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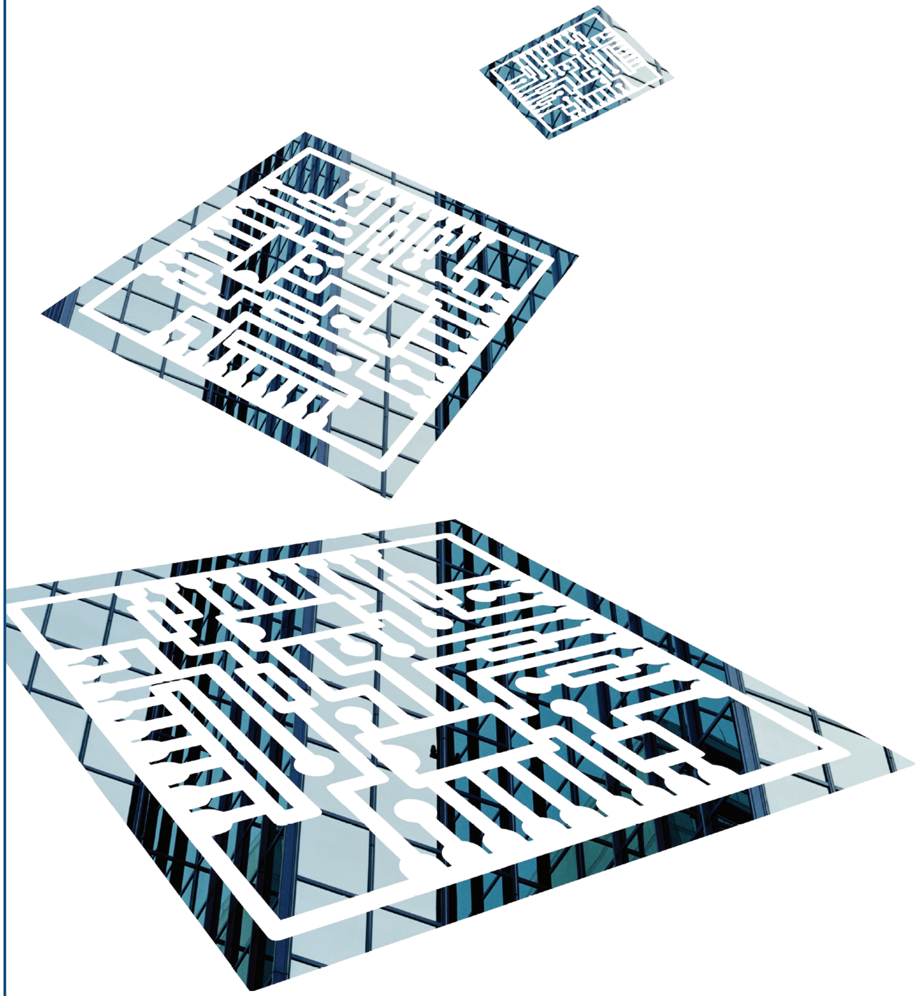

How IT Enables Productivity Growth

The US experience across three sectors in the 1990s

McKinsey&Company

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McKinsey Global Institute

High Tech Practice

Business Technology Office

San Francisco

November 2002

Preface

This report is the product of a six-month project by the McKinsey Global Institute (MGI), working in collaboration with McKinsey's High Tech Practice and Business Technology Office. The objective of the project was to determine how information technology (IT) enabled the managerial innovations that drove US productivity growth in the 1990s. The undertaking of this project is part of the fulfillment of the McKinsey Global Institute's mission to help global leaders: (1) understand the forces transforming the global economy, (2) improve the performance of their corporations, and (3) work for better national and international policies.

Technology is one of the most important forces at work in the global economy and information technology is increasingly built into most aspects of modern economic activity. In 2001, MGI's US Productivity Growth report[1] found that IT was only one of several factors at work in the acceleration of US productivity growth rate in the mid-1990s, but that it was a key enabler of the managerial innovations that generated the high growth. Exactly how did IT enable the managerial innovation that drove the productivity growth in the US? This new study tackled this question by applying our unique microeconomic approach to three major sectors over the 1990s: retail, retail banking and semiconductors.

The findings are in this report, which consists of an executive summary, a summary of our objectives and approach, four chapters, and an appendix. The Objectives and approach summary and the Synthesis chapters review our methods and conclusions across sectors. The following three chapters present our detailed case studies on retail, retail banking, and semiconductors. Each of these cases has a brief summary in the beginning.

This project was conducted under my direction, along with Lenny Mendonca, Mike Nevens, James Manyika, Shyam Lal and Roger Roberts. Martin Baily, Senior Advisor to MGI and Senior Fellow at the Institute for International Economics (IIE), played a principal advisory role.

Terra Terwilliger was responsible for the day-to-day management of the project, and a core group of four consultants from McKinsey's San Francisco, Silicon Valley, and Business Technology Offices made up the dedicated working team.

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[1] MGI "US Productivity Growth 1995-2000, Understanding the Contribution of Information Technology Relative to Other Factors," released October 2001.

Allen Webb from the Seattle office, who co-managed the 2001 US productivity study, ensured the necessary integration across both projects and played a critical editorial role in the final publication. The consultants, with the sections of the report to which they contributed were: Anil Kale (semiconductors); Mukund Ramaratnam (retail banking, retail banking and mobile telecom productivity updates); Eva Rzepniewski (overall publication, synthesis, retail and wholesale productivity updates); and Nick Santhanam (retail, semiconductors, macroeconomic, computer manufacturing, and semiconductors productivity updates). Mike Cho (alum) provided invaluable guidance on macroeconomic topics. Terry Gatto provided administrative assistance to the team.

Throughout the project we also benefited from the unique worldwide perspectives and knowledge that McKinsey consultants brought to bear on the industries researched in our case studies. Their knowledge is a product of intensive work with clients and a deep investment in understanding the structure, dynamics, and performance of industries to support client work. McKinsey sector leaders provided valuable input to our case studies and reviewed our results. McKinsey's research and information specialists provided timely response and critical information under trying deadlines. Finally, we appreciate the warm response, useful information, and insight we received from numerous interviews with corporate executives, industry associations, government officials, and others. We thank all those who gave us their time and help.

Before concluding, I would like to emphasize that this work is independent and has not been commissioned or sponsored in any way by any business, government, or other institution.

Diana Farrell
Director of the McKinsey Global Institute
November 2002

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Executive Summary

The economic uncertainty of the past year has renewed the focus on productivity in the US economy and generated a new skepticism about the "new economy." Government, firms, and, increasingly, the broader public see continued productivity growth as a way to drive recovery in both the US and the world economy. It is therefore more important than ever to understand the sources of productivity growth and to determine what both governments and individual firms can do to encourage it.

In 2001, the McKinsey Global Institute's (MGI's) US Productivity Growth report[2] found that the productivity acceleration of the mid to late 1990s, the so called "new economy," was concentrated in only six sectors and that the role of information technology (IT) was only one of several factors at work in the productivity jump. Innovation (including but not limited to IT and its applications), competition, and, to a lesser extent, cyclical demand factors were the most important causes. At the sector level, vigorous competition and limited restrictions on products, services, distribution, and prices created conditions that rewarded innovation of all kinds, including innovation involving IT. IT, while a critical enabler of productivity acceleration , was not a silver bullet, but rather had diverse and complex impact depending on when, where, and how it was deployed.

These results were sometimes interpreted by outside observers as "McKinsey says IT doesn't matter." On the contrary, MGI's US Productivity Growth report highlighted IT's enabling role as a key component of the managerial innovation that allows firms to compete in the modern economy. In this report, the examination of US growth (rather than acceleration) over the course of the entire decade underscores the point more forcefully. While the majority of productivity growth over the 1990s was also concentrated in a few highly competitive and innovative sectors, most of the economy experienced positive growth (Exhibit 1). In the three sectors studied in this report, IT was critical in enabling that strong baseline growth.

Consequently, the question MGI has sought to answer in this work is not whether, but "*How* did IT enable the managerial innovation that drove productivity growth in the US economy in the 1990s?" To answer it, we partnered with McKinsey's

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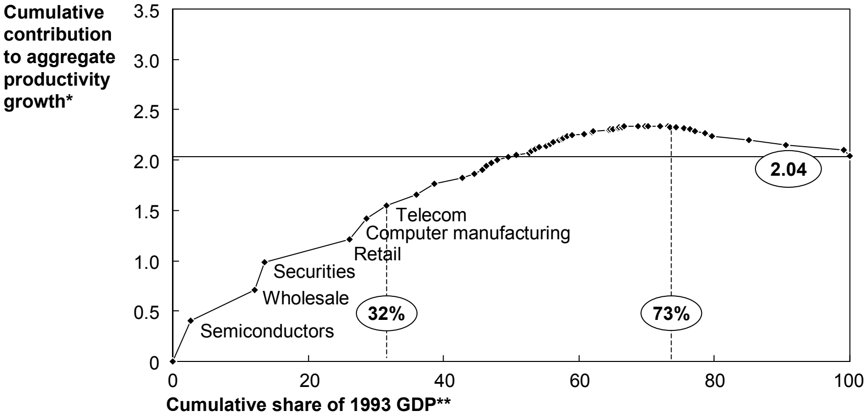
[2] MGI "US Productivity Growth 1995-2000, Understanding the Contribution of Information Technology Relative to Other Factors," released October 2001.

Exhibit 1

PRODUCTIVITY GROWTH IN THE 1990s WAS CONCENTRATED IN SIX SECTORS, THOUGH MOST EXPERIENCED GAINS

Percent



* CAGR from 1993-2000; does not include farm and government sectors; real estate and holdings contribution evenly divided among sectors excluding the top 6

** GDP does not include farm, government, holdings, and real estate sectors

Note: MGI's US Productivity Growth report identified semiconductors and computer manufacturing as the predominant (by contribution to growth) subsectors of electronic machinery and industrial machinery, thus the sector and the corresponding subsector are used interchangeably in this chart

Source: Bureau of Economic Analysis; MGI analysis

High Tech Practice and Business Technology Office to conduct in-depth case studies of three sectors: retail, retail banking and semiconductors. Two of the sectors, retail and semiconductors, exhibited both high productivity growth over the 1990s and productivity growth acceleration in the mid-1990s, while retail banking experienced high productivity growth rates throughout the 1990s but saw those growth rates slow in the mid-1990s (Exhibit 2). In all three cases, IT spend grew rapidly over the decade.

Our examination shows clearly that IT was critical in enabling productivity growth in the US economy over the past decade. Its impact, however, was complex, and varied across industries. In the first place, the IT-producing[3] sectors made a significant direct contribution to productivity growth, accounting for 8 percent of gross domestic product (GDP) in 1993 yet contributing a disproportionate 36 percent to productivity growth between 1993 and 2000.

