values from published corporate reports.
[24] David Lammers, "iPod upsets NAND flash Applecart," EE Times, August 19, 2005.
[25] For the company as a whole, a 29% gross margin for fiscal year 2006 falls to 10% net margin after all expenses.

ownership and maintenance of valuable standards (operating system and processor architecture, respectively) allow them to charge a considerable premium for their components. Network effects that favor these inputs make it hard for computer companies to find alternate suppliers. In the HP nc6230, for example, we estimate HP's gross profit as a percentage of wholesale price to be 16 percent. Intel and Microsoft combined have a gross margin of about 66 percent on components whose value equals about 30 percent of the wholesale price, which means their combined gross profit works out to 20 percent of the wholesale price. In other words, the Intel-Microsoft gross profit is 125 percent of the HP gross profit.

As noted earlier, the iPod is not just a hardware innovation, but an integrated system comprised of the iPod product family and closely integrated with its iTunes software and iTunes Music Store. Apple built up its iPod ecosystem in stages, as acceptance of the product justified additional effort. The initial iPod, introduced in Fall 2001, was integrated with iTunes only on Apple's own Macintosh platform. Two years later, Apple added support for the Windows platform, greatly expanding the available market. None of the technologies behind the iPod or iTunes were controlled exclusively by Apple.

This changed in April 2003 with the introduction of iTunes Music Store (iTMS) with cooperation from all the major music labels. The iTMS uses an exclusive system of digital rights management called FairPlay, which limits the number of computers on which the purchased tracks can be played. More importantly, FairPlay-encoded tracks will not play back on any portable players other than the iPod or Apple-licensed players such as Motorola's ROKR phone, since Apple has chosen not to license the system to its rivals.

The combination of Apple's radical innovation, the first legal music downloading service with a large library, and its control of the underlying digital rights management system produced a network effect that helped keep the iPod ahead of its many competitors. To take advantage of this opportunity, Apple reportedly spent $200 million on advertising in the iPod's first four years, which was far more than the advertising of its music-player rivals.[26]

The iPod case makes clear how a successful radical innovation creates the potential for a firm to retain a significant share of profits even when relying on a global network. Apple maintains control over its supply chain by controlling essential elements such as core software, a proprietary standard, or complementary infrastructure.[27] Table 7 shows how Apple's total gross profit compares to that of other firms in the value chain for sales inside and outside the U.S. According to International Data Corporation (IDC), about 40 percent of its hard-drive-based iPod sales are overseas.[28] In the table, the gross margin for "Retail" has been subdivided to reflect our estimate of the share of Apple sales that are made through its website or its growing chain of Apple Stores.

[26] Levy (2006), Chapter, "Cool."
[27] For related analyses, see Chesbrough and Teece (1996) and Jacobides, et al. (2006).
[28] Estimated from data for 2006 in "Worldwide and U.S. Portable Media Player 2007-2011 Forecast and Analysis." IDC Report #206016, March 2007.

Table 7. The Distribution of $190 of Captured Value in a Single 30GB Video iPod

	Sales in the U.S.		***Sales outside U.S.***	
Value Chain Segment	**Apple**	**All other firms**	**Apple**	**All other firms**
Apple Gross Margin (development, software, marketing)	$76		$76	
Parts Suppliers (key inputs only, Table A-2)		$35		$35
Manufacturing (assembly, test)		$4		$4
Distribution		$30		$30
Retail*	$23	$22	$11	$34
TOTAL VALUE CAPTURE	$99	$91	$87	$103

*"Retail" is split between Apple and other firms based on our estimate that one-half of all retail sales in the U.S. and one-quarter of all retail sales outside the U.S. are by Apple through its stores and online website.
Source: Authors' calculations; see text.

Table 7 shows that Apple, the lead firm in the iPod value chain, fares significantly better than any of its partners. Apple captures 52 percent of the measured value from U.S. sales and 46 percent from sales outside the U.S. – well beyond the 18 percent captured by all suppliers of key parts or the shares for distribution and non-Apple retail. *This underscores the importance of innovation by a lead firm.*

The Geography of Value Capture

Our analysis can also be used to study the distribution of value capture by country. Table 8 shows this for the Video iPod.