More generally in the three sectors studied, IT was critical as one of a range of tools that creative managers used to redesign core business processes or innovate around products and services in response to changing business conditions. All three case studies offer rich examples of how IT enabled managerial innovation, allowed firms to compete more effectively, and helped firms to quickly ramp up output to meet demand. Retail saw strong growth of dominant players and thus continued increases in competitive intensity. Large retailers leveraged IT to manage the increasing complexity of their operations and to improve their efficiency vis-à-vis the competition. Deregulation, along with the IT that helped banks manage transaction complexity and achieve scale benefits, continued to enable productivity improvement in retail banking, as they have since the 1980s. IT allowed banks to consolidate operations, offer multichannel access, and begin the shift to a customer-centric architecture. Finally, the semiconductor sector was affected by increases in demand in the 1990s, and IT deployed against building design capabilities and embedded in manufacturing and testing equipment allowed firms to respond to this demand surge with new product offerings.

While IT enabled productivity gains in the three sectors, its impact was quite varied and complex. Interestingly, there was no dominant answer to where and how IT had high impact on productivity. No single application emerged as a "killer application" that played a particularly critical role in all three sectors. Nor were there cross-sector similarities in the productivity levers affected. The case studies emphasize that much of the richness in trying to understand the enabling role of IT in productivity growth involved understanding the specific environment and dynamics of each particular industry, its business processes, and key performance levers.

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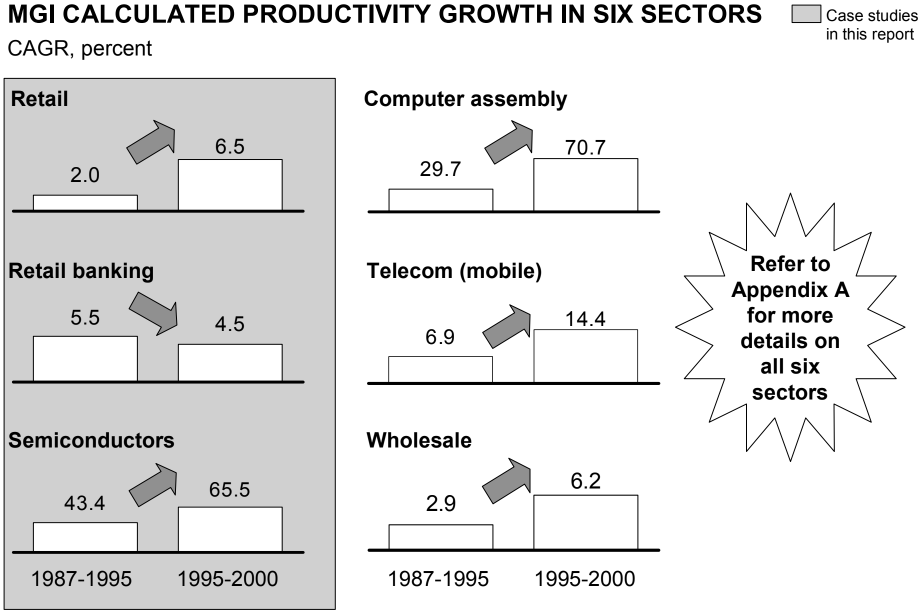
[3] IT-producing sectors refer here to sectors that both produce IT (computer assembly, semiconductors) and those that provide IT (telecom).

Exhibit 2

MGI CALCULATED PRODUCTIVITY GROWTH IN SIX SECTORS

CAGR, percent



Source: Bureau of Economic Analysis; MGI analysis

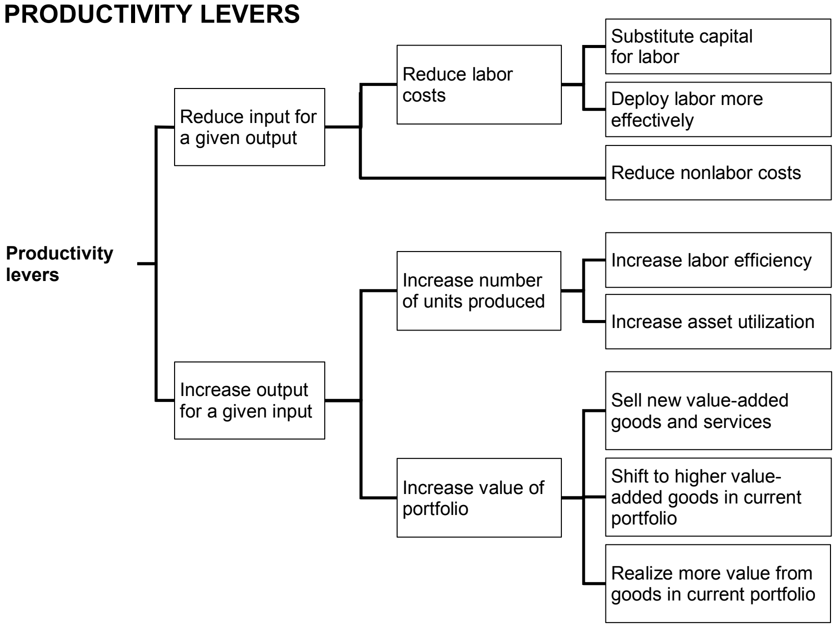
In reviewing our case studies, the IT applications that had a high impact on productivity shared three general characteristics. They were:

¶ **Tailored to sector-specific business processes and linked to performance levers.** Across the eight company-level operational productivity levers—substituting capital for labor, deploying labor more effectively, reducing non-labor costs, increasing labor efficiency, increasing asset utilization, selling new value-added goods and services, shifting to higher value-added goods and services within the current portfolio, and realizing more value from the existing goods and services in the current portfolio—(Exhibit 3), effective IT differed by industry, by subsector within the industry, and even by business strategy within the subsector. For example:

- In the retail sector, IT applications impacted productivity by increasing labor efficiency and asset utilization. They also reduced nonlabor costs like inventory carrying and obsolescence costs in distribution and logistics, and they increased the value of existing goods portfolios by allowing retailers to better match supply and demand with merchandise planning and management systems. However, the level, degree, and mechanism whereby they did so varied significantly by subsector and by business model within subsector. For example, stores in the general merchandise (GMS) subsector saw particular improvements in merchandise velocity and turns through operational improvements involving key IT investments such as sophisticated warehouse management systems, transport management systems, and vendor coordination systems (e.g., Wal-Mart's RetailLink). In other subsectors – apparel and electronics – higher product margins and a mix of short and long lifecycle products placed emphasis on demand forecasting, assortment and allocation planning, and price and markdown management.
- Retail banking IT applications, such as credit scoring software and underwriting modules, addressed specific process bottlenecks in lending operations, enabling the automation of various manual steps associated with credit verification and authorization. They affected two productivity levers critical to retail banking – substituting capital for labor and deploying labor more effectively.
- Finally, firms in the semiconductor sector used IT tools to impact the most critical performance lever for this industry in the past decade, namely, output quality in the design and manufacturing processes. IT, in concert with improved material and process technologies, allowed firms to respond to the increases in demand from the PC and other electronics industries for more and faster chips. The sale of these new

Exhibit 3

THERE ARE EIGHT COMPANY-LEVEL OPERATIONAL PRODUCTIVITY LEVERS



Source: MGI analysis

value-added goods and services, coupled with increased capacity utilization drove the productivity increases. Again, specific segment characteristics, success requirements, and therefore key IT investments, differed substantially between the DRAM and MPU subsectors.

¶ **Deployed in a sequence that built capabilities over time.** Where productivity gains were highest, IT and business skills were developed over time in a sequence that allowed firms to leverage their previous IT investments effectively. The notion of sequentially building capabilities was particularly important to deriving useful information from data to make better execution decisions. Leading retailers, for example, first automated data capture and storage and then used this data to develop enhanced decision-support capabilities in areas like merchandise planning. A "stack" of effective IT investment enabled leading retailers to achieve performance improvements from differentiating applications (Exhibit 4). Efforts to deploy IT without the prerequisite infrastructure yielded little impact.

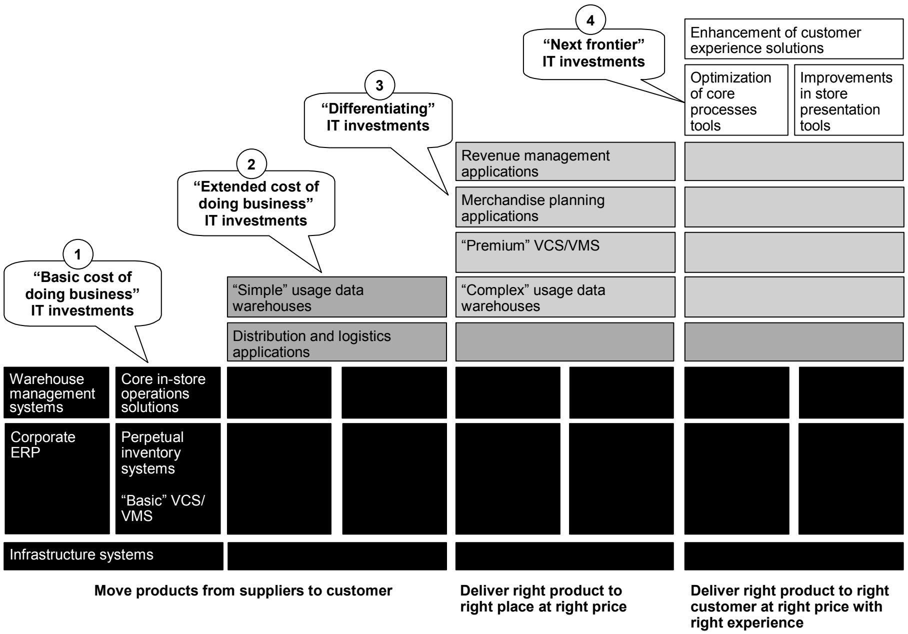
¶ **Co-evolved with managerial and technical innovation.** In concert with managerial and technical innovation, IT was used to change business processes leading to increased efficiency or the creation of new products and services in an incremental process. For example, in retail banking, while a leading player initially used imaging technology to automate loan processing and lower cost soon thereafter, managers innovated by diffusing the technology to auto dealers, capitalizing on the dealers' ability to attract customers with lower-cost loans thereby gaining volume and share. This close link and continuous co-evolution was critical to deriving large benefits from IT investments.

As with other forms of capital, firms are motivated to invest in IT to increase their productivity, to gain an advantage over their competitors, and ultimately to increase their profitability. Competitive advantage through investment in IT alone, however, was difficult to achieve and sustain and was vulnerable to the ability of competitors to replicate the productivity and profitability improvements gained by the innovators. Investments in IT were more likely to remain differentiating where coupled with other more sustainable advantages such as scale, significant changes in the business process, and associated learning effects, which were not as easily replicated.

In some cases, retail in particular, new IT investments in differentiating capabilities were an element of IT's enabling role in driving productivity gains and, for some time, profits for individual firms. With intense competition, however, these gains in productivity tended to devolve away from profits to consumer surplus in the form of lower prices in retail, greater convenience of new channels in retail banking, and higher quality products in semiconductors. Over

Exhibit 4

IT INVESTMENTS CAN BE SEGMENTED INTO FOUR TIERS



Source: Interviews; MGI analysis

time, most of the underlying IT investments eventually became "core," or a basic cost of doing business in every sector. Additional productivity gains accrued to the sector only in so far as laggard firms were still catching up to the best practice established by the leaders. This dynamic relationship between productivity gains and profitability associated with IT investments is a core element of the competitive market process and helps explain why individual firms derive such variable impact from their IT capital over time.