Table 8. The Geography of $190 of Captured Value in a 30GB Video iPod for a Unit Sold in the U.S.

	U.S.	**Japan**	**Korea**	**Taiwan**	**Total**
Apple Gross Margin (development, software, marketing)	$76				$76
Parts Suppliers (key inputs only, Table A-2)	$7	$27	$1		$35
Manufacturing (assembly, test)				$4	$4
Distribution	$30				$30
Retail	$45				$45
TOTAL VALUE CAPTURE	**$158**	**$27**	**$1**	**$4**	**$190**

Note: For this table it is assumed that the unit is sold in the U.S.
Source: Authors' calculations.

As noted above, hundreds of low-value inputs with a total estimated price of $24 have not been included, but the dominance of the U.S. share is robust to any possible distribution of supplier geography of these inputs. Even if the as-yet-unanalyzed inputs have a gross margin as high as 40 percent and were all from a single country, which is unlikely, the most this would add to that country is $9.12.

In the case of retail units sold in other countries, a significant portion of the U.S. share would shift elsewhere. For a unit sold in Japan through a non-Apple retailer, the total value captured by Japanese companies might even be larger than the U.S. share, as shown in Table 9.

Table 9. The Geography of $190 of Captured Value in a 30GB Video iPod for a Unit Sold in Japan (Totals Only)

	U.S.	Japan	Korea	Taiwan	Total
TOTAL VALUE CAPTURE	$83	$102	$1	$4	$190

Note: For this table it is assumed that the unit is sold in Japan through a non-Apple retailer.
Source: Authors' calculations.

Applying this methodology to all five products in our study yields the results shown in Table 10.

Table 10. The Geography of Value Capture for Five Products

	Retail Price	Distrib.	Retail	Lead Firm Gross Margin	U.S. Inputs	Japan Inputs	Korea Inputs	Taiwan Inputs	Total
30GB iPod, 2003	$399	$40	$60	$114	$4	$32	$2	$5	$257
30GB Video iPod	$299	$30	$45	$76	$7	$27	$1	$4	$190
4GB iPod Nano, 2005	$249	$25	$37	$30	$3	$4	$32	$3	$134
HP nc6230, 2005	$1,399	$140	$210	$171	$216	$81	$11	$23	$852
Lenovo T43, 2005	$1,479	$148	$222	$212	$214	$81	$15	$22	$914

Source: Authors' calculations

To facilitate cross-product compatibility, Table 11 restates the geographic breakdowns in terms of percentages.

Table 11. The Geography of Value Capture for Five Products
(percentages relative to total measured value capture as described in text)

	Total Value Capture	Distrib.	Retail*	Lead FIrm Gross Margin	U.S. Inputs	Japan Inputs	Korea Inputs	Taiwan Inputs	
30GB iPod, 2003	$257	16%	23%	44%	2%	12%	1%	2%	100%
30GB iPod, 2005	$190	16%	24%	40%	4%	14%	1%	2%	100%
4GB iPod Nano, 2005	$134	19%	28%	22%	2%	3%	24%	2%	100%
HP nc6230, 2005	$852	16%	25%	20%	25%	10%	1%	3%	100%
Lenovo T43, 2005	$914	16%	24%	23%	23%	9%	2%	2%	100%

*Retail value capture earned by Apple for units sold through Apple Store outlets.
NOTE: Apple and Hewlett-Packard are U.S.-based firms. Lenovo is, in terms of ownership at the time of the Portelligent reports, 25 percent U.S. and 75 percent Chinese (see footnote 29).
Source: Authors' calculations.

The total U.S. share is determined by a combination of the country where the unit is sold and the identity of the lead firm. This is shown in Table 12, in which the retail and distribution shares for the two notebooks are assigned based on where the unit is sold. The high margins of Intel and Microsoft (Appendix Tables A-4 and A-5) secure a large share of value for the U.S. However, the bulk of value from non-U.S. sales still goes overseas, and the effect is increased when the brand belongs to the Sino-American firm Lenovo rather than the U.S.-based Hewlett-Packard.[29]

Table 12. Value Capture by Location of Sale

	HP nc6230		Lenovo T43	
	If sold in the U.S.	**If sold elsewhere**	**If sold in the U.S.**	**If sold elsewhere**
U.S. Value Capture	$737	$387	$637	$267
Other Value Capture	$115	$465	$277	$647
U.S. Share of Value Capture	87%	45%	70%	29%

Source: Authors' calculations.