In short, IT does matter, but its ability to impact productivity depends upon how it is employed. When tailored to sector-specific business processes, deployed in an appropriate sequence, and co-evolved with managerial innovation, its impact on productivity and, in some cases, profitability, can be large. Strong US productivity growth in the 1990s arose in no small part because firms in several key sectors fulfilled these requirements. By acting on the requirements going forward, and systematically managing the appropriate operational productivity levers, even more firms in more sectors of the economy can experience productivity gains. The technology sector, by tailoring its offerings to the productivity levers in specific sectors and subsectors, can play a powerful enabling role. If successful, these efforts will help propel both the firms that make them, and the economy as a whole, toward stronger ongoing performance.

Objectives and approach

In 2001, the McKinsey Global Institute's (MGI's) US Productivity Growth report[1] found that the productivity acceleration of the mid to late 1990s was concentrated in only six sectors and that the role of information technology (IT) was only one of several factors at work in the productivity jump. Innovation (including but not limited to IT and its applications), competition, and, to a lesser extent, cyclical demand factors were the most important causes. At the sector level, vigorous competition and limited restrictions on products, services, distribution, and prices created conditions that rewarded innovation of all kinds, including innovation involving IT. IT, while a critical enabler of productivity acceleration, was not a silver bullet but rather had diverse and complex impact depending on when, where, and how it was deployed.

To further probe on this issue, the current study seeks to answer the question, "How did IT enable the managerial and technical innovation that drove productivity growth in the US economy in the 1990s?" The answers are tackled through an in-depth examination of three industry case studies.

FOCUS OF CURRENT PROJECT

This report focuses on the relationship between IT and productivity in three sectors: retail, retail banking, and semiconductors. Two of these sectors made significant contributions to both economy-wide growth and acceleration during the 1990s. Retail was the largest contributor to the productivity jump 1995-2000 and the fourth largest contributor to productivity growth in the period from 1993 to 2000. Semiconductor manufacturing, an IT-producing sector, was a top contributor to productivity growth and significantly impacted the productivity of other sectors, such as computer assembly, as rapid technological advances in its products flowed through to the output of other sectors. The retail banking sector was chosen because it presents an interesting paradox. Retail banking has a long history of investment in IT and experienced productivity growth throughout the 1990s. This sector was classified as a "paradox" case in the 2001 US Productivity Growth report because it experienced acceleration in IT intensity from 1995-1999 while labor productivity growth during this period actually slowed.

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[1] MGI "US Productivity Growth 1995-2000, Understanding the Contribution of Information Technology Relative to Other Factors" report, released in October 2001.

DEFINITION AND SCOPE

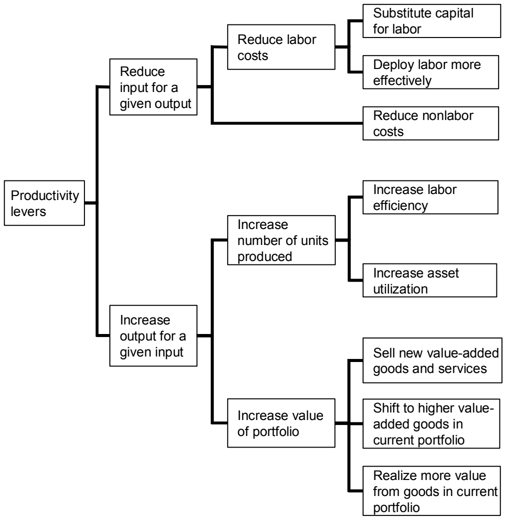
We conducted a case study of each sector by first outlining the business processes and evaluating the impact of key IT applications deployed against each of these elements. IT applications were chosen over other forms of IT because they allow a high level of specificity in identifying the type of spending and in making a close link between productivity metrics and IT investments. Any hardware and communications infrastructure necessary for deployment of these applications was not called out as a separate investment. By adopting this approach we deliberately focused on the role of IT in enabling productivity growth in these sectors.

PRODUCTIVITY FRAMEWORK

The impact of IT applications on productivity within the business process was studied by disaggregating productivity into eight company-level operational levers (Exhibit 1). Through detailed microeconomic analyses and more than 100 interviews and surveys with users and vendors in the three sectors studied, investments in IT applications were evaluated as having high, medium, or low impact on the various productivity levers over the 1990s. Consistent with last year's findings, while IT had significant impact across all of the sectors, we found no discernable patterns in how this impact was achieved. These findings further bolster the conclusion that IT's impact on productivity cannot be boiled down to a simple formula. Like other types of capital, if it is to have impact, IT must be deployed in a targeted, sector- and even firm-specific way and in conjunction with other types of innovation and process change.

Exhibit 1

PRODUCTIVITY CAN BE DISAGGREGATED INTO EIGHT COMPANY-LEVEL OPERATIONAL LEVERS



Description

- Reduce headcount through automation or process redesign
- Reduce labor hours through scheduling
- Reduce nonlabor cost (e.g., materials, overhead)
- Increase output of existing workforce through
  - Automation
  - Process redesign
  - Skill enhancement
- Enhance utilization of tangible and nontangible resources to increase output per unit input
- Introduce new products/services with more features per unit cost
- Change existing product mix to increase fraction of higher-quality products sold
- Change pricing to increase value capture

Source: MGI analysis

MGI's 2001 US Productivity Growth report[2]

MGI's US Productivity Growth report, released in October 2001, answered the question, "What drove the post-1995 productivity growth jump and how sustainable was it?" MGI analyzed causes of the jump in productivity growth from after 1995 versus 1987-1995 by pursuing analysis at the aggregate economy level, and more in-depth analysis at the sector and firm levels. In Appendix A of this report, sector perspectives updated for the year 2000 form the basis of a continuing investigation into the evolution of US productivity growth begun by MGI in 2001.

The causes of a jump in the productivity growth rate from 1995-1999 as compared to 1987-1995 were examined by pursuing analysis first at the aggregate level and then on an in-depth sector- and firm-level. Aggregate-level analysis broke down the productivity acceleration into the contribution made by each sector of the US economy (Exhibit 2). The breakdown helped to focus the sector and firm-level analysis on key sectors explaining the growth jump: wholesale, retail, securities, semiconductors, computer manufacturing, and telecom (mobile and long-distance voice). Although the number of jumping sectors was not unusual, the disproportionate contribution of the six sectors was a result of two of the sectors being extremely large (retail and wholesale) and two of the jumps being extremely large (semiconductors and computer manufacturing). MGI also investigated two sectors that did not experience productivity growth acceleration despite large IT-intensity increases in order to help develop explanations for why, in some cases, IT intensity jumps did not yield productivity growth jumps, and to act as a "control" group for the jumping sectors. The two "paradox" cases were retail banking, and hotels and lodging. Examining common patterns across the industry case studies using its well-established productivity causality framework, MGI identified the sources of the uncommonly rapid productivity growth in the mid-1990s, since there was no obvious correlation between jump in productivity and jump in IT intensity (Exhibit 3).

The appendix at the end of this report applies the most recently available data to the productivity analysis developed in the US Productivity Growth report for six sectors: retail and subsectors, retail banking, semiconductors, computer manufacturing, telecommunications services, and wholesale trade. The update for each sector incorporates newly available 2000 data to examine the productivity growth rates from 1995-2000 as compared to 1987-1995. Each update focuses on examining the causes of any changes in trends observed in the original report. Overall, we find that the general conclusions of the original report continue to hold true. The perspectives and changes detailed in the appendix for each sector form the basis of a continuing investigation into the evolution of US productivity growth begun by MGI in 2001.

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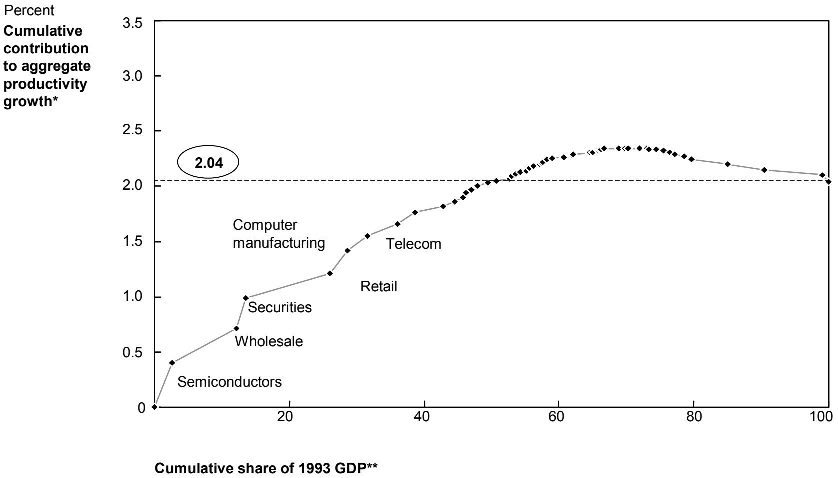
[2] MGI "US Productivity Growth 1995-2000, Understanding the Contribution of Information Technology Relative to Other Factors," released in October 2001.

Exhibit 2

CONTRIBUTION OF EACH SECTOR OF THE ECONOMY TO AGGREGATE PRODUCTIVITY GROWTH



* CAGR from 1993-2000; does not include farm and government sectors; real estate and holdings contribution evenly divided among sectors excluding the top 6

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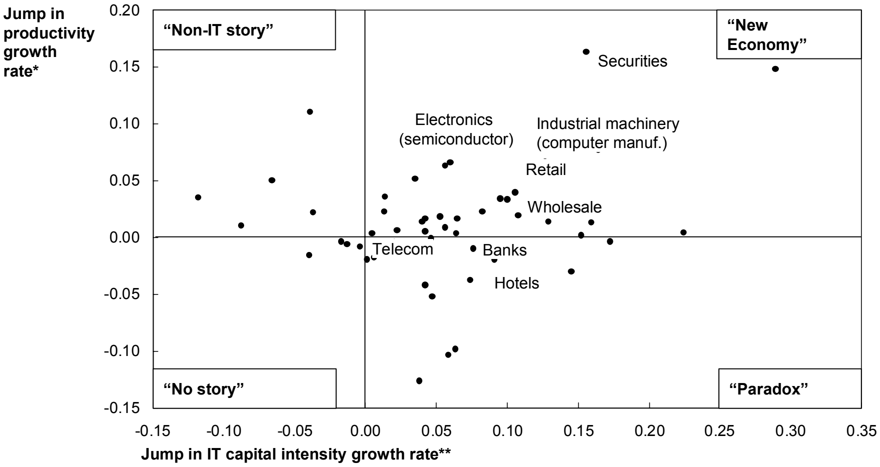
Source: Bureau of Economic Analysis; McKinsey analysis

Exhibit 3

IT WAS NOT A SILVER BULLET; NO CORRELATION BETWEEN PRODUCTIVITY JUMP AND IT INTENSITY JUMP

CAGR, Percent



* Jump in real value-added per persons engaged in production (PEP) growth rate between 1987-95 and 1995-2000

** Jump in real IT capital stock per PEP growth rate between 1987-95 and 1995-2000

Source: Bureau of Economic Analysis; MGI analysis

Synthesis of findings across sectors

The economic uncertainty of the past year has renewed the focus on productivity in the US economy and generated a new skepticism about the "new economy." Government, firms, and, increasingly, the broader public see continued productivity growth as a way to drive economic recovery in both the US and the world economy. It is therefore more important than ever to understand the sources of productivity growth and to determine what both governments and individual firms can do to encourage it.

In 2001, the McKinsey Global Institute's (MGI's) US Productivity Growth report[1] found that the productivity acceleration of the mid to late 1990s, the so called "new economy," was concentrated in only six sectors and that the role of information technology (IT) was only one of several factors at work in the productivity jump. Innovation (including but not limited to IT and its applications), competition, and, to a lesser extent, cyclical demand factors were the most important causes (Exhibit 1). At the sector level, vigorous competition and limited restrictions on products, services, distribution, and prices created conditions that rewarded innovation of all kinds, including innovation involving IT. IT, while a critical enabler of productivity acceleration, was not a silver bullet but rather had diverse and complex impact depending on when, where, and how it was deployed.

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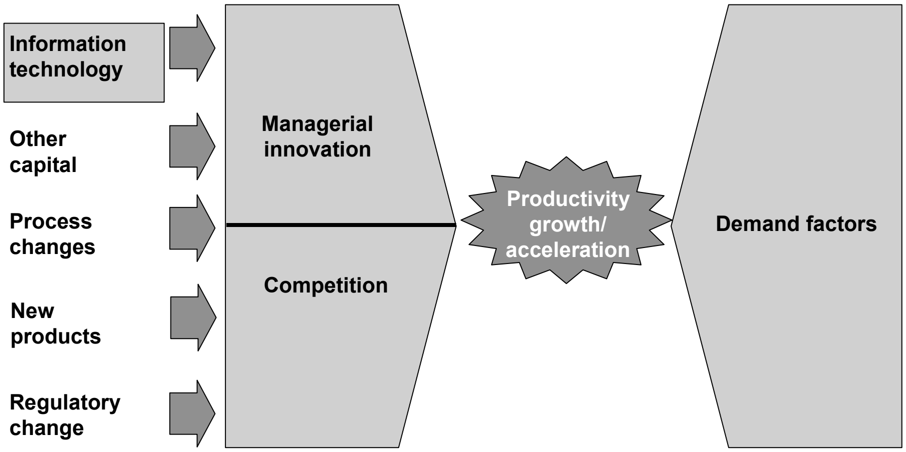
[1] MGI "US Productivity Growth 1995-2000, Understanding the Contribution of Information Technology Relative to Other Factors," released in October 2001.

Exhibit 1

IT WAS A KEY ENABLER, BUT ALONE NOT SUFFICIENT



Source: MGI analysis

Exhibit 2

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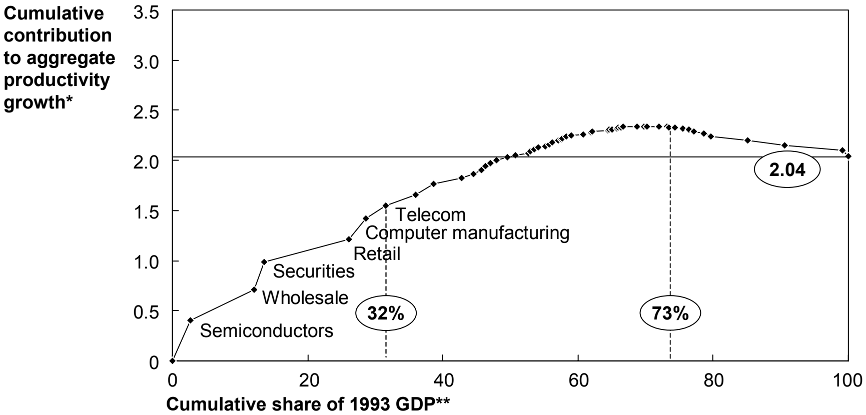
Percent



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Source: Bureau of Economic Analysis; MGI analysis

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This chapter synthesizes the key conclusions that these case studies, taken together, have generated:

¶ **IT is important to productivity growth, but in context**. An examination of the baseline growth from 1993-2000 in the three sectors indicates that IT is critical in enabling productivity growth, but it does so in the context of a broader set of managerial decisions.

¶ **Productive IT applications share three characteristics**. Three general characteristics were shared by IT applications that impacted productivity in the three sectors over the past decade: 1) the applications were tailored to sector-specific business processes and linked to key performance levers, 2) they were deployed in a sequence that built capabilities over time, and 3) they co-evolved with managerial and technical innovation to change business processes and create new products and services.

¶ **The relationship between productivity and profitability is dynamic**. In a dynamic and competitive environment, profitability is a transient reward for productivity improvements. Managers can use IT as a tool to improve productivity by innovating and closing gaps with best practice. However, competitive advantage through investment in IT alone is difficult to sustain. If IT is not linked to other investments, capabilities, and strategies, it will not differentiate firms sufficiently to create excess value but will become "core" or the cost of doing business.

IT IS IMPORTANT TO PRODUCTIVITY GROWTH, BUT IN CONTEXT

Our examination shows that IT was critical in enabling the strong baseline growth in productivity of the US economy over the past decade. The United States experienced a labor productivity growth rate of 2 percent between 1993 and 2000.[2] There is compelling evidence that IT was critical to ongoing productivity growth

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[2] At the time of this report the latest available data released by the Bureau of Economic Analysis and Bureau of Labor Statistics incorporates the year 2000. The time period 1993-2000 was chosen in order to exclude the effects of the recession in the early 1990s.

in two ways. First, the IT-producing sectors[3] made a disproportionately large contribution to overall productivity growth. Second, IT enabled the managerial and technical innovations that emerged in response to the changing competitive landscape and demand environment faced by firms in the 1990s.

IT-producing sectors contributed significantly to US productivity growth

In addition to the enabling role played by IT, the direct contribution to productivity of the IT-producing sectors themselves was significant. IT-producing sectors, including semiconductors, computer manufacturing, and telecommunications, accounted for 8 percent of GDP in 1993 yet contributed a disproportionate 36 percent to productivity growth between 1993 and 2000 (Exhibit 3). For example, the semiconductor industry experienced one of the highest labor productivity growth rates in the 1990s – more than 35 times the overall US rate. In addition, the large improvements in product quality increased productivity not only for the semiconductor sector; they also flowed through to improve productivity in other sectors, like computer assembly and retail, which were ultimately able to provide higher-value goods (e.g., computers) to consumers (Exhibit 4).

Drawing a comparison between the US and Europe further underscores the importance of IT-producing sectors to overall productivity.[4] According to a recent study, the disproportionate contribution of the IT-producing sectors explains one third of the productivity growth gap of France and Germany versus the US since the mid 1990s.[5] The difference in contribution to productivity growth between IT-producing sectors in Europe and the US is mostly attributable to the smaller size of the European sectors, which account for only 1.3 percent of total GDP in France and 1.5 percent in Germany versus 2.3 percent in the US. In short, it was both the leaps in productivity and the size of the IT-producing sectors that made them important to US productivity growth in the 1990s.

IT enables productivity growth through managerial innovation

At the sector level, vigorous competition and limited restrictions on products, services, distribution, and prices create conditions that reward innovation of all

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[3] IT producing sectors refer here to sectors that both produce information technology (computer assembly, semiconductor manufacturing), and those that help provide it (telecommunication services).

[4] Germany and France were studied in the 2002 MGI European Productivity report.

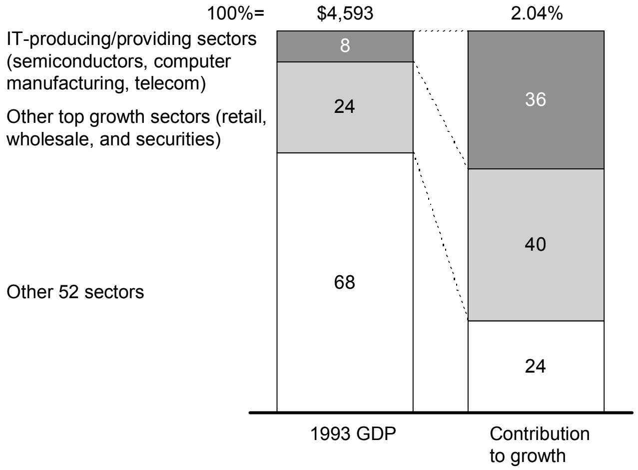
[5] The Conference Board and the Groningen University: "Changing Gear: Productivity, ICT and Service Industries: Europe and the United States," 2002. This report did not include telecommunications services in its definition of IT-producing sectors.

Exhibit 3

IT-PRODUCING SECTORS CONTRIBUTED DISPROPORTIONATELY TO PRODUCTIVITY GROWTH

1993-2000 CAGR

Percent; $ billions



Note: Farms, real estate, holdings, and government excluded from GDP calculations; contributions from these sectors to growth distributed among sectors excluding top 6

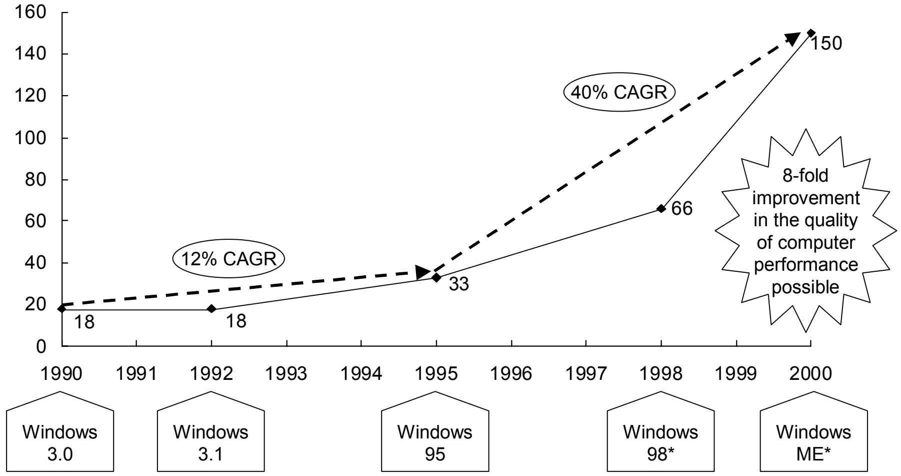
Source: Bureau of Economic Analysis; MGI analysis

Exhibit 4

IMPROVEMENTS IN SEMICONDUCTOR OUTPUT WERE INSTRUMENTAL IN ACCELERATING PERFORMANCE OF MODERN COMPUTERS

Processor speed requirements

MHz



* Second edition

Source: Microsoft; Datapro; MGI analysis kinds, including innovation involving IT. This is particularly apparent in the six sectors of the economy that contributed disproportionately to US productivity growth. While more than 70 percent of the US economy experienced positive productivity growth from 1993-2000, six sectors accounting for 32 percent of GDP contributed 76 percent of productivity growth during this time period (Exhibit 2).[6] The semiconductor sector was the largest contributor, followed by wholesale, securities, retail, computer manufacturing, and telecommunications services. As the MGI US Productivity Growth report detailed, the six sectors were highly competitive due to the presence of aggressive market leaders, as in retail, wholesale, and electronics, or as a result of deregulation, as in telecom and securities. They were also free to respond to demand factors through the creation and pricing of new products and services.