As noted above, there are additional parts that have not been analyzed. As a robustness check, we assumed a relatively high 40 percent all-non-US margin on these extra inputs (which work out to just over $70 in both cases) and the results (not shown) are qualitatively the same.

[29] In 2005, Lenovo acquired IBM's PC business. IBM accepted shares equal to about 15% in partial payment. At the same time, Lenovo received an equity infusion equal to 10% from three U.S. based investment firms. We assign Lenovo's profits here to the U.S. and China using a 25-75 split.

Table 12 makes clear how important the headquarters location of a firm can potentially be for the headquarters country. Our estimate of the U.S. share of value capture from the HP notebook is 87 percent of the total when the sale is in the U.S., and this falls to somewhat less than half when the sale is elsewhere. By contrast, the U.S. share when the Lenovo notebook is sold in the U.S. is 70 percent and falls to 29 percent when the sale is elsewhere.

The comparison would be even more extreme if we compared the results for the iPod in Tables 8 and 9 with a hypothetical case in which everything was the same except that the lead firm was Japan's Sony.

Although distribution and retail loom large in terms of value capture, headquarters location of the lead firm is the most relevant variable for policy. A policy that reduced overseas sales would obviously be counter-productive, whereas policies to stimulate the creation, growth, and retention of innovative firms are well within the reach of governments.

The gross profit that we are calling "value capture" is of paramount importance for countries. Some of it goes to shareholders, but mostly it goes to high-paying jobs in product development, marketing, and middle management that coordinate the lead firm's development and manufacturing partners. Although some of this work will be done offshore, most of these core jobs are still located near company headquarters (Dedrick and Kraemer, 2006).

Geography, value capture, and innovation

At the country level, the greatest value in iPods and notebook PCs is captured by the U.S. and Japan. Korea also has a significant role thanks to its strengths in a few core technologies, while Europe, Taiwan, and China are less visible. We now look briefly at the generalizability of these results.

The value-capture results reflect the global distribution of companies. The U.S. and Japan are home to most of the world's major brand-name electronics companies, and also to the most advanced suppliers of most core technologies such as semiconductors, storage, displays and software. Europe, where significant innovation still occurs, has seen a gradual retreat of its lead electronics firms, with Thomson (RCA brand), Siemens, and Philips all consolidating or diversifying their activities.

Korea also has two major global brand-name manufacturers: Samsung, which is a strong competitor in other product categories such as mobile phones and TV sets, and LG Electronics, its smaller rival. Taiwan has produced one significant lead firm, Acer, and several major producers of components, such as TSMC (logic chips) and AUO (flat-panel displays), but Taiwanese firms have generally adopted fast-follower or trailing-edge strategies that may be denying them the opportunity to capture value from innovation and brand leveraging.

As we have seen, China, where most of the world's notebook PCs and all of Apple's iPods are assembled, captures very little value from either. In spite of the success of a few Chinese brands (e.g. Lenovo and Huawei), China has yet to move much beyond its role as provider of low cost labor to support the firms who capture most of the value of innovation.

The discussion so far has focused primarily on brand-name capital, but it is also supported by data on innovation. Table 13 summarizes the top 50 grantees of U.S. invention patents for 2005.[30] The grantee companies (not shown) are primarily electronics companies, with automotive companies also represented.[31]

Table 13. Top 50 U.S. Patent Grantees by Country, 2005

Country or Region	Number of Grantees	Number of Patents
United States	25	18,310
Japan	16	14,710
Europe	5	3,359
Korea	3	2,490
Taiwan	1	441

Source: Calculated from data in "IFI Issues List of 2005's Top Patent Companies," IFI Patent Intelligence Press Release, January 10 2006.

Although the quantity of patents does not address the widely-varying value of the underlying inventions, the data are suggestive and generally support the qualitative discussion above. The United States and Japan have the most companies and patents. Europe and Korea form a second tier. Taiwan is represented only by TSMC, and China is absent.