This study, with its narrower focus on how IT enabled growth in three sectors, also revealed the tight relationship between the competitive environment and the role of IT. While many of the advances that enabled baseline growth in retail, retail banking, and semiconductors would not have been possible without leveraging IT capabilities, the right competitive context was also essential. Retail saw strong growth of dominant players and thus continued increases in competitive intensity. Large retailers like Wal-Mart and Target leveraged IT to manage the increasing complexity of their operations and to improve their efficiency in the face of competition. Competition-enhancing deregulation, along with the IT that helped banks to manage transaction complexity and achieve scale benefits, continued to enable productivity improvement in retail banking, as they have since the 1980s. IT allowed retail banks to build scale, offer multichannel access, and begin the shift to a customer-centric architecture. Finally, the semiconductor sector was affected by large increases in demand over the past decade. IT deployed against building design capabilities and embedded in manufacturing and testing equipment allowed firms to respond to this demand surge—and to the efforts of their competitors—with new product offerings.

PRODUCTIVE IT APPLICATIONS SHARE THREE CHARACTERISTICS

In reviewing our case studies, we were struck that there was no dominant answer to where and how IT had high impact on productivity. No single application emerged as a "killer application" playing a particularly critical role in all three sectors. Nor were there cross-sector similarities in the productivity levers

---

[6] The six sectors contributed 76 percent of net productivity growth—or 1.55 percentage points of the 2.04 percent annual growth experienced by the US economy. The same sectors also contributed 66 percent of gross productivity growth—or 1.55 percentage points of the 2.34 percent annual growth contributed by only the positive contributing sectors, before netting out sectors with negative contributions.

affected. Instead, IT that had a high impact on productivity shared three general characteristics. It was:

¶ Tailored to sector-specific business processes and linked to key performance levers

¶ Deployed in a sequence that built capabilities over time

¶ Co-evolved with managerial and technical innovation.

Tailored to sector-specific business processes and directed at key performance levers

IT applications that had a high impact on productivity were generally tailored to and directed specifically toward the sector's key business processes and performance levers. The eight company-level operational productivity levers are: substituting capital for labor, deploying labor more effectively, reducing non-labor costs, increasing labor efficiency, increasing asset utilization, selling new value added goods and services, shifting to higher value added goods and services within the current portfolio, and realizing more value from the existing goods and services in the current portfolio (Exhibit 5). Effective applications met the sector's performance requirements, and embedded a significant amount of knowledge about the underlying business process in the IT itself. Business processes and productivity levers affected by IT were not uniform across or even within sectors. Instead, they often varied by subsector and business model based on the characteristics and market dynamics of the specific industry or its subsegments.

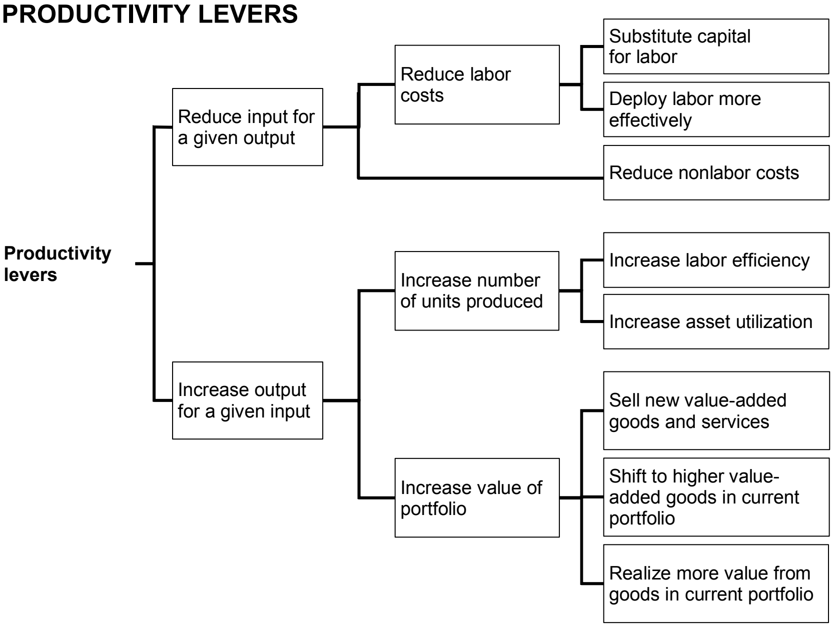
Retail

In retail, applications deployed in distribution/logistics processes, merchandise planning and management, and store operations had the most impact on productivity, but the level of impact varied by subsector (Exhibits 6 and 7). IT applications impacted productivity levers through increased labor efficiency, increased asset utilization, and substitution of capital for labor. IT applications also reduced nonlabor costs like inventory handling and obsolescence costs and increased the value of the existing goods portfolio by allowing retailers to better match supply and demand through improved merchandise management tools.

However, the level, degree, and mechanism whereby applications contributed varied significantly. In some cases, applications were tailored to specific subsector needs. For example, different parameters/tools were necessary to serve the needs of grocery retailers replenishing perishable basics and apparel retailers ordering seasonal fashion merchandise. IT applications such as warehouse management systems (WMS) and transportation management systems (TMS) were even customized for the distribution and logistics processes of particular

Exhibit 5

THERE ARE EIGHT COMPANY-LEVEL OPERATIONAL PRODUCTIVITY LEVERS



Source: MGI analysis

Exhibit 6

PRODUCTIVITY LEVERS IMPACTED BY KEY IT INVESTMENTS IN RETAIL VARIED BY SUBSECTOR

○ Low
◑ Moderate
● High

	Sector average of impact of IT on productivity levers			
Productivity levers	**GMS**	**Apparel**	**Electronics**	**DIY**
Substitute capital for labor	◑	◑	◑	○
Deploy labor more effectively	◑	◑	◑	◑
Reduce nonlabor costs	◑	◑	◑	◑
Increase labor efficiency	●	◑	●	●
Increase asset utilization	●	◑	●	◑
Sell new value-added goods and services	○	○	○	○
Shift to higher value-added goods in current portfolio	◑	◑	◑	○
Realize more value from goods in current portfolio	○	○	○	○

Source: Retail interviews; MGI analysis

Exhibit 7

HIGH-IMPACT APPLICATIONS IN RETAIL CAN EVEN VARY ACROSS SUBSECTORS AND BUSINESS MODELS

Subsector	Business model	Impact of IT applications
GMS	• Every Day Low Price retailer (e.g., Wal-Mart)	• Improved **distribution/logistics and inventory visibility** improves operational effectiveness, thereby reducing costs
	• High-/low-pricing retailer (e.g., Sears, Kmart)	• **Promotions/campaign management tools** needed to determine and monitor promotional effectiveness • In-store apps (e.g., **labor scheduling**) need to support promotions
	• Department stores (e.g., May, Federated)	• **Inventory visibility and enhanced merchandise allocation tools** needed to reduce lead times and markdowns for their low-volume, high-margin items (e.g., apparel)
Apparel	• Vertically integrated specialty apparel provider (e.g., Gap, The Limited)	• **Vendor management systems** have highest impact by shortening time to market and improving production/sourcing
	• Apparel discounter (e.g., Ross)	• Optimum **pricing and markdowns** in stores drive firm's top line
	• Catalog players (e.g., Spiegel)	• CRM allows **revenue/margin optimization**
	• High-end retailers (e.g., Neiman Marcus, Saks)	• **Customer data warehouse allows microclustering** of customers for targeted promotions to increase up-sell/cross-sell opportunities

Source: Interviews; MGI analysis

firms within subsectors. In terms of impact, the general merchandise stores (GMS) subsector saw particular improvements in increased merchandise velocity and turnover through operational improvements. Key IT investments made by firms in the subsector to improve inventory handling included sophisticated WMS, TMS, and vendor coordination systems (e.g., Wal-Mart's RetailLink). The low margins, high velocities, and high number of stock keeping units (SKUs) meant that firms in this subsector also benefited from the increased sophistication of allocation and replenishment planning tools, as well as from investments in clean, aggregated data sources such as data warehouses. In other subsectors – apparel and electronics, for instance – higher product margins and a mix of short and long lifecycle products placed additional emphasis on demand forecasting, assortment and allocation planning, and price and markdown management, with IT applications helping to increase the value of the portfolio of goods offered.

Retail banking

In retail banking, IT applications had the most impact when they were focused on sector-specific business processes such as lending, credit card operations, and banking channel operations, and when they affected key business performance levers relating to automation, development and support of alternate channels, and scale-enablement (Exhibit 8). More specifically, IT applications directed at levers in substituting capital for labor, deploying labor more effectively, increasing asset utilization and selling new products and services, or shifting the mix of the current goods portfolio, had the most impact on productivity. For example, applications such as credit scoring software and underwriting modules automated various manual steps associated with credit verification and authorization in lending operations. These improvements in lending systems, specifically in credit scoring and underwriting, allowed banks to offer new services, to realize more value out of the loans in their current portfolio, and to increase the number and quality of loans processed (Exhibit 9). Check imaging impacted productivity by lowering some labor and storage costs, although this was mitigated in part by lack of end-to-end automation and higher transaction volumes. IT applications such as voice response units (VRUs) and computer telephony integration (CTI) have helped to control call center personnel costs through automation and more effective labor deployment at a time when call volumes were increasing dramatically (Exhibit 10). On the other hand, IT applications like customer relationship management (CRM) demonstrate how the lack of clear business performance objectives can be problematic. CRM did not meet expectations partly because it was not targeted at specific performance levers, as evidenced by the fact that managers were generally not clear how to evaluate its impact on business performance (Exhibit 11).

Semiconductors

Finally, the semiconductor sector experienced high productivity growth, particularly in the microprocessor and memory subsectors. IT, in concert with

Exhibit 8

IT DID HAVE SIGNIFICANT IMPACT ON SOME PRODUCTIVITY LEVERS IN RETAIL BANKING

○ Low
◑ Medium
● High

Productivity levers	Level of impact	IT applications associated with productivity lever*	Description
Substitute capital for labor	●	• Lending systems • Check imaging • VRU/call center	• Lower call center costs from use of VRU/CTI in handling inquiries • Check imaging lowered some labor/storage costs • Increase in number and quality of loans processed due to credit scoring/ underwriting software
Deploy labor more effectively	◑	• Lending systems • Core banking systems	• Centralized credit authorization and review process by moving functions from branches to remote locations • Some banks reduced maintenance costs through standardization of core systems
Reduce nonlabor costs	○	• Check imaging	• High-volume image capture cut fixed costs but systems needed additional technicians
Increase labor efficiency	○	• VRU/call center • Branch automation • CRM	• Disappointing results from attempting to enable tellers and call center agents to cross sell
Increase asset utilization	◑	• VRU (voice response unit)/call center	• VRU/IVR systems handled greater call volumes without additional customer service reps
Sell new value-added goods and services	◑	• VRU/call center • On-line banking • Lending systems • CRM • Core banking systems	• Improved customer experience from new channels, but limited productivity impact • New products from improved ability to design/price but higher costs from complexity
Shift to higher value-added goods in current portfolio	◑	• CRM • On-line banking • Application integration	• Disappointing results from cross-selling using better information • Low adoption of on-line banking • Increased number of transactions from new products, but higher overall transaction costs
Realize more value from goods in current portfolio	○	• n/a	

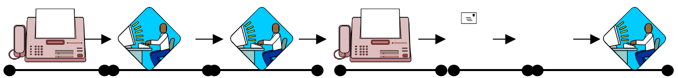
* ATMs not included because majority of investments in ATM networks occurred before 1990

Source: Interviews; MGI analysis

Exhibit 9

CREDIT SCORING AND AUTO-DECISIONING IMPROVED PRODUCTIVITY IN LENDING OPERATIONS

▨ Key IT investment areas



	Decision turnaround				Compliance and booking		
	Dealer faxes application	Data entry	Underwriting	Dealer receives decision notification	Dealer mails contract	Scan and index	Compliance and book
Today's technology	Fax server technology places image on screen	▨ Work flow system manages electronic flow of information	▨ Use decision engine for auto-decisioning (e.g., AMS's Strata)	Reply by fax server from underwriter desktop or decision engine	n/a	▨ Use work flow system and provide interface to image archive and loan accounting systems (e.g., Hogan, Lemans)	

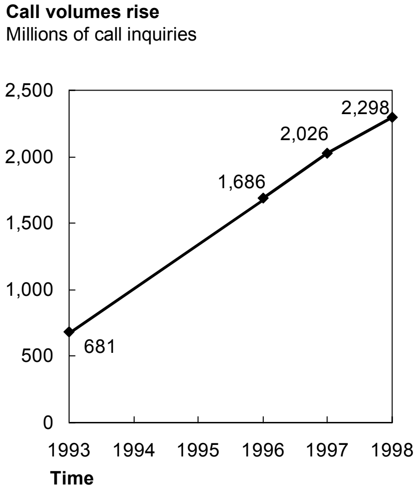
"We have seen an 80% reduction in paper work in the lending process. Lending systems have reduced the time to process applications – on the back end, entries are processed automatically in the credit bureau, and the ranking and profiling of applications is done through IT."
– Senior retail banking executive

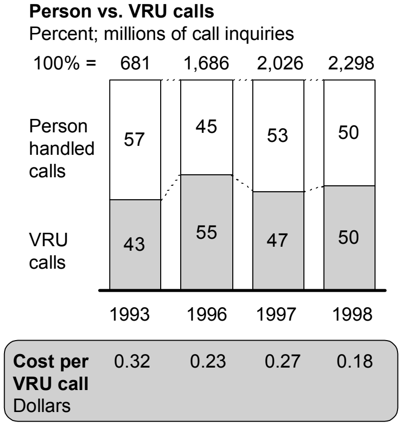
Credit scoring and underwriting modules automated the decision process, allowing banks to
- **Process more applications per employee**
- **Improve the quality and consistency of decisions**
- **Centralize credit officer review process by moving function from branches to remote operations, thereby reducing costs**

Source: Retail banking CIOs/interviews; industry analysts; MGI analysis

Exhibit 10

IT INVESTMENTS IN VRUs HELPED CONTROL SPIRALING CUSTOMER SERVICE COSTS





- In 1998, VRUs handled nearly 4 times the call volume they had in 1993
- Cost per call handled by VRU decreased 44% from 1993 to 1998

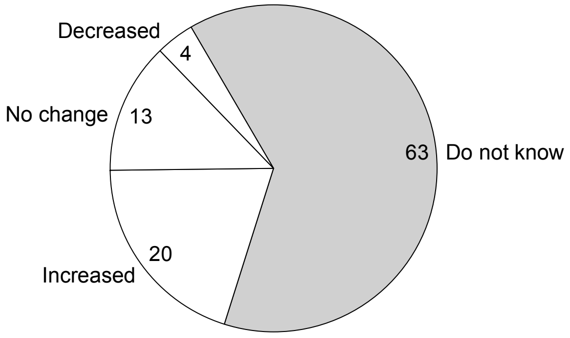
Source: ABA; MGI analysis

Exhibit 11

PERFORMANCE LEVERS AFFECTED BY CRM WERE IN MANY CASES UNKNOWN

Impact of CRM – change in customer profitability

Percent of surveyed banks



Over 60% of managers did not know whether CRM had affected customer profitability

Source: 1999 E&Y Special Report on Technology and Financial Services improved material and process technologies, allowed firms to respond to the increases in demand from the PC and other electronics industries for more and faster chips. This increased productivity primarily through the selling of new value-added goods and services and increasing capacity utilization, as well as through increased labor efficiency (Exhibit 12). IT applications such as electronic design automation (EDA) tools, process control systems embedded in wafer processing equipment, and process diagnostic tools enabled design and manufacturing processes to play a role in enabling productivity growth by affecting the most critical performance lever for this industry, namely, output quality in the design and manufacturing processes. Specific segment characteristics, success requirements and hence key IT investments differed substantially between the DRAM and MPU subsectors (Exhibit 13).

Deployed in a sequence that built capabilities over time

Firms that derived the most benefit and were acknowledged as leading users of IT deployed IT applications by sequentially building capabilities within the organization. This was not a simple matter of increasing and layering IT functionality. Building business capabilities required evolving both IT systems as well as decision and execution systems within the business process. Significant improvements could be obtained from IT enabling a specific business process. However, even greater benefits were available when specific processes were linked together, to optimize the efficiency of the system and enable higher-level decision- making.

The notion of building capabilities sequentially was particularly important to deriving useful information from data to make better execution decisions. Successful retailers, for example, first automated data capture and storage and then used this data to develop enhanced decision-support capabilities in areas like merchandise planning, leading to a “stack” of effective IT investments (Exhibit 14). When retailers tried to deploy more sophisticated applications out of sequence, they were generally not successful.

In retail banking, successful IT investments were part of a disciplined and deliberate approach to ensuring that key IT capabilities were in place prior to IT investments. For example, accurate customer data and information linkages to customer service representatives (CSR) or loan agent desktops allowed banks to exploit investments in call center technologies and lending systems. On the other hand, the lack of consistent and reliable customer data across different channels, a prerequisite to making CRM effective, partly explains the low impact of CRM investments to date.

Exhibit 12

PRODUCTIVITY LEVERS IMPACTED BY KEY IT INVESTMENTS IN 1990s VARIED BY SEMICONDUCTOR SUBSECTOR

○ Low
◑ Moderate
● High

Productivity levers	Sector average of impact of IT on productivity levers	
	MPUs*	DRAMs*
Substitute capital for labor	○	○
Deploy labor more effectively	○	○
Reduce nonlabor costs	○	○
Increase labor efficiency	◑	◑
Increase asset utilization	◑	●
Sell new value-added goods and services	●	○
Shift to higher value-added goods in current portfolio	○	○
Realize more value from goods in current portfolio	○	○

* Microprocessors (MPUs); memory (DRAMs)
Source: Interviews; MGI analysis

Exhibit 13

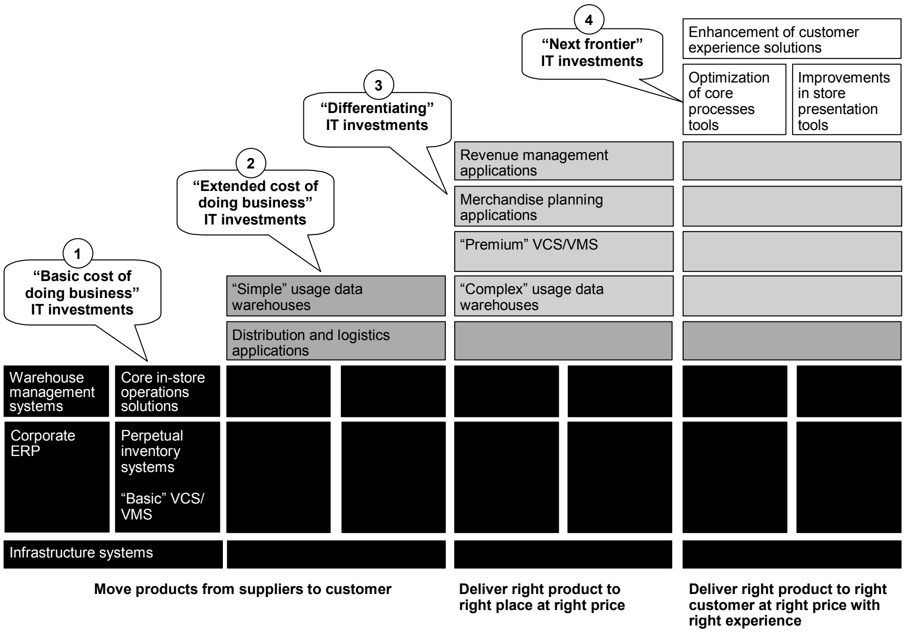
SUBSECTOR CHARACTERISTICS AND REQUIREMENTS DETERMINE CRITICAL IT INVESTMENTS

	DRAMs*	MPUs*
Sector characteristics	• Commodity market with no product differentiation • Firms are price takers, and prices drop as more production capacity comes on-line • Competitive advantage gained from improved process capabilities	• Market with perceived differentiated products with accelerated new products introduction • Customers willing to pay for higher quality products and market rewards reduced throughput time for new chips • Competitive advantage gained from improved design capabilities
Sector requirements	• Sector requires low cost structure and operational effectiveness to compete effectively • Sector dynamics demand reducing unitized fixed costs and labor costs by better asset utilization and improved labor efficiency	• Sector values reduced time to market for new products and hence requires faster ramp-up rates • Sector requires exponential quality increase in products
Key IT investments	• Process control systems • Process diagnostic tools • Manufacturing automation systems	• Design reuse methodology/tools • Process control systems • Process diagnostic tools

* Microprocessors (MPUs); memory (DRAMs)
Source: Interviews; MGI analysis

Exhibit 14

IT INVESTMENTS CAN BE SEGMENTED INTO FOUR TIERS



Source: Interviews; MGI analysis

Co-evolved with managerial and technical innovation

IT was effective when used in concert with managerial innovation and other advances in technology to change business processes to increase efficiency or to create new products and services. In retail for example, Wal-Mart evolved its IT capabilities in concert with business innovation targeted at redefining its relationship with suppliers and radically simplifying distribution center logistics. In this incremental way it was better able to provide assortment choice at an every day low price, and take advantage of new store formats. Other general merchandise retailers followed in evolving their own capabilities and innovations (Exhibit 15). In retail banking, while JPMorgan Chase initially used imaging technology to automate loan processing and lower cost, it innovated by diffusing the technology to auto dealers, capitalizing on the dealers' ability to attract customers with lower-cost loans (Exhibit 16). Similarly, Citibank applied learnings from the competitive and innovative credit card business to enhance business processes in retail banking and lending operations (Exhibit 17). And in semiconductors, Intel and AMD used IT to push the design frontier and continued to innovate in materials technology and in manufacturing processes. IT allowed firms to continuously take advantage of advances in materials technology by enabling them to design and manufacture chips with dramatically increased gate count and shrinking line widths (Exhibit 18).