Taiwanese firms are generally smaller than the conglomerates of Korea and Japan, so we also looked at a broader selection of Taiwanese firms. The top 10 Taiwanese grantees of U.S. invention patents received a total of 1,571 patents in 2005, still well below Korea's top three (Samsung, LG Electronics, and Hynix Semiconductor).[32]

Therefore, both casual observation and patent data indicate that the geographic distribution of value capture that we noted in our study is firmly rooted in the innovative activities of the companies in each region.

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[30] All grantees are private companies except for the Regents of the University of California, who were granted 410 patents in 2005.
[31] Because some of the Japanese conglomerates, such as Toshiba and Hitachi, also produce heavy industrial goods, it was not possible to make an electronics-only sub-list.
[32] Data for Taiwan's top 10 patent grantees from Yen-ting Chen and Adam Hwang, "TSMC tops Taiwan companies in US patents in 2005," DigiTimes.com, September 22, 2006.

Conclusions

As we have shown, the distribution of value captured in the iPod and notebook PC models is quite different between firms, yet relatively consistent at the national level. Therefore, our study has different implications for managers and policymakers.

The firm level

The firm level is where the difference between radical and incremental innovation can be seen.

The greatest value for the more radical iPod innovation is captured by the brand-name system integrator, Apple, which controls the product architecture and was successful in finding the right combination of hardware, software and content distribution to have a winning product. For notebook PCs, a mature product category, the greatest value is captured by Microsoft and Intel, who were able to usurp control of the architecture from the system vendors (namely IBM) and now largely control the trajectory of software and hardware evolution.

This dominance over value capture is generally asserted in the formative years of a new technology, when the technology direction is not yet defined, and then tends to harden in place once the incremental stage is reached. In PCs, Microsoft has no real competitors, and Intel faces only limited competition from AMD. In portable music players, there seem to be fewer "iPod killers" over time, and those who predicted Apple would succumb to Microsoft as it did in PCs have become quite silent as Microsoft gave up on its open architecture approach ("Plays for Sure") and has had little success with its proprietary Zune. Of course the battle is not over, but it seems to be shifting to other fronts such as mobile phones and the digital home.

The implication for managers is that strategy should be conceived in terms not of products, but of ecosystems. What bundles of market requirements are not yet being met? What complementary products would raise the value of what your firm can offer?

Opportunities to define and dominate a new product category through radical or architectural innovation are rare, but can occur at any time and can be pioneered by any company. Earlier examples include Seagate in hard drives, Nokia in mobile phones, and Nintendo in video games.[33]

The national level

Our results show that, on average, countries tend to occupy well-defined spaces in global supply chains. The innovative countries innovate, while the other countries nip at their heels and capture a small share of the value created. These relationships are not written in stone, but are slow to change.

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[33] See for example, Mitchell (1991) and Rosenbloom and Christensen (1994) for discussions of how newcomers and industry incumbents fare following the introduction of innovations.

For policymakers, this means that support policies should be geared toward improving or maintaining a country's position. Lead countries such as the U.S. and Japan have been well served by policies supporting R&D and innovation.

Policymakers also should embrace the fact that no single company or country is the source of all innovation, and all companies need to work with international partners. This is simply a fact of the electronics industry in the 21st century, and policy makers should do what they can, in terms of trade and other policies, to facilitate the participation of local companies in these networks.

Developing countries benefit from their roles as low-cost manufacturers and offshore product development centers, creating jobs and export earnings, but do not capture much of the value created through innovation. Policymakers in developing countries need to look for ways to leverage local knowledge into commercial success. Examples such as Korea's Samsung, Taiwan's Acer and TSMC, China's Lenovo and Huawei, and India's Wipro and Infosys show that companies from developing nations can compete on the global stage. As in the case of Samsung, they can, on occasion, even humble the strongest U.S. or Japanese competitors.

China provides an example of a country with an active industrial policy that is not limited to its current place in global value chains. The government of China is not satisfied with China's role as a source of cheap labor and is promoting the development of global brand-name companies. With its huge domestic market to provide a strong home base, it is likely that at least some of these national champions will succeed. The government is also supporting efforts to develop China-only product standards that could potentially become global standards, although for the time being its reach exceeds its grasp (Linden, 2004).