THE RELATIONSHIP BETWEEN PRODUCTIVITY AND PROFITABILITY IS DYNAMIC

As with other forms of capital, firms are motivated to invest in IT to increase their productivity, to gain an advantage over their competitors, and ultimately to increase their profitability. Our case studies showed that achieving and sustaining competitive advantage through investment in IT alone was difficult, and was vulnerable to the ability of competitors to replicate the productivity and profitability improvements gained by the innovators. Investments in IT were more likely to remain differentiating where coupled with other more sustainable advantages such as scale, significant changes in the business process, and associated learning effects.

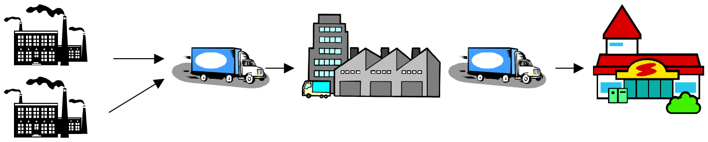
In some cases, retail in particular, new IT investments in differentiating capabilities were an element of IT's enabling role in driving productivity gains and, for some time, profits for individual firms. With intense competition, however, these gains in productivity tended to devolve away from profits to consumer surplus in the form of lower prices in retail, greater convenience of new channels in retail banking, and higher quality products in semiconductors. Over time, most of the underlying IT investments eventually became "core," or a basic cost of doing business in every sector. Additional productivity gains accrued to the sector only in so far as laggard firms were still catching up to the best practice

Exhibit 15

SUCCESSFUL RETAILERS EVOLVED IT CAPABILITIES IN CONCERT WITH BUSINESS INNOVATION

RETAIL EXAMPLE

Business innovation in



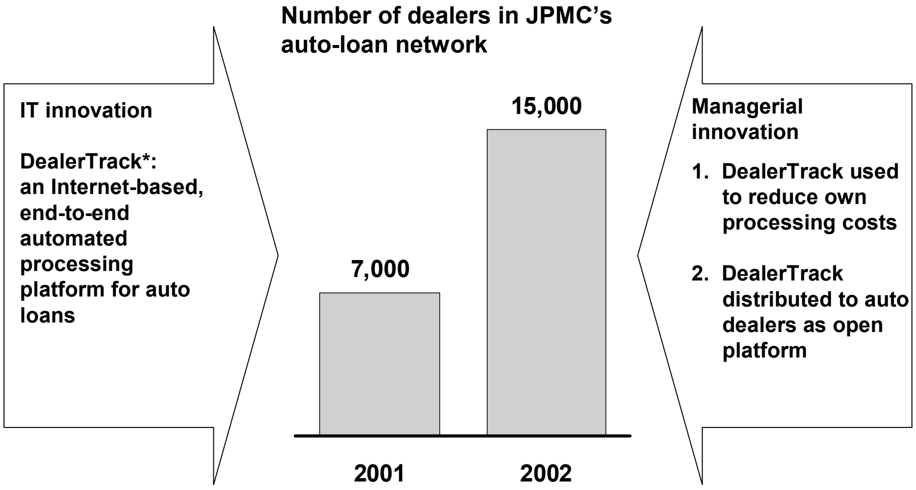
	Supplier relationships	Distribution/logistics	Store diversification
Business innovations	• Vendor collaboration • Vendor and buyer accountability	• Reduction in inventory costs • Frequent store replenishment	• New formats • Store conversions • Store experience
Supported by IT	• Communication links (e.g., EDI "Retail Link") • Vendor/buyer scorecards • Company extranets • Purchasing/sourcing exchanges	• Warehouse automation and management systems • Cross-docking • Inventory tracking	• In-store systems; POS and electronic scanning, "line busters" • Micromerchandising applications

Source: Interviews

Exhibit 16

CO-EVOLUTION OF MANAGERIAL AND TECHNOLOGY INNOVATION

RETAIL BANKING EXAMPLE



IT innovation

DealerTrack*: an Internet-based, end-to-end automated processing platform for auto loans

Managerial innovation

1. **DealerTrack used to reduce own processing costs**
2. **DealerTrack distributed to auto dealers as open platform**

* System developed by LabMorgan, a JPMorgan Chase subsidiary

Source: DealerTrack Web site; JPMorgan Chase Web site

Exhibit 17

CITIBANK INNOVATED IN COMPETITIVE CREDIT CARD BUSINESS AND APPLIED INNOVATION IN OTHER BUSINESS UNITS TO GAIN COST ADVANTAGE

RETAIL BANKING EXAMPLE

Citibank applies imaging technology innovation to multiple business processes

1986 | 1995 | 1997

Check processing

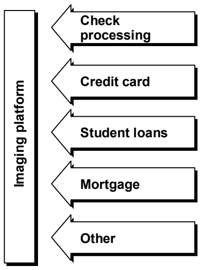
- Developed check imaging in 1985
- Used it in “proof-of-deposit” in early 1990s

Credit card unit

- Deployed scanning and imaging technology to capture data elements and reduce data entry
- Streamlined credit processing eliminating bottlenecks such as credit bureau
- Used imaging in query and remittance processing

Lending operations

- Applied imaging technology in other lending operations, e.g., student loans, mortgages, retail installment loans



- Integrated imaging platforms allowing Citibank to further lower unit costs and increase productivity through better asset utilization

Source: Interviews

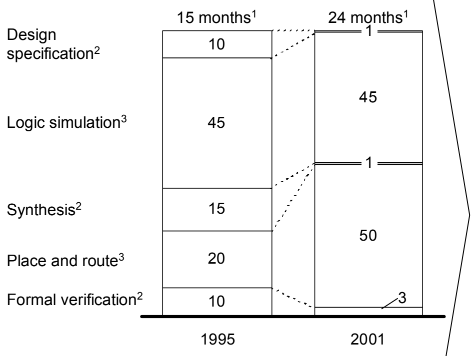
Exhibit 18

EDA TOOLS HELPED REDUCE “REAL” DESIGN TIME

ASIC EXAMPLE

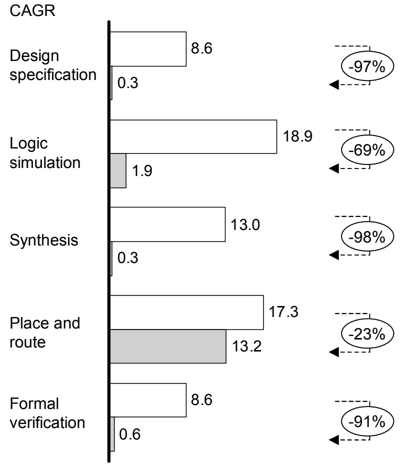
☐ 1995
▨ 2001

Nominal time for new design



	1995	2001
Average gate count for new design	6 million	94 million
Average team size for new design[4]	60	180

Effort per gate (person seconds)
CAGR



1 Average time for new design based on prevalent process technology (250 nm in 1995, 130 nm in 2001)
2 Computing effort (e.g., computer time spent to calculate power consumption) scales roughly linearly with gate count
3 Computing effort (e.g., computer time spent in checking for timing violations) scales nonlinearly with gate count
4 Design team sizes have tripled in the past 10 years

Source: Interviews; McClean Report; MGI analysis established by the leaders. This dynamic relationship between productivity gains and profitability associated with IT investments is a core element of the competitive market process and helps explain why individual firms derive such variable impact from their IT capital over time.

IT as a source of differentiation

While managers can use IT as a tool to innovate and to close gaps with best practice, competitive advantage through investment in IT alone is difficult to sustain. As many firms in a sector adopt IT applications over time, the applications become core, or the cost-of-doing-business, rather than a source of differentiation. In retail, for instance, central support systems, warehouse management and automation systems, and POS upgrades are core IT investments made by all large firms across the sector. They improve productivity for the whole sector but are not differentiating for any individual firm.

The ability of competitors to make the same investment in IT and catch up in productivity determines how quickly IT applications go from differentiating to core. Thus, investments in IT are more likely to remain differentiating if accompanied by significant changes in the business process or other advantages such as scale and learning effects that are not easily replicated.

In the case of retail, leading firms captured competitive advantage from their IT systems because they advanced their IT capabilities well beyond the competition in terms of being able to capture data, analyze the information, and then use their supply chain to execute directives on the basis of this information. In retail banking, however, most IT investments were simply a cost of doing business and therefore not differentiating. Strict reporting requirements, and the necessity of information flow between banks, meant that all banks had to develop roughly similar IT capabilities. In addition, the retail banking sector is served by a well-developed vendor community that helps competitors catch up to innovators. In semiconductors, no player has yet used IT alone to differentiate itself, but some firms are better able to leverage their IT investments through the application of in-house knowledge of process technology developed by producing previous generations of products.

Thus, at the firm level, IT must be one of several tools and investments that managers use to innovate. If IT is not linked to other investments, capabilities, and strategies, it will not differentiate firms sufficiently to create excess value. Furthermore, over time, successful innovations will be copied and advantages will be competed away; sustaining returns requires continued innovation.

Productivity and profitability

In our sector cases we observed instances where IT investments enabled productivity gains in the sector, but to date have not translated into competitive advantage or increased profitability for individual firms. This outcome is a consequence of the dynamic relationship between productivity and profitability, which changes over time, particularly in very competitive industries.

Within any given market, a firm that is more productive will enjoy higher profitability, unless it suffers from some other source of cost disadvantage. A more productive firm will either produce the same output with fewer inputs and thus enjoy a cost advantage, or produce more or better output with the same inputs and thus enjoy higher revenues, either by selling more units or by commanding a price premium. Over time, the higher profitability of productive firms attracts competition. As competitors catch up in productivity, profitability will be competed away. In such an environment, the only way a firm can enjoy higher profitability is by advancing the productivity frontier beyond its competitors. In other words, profitability, in a dynamic and competitive environment, is a transient reward for productivity improvements.