As long as the U.S. market remains dynamic, with innovative firms and risk-taking entrepreneurs, global innovation, both radical and incremental, should continue to create value for American investors and well-paid jobs for knowledge workers. But if those companies get complacent or lose focus, there are plenty of foreign competitors ready to take their places. If this happens, the benefits from the global innovation system could quickly shift away from the U.S.

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Appendix

Table A-1. Key Inputs in the 30GB 3rd-Generation iPod, 2003

Type	Input	Supplier	Supplier HQ Country	Estimated Input Price	Price as % of Factory Cost	Supplier Gross Profit Rate	Estd. Value Capture
Storage	Hard drive	Toshiba	Japan	$112.00	61%	26.9%	$30.18
Processor	Controller chip	PortalPlayer	US	$6.18	3%	41.4%	$2.56
Display	Monochrome display assembly	Unknown	Japan*	$5.81	3%	20.0%*	$1.16
Memory	SDRAM - 32MB	Samsung	Korea	$5.23	3%	32.3%	$1.69
Battery	Battery pack	Unknown	Japan*	$3.46	2%	30.0%*	$1.04
		Sub-Total		$132.68	72%		
		Other Parts		$42.64	23%		
		Estimated assembly and test		$9.60	5%		$4.80
		Estimated factory cost		**$184.92**	**100%**		**$41.43**

* - supposition

Source: Portelligent, Inc., 2003 and authors' calculations.

Table A-2. Key Inputs in the 30GB 5th-Generation iPod (Video iPod), 2005

Type	Input	Supplier	Supplier HQ Country	Estimated Input Price	Price as % of Factory Cost	Supplier Gross Profit Rate	Est'd. Value Capture
Storage	Hard Drive	Toshiba	Japan	$73.39	50%	26.50%	$19.45
Display	Display Assembly	Toshiba-Matsushita	Japan	$23.27	16%	28.70%	$6.68
Processors	Video/Multimedia Processor	Broadcom	US	$8.36	6%	52.5%	$4.39
Processors	Controller chip	PortalPlayer	US	$4.94	3%	44.8%	$2.21
Battery	Battery Pack	Unknown	Japan*	$2.89	2%	30.0%*	$0.87
Memory	Mobile SDRAM Memory - 32 MB	Samsung	Korea	$2.37	2%	28.2%	$0.67
Memory	Mobile RAM - 8 MBytes	Elpida	Japan	$1.85	1%	24.0%	$0.46
Memory	NOR Flash Memory - 1 MB	Spansion	US	$0.84	1%	10.0%	$0.08
			Sub-Total	$117.91	80%		
			Other parts	$22.79	15%		
			Estimated assembly and test	$7.40	5%		$3.70
			Estimated factory cost	**$148.10**	**100%**		**$38.50**

* - supposition

Source: Portelligent, Inc., 2006 and authors' calculations.

Table A-3. The Most Expensive Inputs in the 4GB iPod Nano, 2005

Type	Input	Supplier	Supplier HQ Country	Estimated Input Price	Price as % of Factory Cost	Supplier Gross Profit Rate	Estd. Value Capture
Storage	NAND Flash – 4GB	Samsung	Korea	$105.20	67%	30.0%	$31.56
Display	Display Module	Optrex or Sharp or Toshiba-Matsushita	Japan	$13.84	9%	23.0%	$3.18
Processors	Main processor	PortalPlayer	US	$5.11	3%	44.8%	$2.29
Processors	ATA Flash Disk Controller	SST	US	$1.62	1%	18.0%	$0.29
Memory	Mobile SDRAM - 32 MB	Samsung	Korea	$2.62	2%	30.0%	$0.79
Memory	Flash - 512 KB	SST	US	$0.80	1%	18.0%	$0.14
Battery	Battery Pack	Amperex (acq.TDK 2005)	Japan	$2.06	1%	26%	$0.54
		Sub-Total		$131.25	84%		
		Other parts		$18.79	12%		
		Estimated assembly and test		$6.24	4%		$3.12
		Estimated factory cost		**$156.28**	**100%**		**$41.91**

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

Table A-4. The Most Expensive Inputs in the Hewlett-Packard nc6230 Notebook PC, 2005

Type	Input	Supplier	Supplier HQ Country	Estimated Input Price	Price as % of Factory Cost	Supplier Gross Profit Rate	Est'd. Value Capture
Processors	Main chipset + Wi-Fi	Intel	US	$205.43	23.4%	59%	$121.20
Processors	Graphics Processor	ATI Technologies	US	$20.50	2.3%	28%	$5.74
Processors	Ethernet controller	Broadcom	US	$2.01	0.2%	53%	$1.07
Processors	Cardbus Controller	Texas Instruments	US	$3.28	0.4%	48%	$1.57
Processors	I/O Controller	Standard Micro-systems (SMSC)	US	$1.42	0.2%	46%	$0.65
Processors	Battery Charge Controller	Texas Instruments	US	$1.22	0.1%	48%	$0.59
Display	Display Assembly	Toshiba-Matsu-shita Display	Japan	$137.14	15.6%	28%	$38.40
Software	Windows XP Pro OEM license	Microsoft	US	$100.00	11.4%	85%	$85.00
Storage	60GB Hard Drive	Fujitsu	Japan	$68.00	7.7%	26%	$17.68
Storage	DVD-ROM/CD-RW Drive	Matsushita	Japan	$40.00	4.6%	31%	$12.40
Battery	Battery Pack	Unknown	Japan*	$40.52	4.6%	30%*	$12.16
Memory	Memory Module (512 MB)	Samsung	Korea	$29.65	3.4%	30%	$8.90
Memory	DDR SDRAM Memory 2x32 MB	Hynix Semiconductor	Korea	$5.68	0.6%	41%	$2.33
			Sub-Total	$654.85	75%		
			Other parts	$177.72	20%		
			Estimated assembly and test	$45.26	5%		$22.63
			Estimated factory cost	**$877.83**	**100%**		**$330.31**

* - supposition

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

Table A-5. The Most Expensive Inputs in the Lenovo ThinkPad T43 Notebook PC, 2005

Type	Component	Supplier	Supplier HQ Country	Estimated Factory Price	Price as % of Factory Cost	Supplier Gross Profit Rate	Estd. Value Capture
Processors	Main chipset + Wi-Fi	Intel	US	$205.34	22.9%	59%	$121.15
Processors	Graphics processor	ATI Technologies	US	$21.70	2.4%	28%	$6.08
Processors	Microcontroller	Renesas	Japan	$2.83	0.3%	24%	$0.68
Processors	Power Supply Controller	Toshiba	Japan	$2.11	0.2%	26%	$0.55
Processors	Single Chip LAN Controller	Broadcom	US	$2.01	0.2%	53%	$1.07
Processors	PC Card Controller	Ricoh	Japan	$1.81	0.2%	42%	$0.76
Processors	Power management ASIC	IBM	US	$1.42	0.2%	40%	$0.57
Processors	Microcontroller	Philips	Europe	$1.16	0.1%	32%	$0.37
Display	Display Module	Toshiba-Matsushita Display	Japan	$138.32	15.4%	28%	$38.73
Software	Windows XP Pro	Microsoft	US	$100.00	11.1%	85%	$85.00
Storage	60GB Hard Drive	Hitachi	Japan	$68.00	7.6%	23%	$15.64
Storage	CD / DVD Drive	Hitachi-LG Data Storage	Japan	$40.00	4.5%	25%	$9.80
Battery	Li-Ion Battery Pack	Sony	Japan	$41.06	4.6%	37%	$15.19
Memory	Memory Module (512 MB)	Hynix	Korea	$29.68	3.3%	41%	$12.17
Memory	32MB DDR SDRAM	Hynix	Korea	$5.68	0.6%	41%	$2.33
			Sub-Total	$661.12	73.7%		
			Other parts	$192.21	21.4%		
			Estimated assembly and test	$43.72	4.9%		$21.86
			Estimated factory cost	**$897.05**	**100.0%**		**$331.94**

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