In the retail, semiconductor, and retail banking sectors during the 1990s, productivity gains often helped drive continued gains in profitability, but did not always translate into sustained profitability improvement for individual firms. With intense competition, gains in productivity tended to devolve away from profits to consumer surplus. Investments simply became a cost of doing business to remain competitive in the sector. In retail banking, for example, banks have not increased profitability or gained competitive advantage from some of their IT investments despite improvements in productivity. With multichannel access, IT has helped to lower the cost per transaction, but the overall number of transactions has increased dramatically. Profitability did not increase because most of the productivity improvements translated into consumer surplus in the form of increased convenience. In retail, intense pressure from value-driven players forced firms to make widespread investments to improve their operations and productivity in order to remain competitive. Achieved gains in productivity translated, at least in part, to consumer surplus in the form of lower prices and wider selection. Finally in semiconductors, extraordinary improvements in productivity driven by dramatic increases in product functionality and quality devolved to consumers who were able to buy higher value-added goods without correspondingly dramatic increases in price.

OUTLOOK AND IMPLICATIONS

Our in-depth examination of these three sectors provides a broad understanding of the character and role of IT investments in enabling productivity gains in the past, and it inevitably prompts questions about future possibilities for improvement and about implications for users and vendors of IT.

Outlook for IT impact

During 1995-2000, most industries dramatically accelerated their spending on IT. While in some cases, like the Y2K updates, these investments were not directly aimed at increasing productivity, other investments in hardware, communications equipment, and IT applications created a set of capabilities that can be used as a platform for future innovation and resulting productivity gains. The challenge will be to leverage existing systems and resources effectively while making high-value incremental investments to maintain parity with the sector average, improve business process efficiency, and identify areas where new IT investment can be differentiating.

In retail banking, as banks seek to reduce costs in the current economic environment, they will look to greater efficiencies from their existing IT investments. Trends in outsourcing, offshoring, standardization of IT applications, and additional IT-related synergies from merged operations will continue to drive productivity enhancements in the future. Furthermore, a decrease in the use of paper-based checks and an increase in electronic forms of payments offer banks the opportunity to derive productivity gains from lower costs in check processing.

Going forward, most retailers are focused on improving communication both within the various groups inside a retailer's organization and with external partners such as first- and second-tier suppliers, and on "catching up" with the industry leaders such as Wal-Mart and Target. There is significant opportunity to improve productivity in retail through catching up to best practice, keeping in mind key subsector and business model characteristics. In addition, retailers at the third level of the "value stack" (Exhibit 14) are already piloting IT-enabled innovations that may become a source of differentiation in the future, further advancing productivity.

The semiconductor sector has seen productivity benefits from existing vertical IT investments, particularly along three productivity levers: increasing labor efficiency, improving capacity utilization, and selling new higher value-added goods and services. As this sector struggles with weakened demand, firms are focused on leveraging their existing IT investments to improve their operational effectiveness and to reduce their cost structure. Further opportunities for productivity improvements can come from incremental investments deployed against other available but underutilized productivity levers.

Our outlook on future gains to be realized from IT investments is in general positive but, as this report clarifies, IT's impact on productivity cannot be boiled down to a simple formula. To have impact, users and vendors must deploy IT thoughtfully and in sector- and even firm-specific ways, in conjunction with other types of innovation and process change.

Implications for users

Given the dynamic relationship between productivity, profitability, and competitive advantage, it is more important than ever for firms to consider their IT investments in the context of their business models and overall strategic goals. Ultimately, IT investments comprise a portfolio of core and differentiating capabilities (Exhibit 19). Firms can seek through their core IT investments to either attain an appropriate level of capability, or selectively catch up to best practice. Differentiating IT investments, on the other hand, represent a substantially new offering of products and/or services, or a step-change in efficiency that creates a significant cost or revenue advantage. Undertaking differentiating investments can be potentially rewarding, but also risky; where investments are easily emulated, they are unlikely to earn high returns. The opportunities to capture the most value from IT investments will come from a deliberate and systematic approach to managing each relevant productivity lever—closing gaps with best practice where required, and selectively differentiating where valuable (Exhibit 20).

Implications for the technology sector

For firms in the technology sector, the findings above have three implications. First, vendors can benefit from tailoring and targeting their offerings to specific sectors, and even subsectors, and their productivity levers. The applications that have had high levels of productivity impact have been quite sector-specific; a focus on vertical markets is a powerful means of developing products that help customers with their key business processes. Such tailoring is easier said than done. It is likely to require deep vertical know-how to enable vendors to tailor the functionality of their products to achieve the greatest impact on the most important levers. IT providers will be forced to master the skills needed to improve their customers' productivity, whether they are helping to improve retail supply chains, or to cut the processing time for insurance claims. The need for know-how and the high cost of acquiring it imply a need to seek out new talent and partnerships to help customers improve their businesses. Providers lacking expertise in particular industries might, for example, form partnerships with smaller, industry-specific independent software vendors and systems integrators to customize products and build tailored modules for core applications.

Second, vendors are likely to benefit from more carefully assessing their customers' state of capability development and building offerings to help them proceed sequentially to higher orders of IT impact. If successful, these efforts should help customers derive additional value from sunken IT investments. Steps

Exhibit 19

INFORMATION TECHNOLOGY CREATES MANY STRATEGIC OPPORTUNITIES

Core – cost of doing business

Differentiating – create competitive advantage

Spectrum of IT opportunities

Continuous improvement

Operational transformation and competitive advantage

Redefinition/ reconfiguration

- **Evolutionary** – incremental changes throughout the enterprise
- Small to medium value and available to most

- **Focused** – efforts that drive competitive advantage by improving and leveraging core processes
- Differentiating IT capabilities offer
  - – Substantially new products and/or services
  - – Step change in efficiency
- High value and widely available

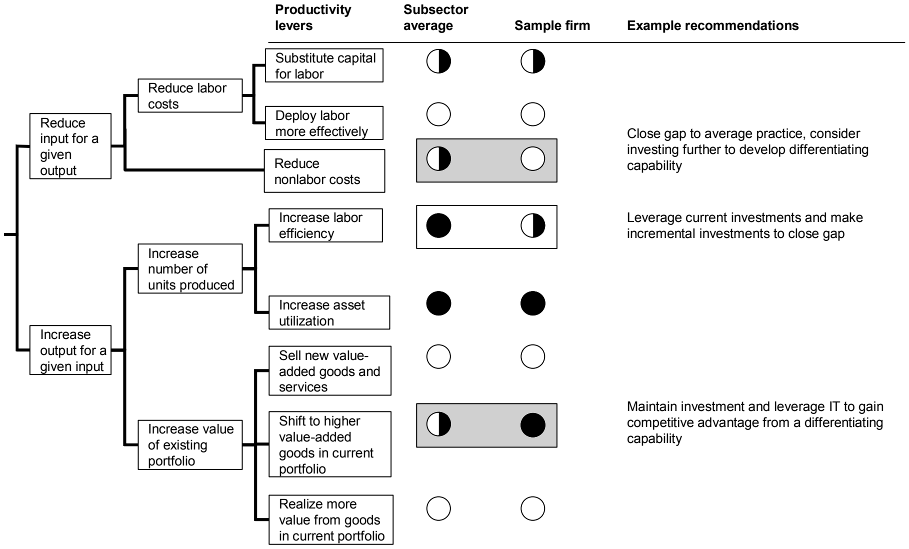
- **Revolutionary** – complete reengineering and redefinition of the business
- High value but rare

Source: MGI analysis

Exhibit 20

INDIVIDUAL FIRMS NEED TO EVALUATE USE OF VARIOUS PRODUCTIVITY LEVERS TO PRIORITIZE OPPORTUNITIES

☐ Gap exists
▨ Highest-priority opportunities
○ Low
● High



Productivity levers	Subsector average	Sample firm	Example recommendations
Substitute capital for labor	◑	◑	
Deploy labor more effectively	○	○	
Reduce nonlabor costs	◑	○	Close gap to average practice, consider investing further to develop differentiating capability
Increase labor efficiency	●	◑	Leverage current investments and make incremental investments to close gap
Increase asset utilization	●	●	
Sell new value-added goods and services	○	○	
Shift to higher value-added goods in current portfolio	◑	●	Maintain investment and leverage IT to gain competitive advantage from a differentiating capability
Realize more value from goods in current portfolio	○	○	

Source: Interviews; MGI analysis

vendors can take to do so include developing products and solutions to help customers turn around unsuccessful technology deployments, and articulating and delivering a clear value proposition that addresses the needs and capabilities of their target customer group(s). Unless they do both, their customers will be less likely to accept big, up-front costs for software and hardware in the future

Third, vendors need to innovate, and even to coinvest with innovative companies, to develop new capabilities. Innovation within the technology sector is a way of life, and technology-driven innovation will remain essential in products, services, and business processes. What is important for vendors to realize is that many productivity enhancing IT applications emerge from the users themselves. Consequently, coinvesting with those leaders can separate winners from losers. Given the importance of this new source of added value, new business arrangements may emerge among IT providers and their customers—the better to share gains and risks. Winning vendors will are likely to be smart innovators on this dimension as well.

Overall, the outlook for the industry depends upon at least two factors. One is the timing and nature of economic recovery. A second is the willingness and ability of vendors to act upon a productivity enabling agenda as we have outlined. From 1980 to 1995, the rate of investment in information technology grew at 8-10 percent per year—a rate faster than nominal GDP growth, but well below its extraordinary 15 percent growth per year from 1995-2000 (and well above the 6 percent annual declines it has suffered since 2000). Given the critical importance of IT to baseline productivity growth during the 1990s, a return to more robust growth rates seems plausible. If the technology sector is able to help its customers reap larger productivity gains from their investments, it is more likely to approach its historical growth rates—something that is good for the sector and for the economy as a whole, given the magnitude of IT's place in the overall economy.

CONCLUSION

Our examination shows that IT was critical in enabling the strong baseline growth in productivity of the US economy throughout the 1990s. Demonstrating its importance is the disproportionate contribution to productivity growth made by the IT producing sectors and the role of IT in enabling the managerial and technical innovations that emerged in response to the changing competitive landscape and demand environment of the past decade.

IT alone did not drive productivity, but it had a diverse and complex impact on productivity depending on when, where, and how it was deployed. IT applications that had a high impact on productivity shared three general characteristics: they were tailored to sector-specific business processes and directed at key performance levers, deployed in a sequence that built capabilities over time, and co-evolved with managerial and technical innovation. Over time, the dynamic relationship between productivity and profitability played out as core IT investments diffused through the various sectors, and as leading firms continued investing in differentiating capabilities that surpassed those of competitors, helping the leaders improve their products, processes, and/or services. It is this competitive dynamic that will continue to drive improvement across the key performance levers of the retail, retail banking, and semiconductor sectors—and in the economy as a whole.

IT and productivity growth in the retail sector

SUMMARY

Retail trade experienced strong labor productivity growth in the 1990s – more than twice the growth rate of the overall US economy. Labor productivity in the retail sector grew at 5 percent CAGR from 1993-2000 compared to 2 percent for the overall US economy. In fact, retail trade was the largest contributor to the US GDP (contributing 13 percent of 1993 nominal GDP) and was the fourth largest contributor to the US labor productivity growth rate (after semiconductors, wholesale, and securities) contributing 11 percent of US labor productivity growth.

However, labor productivity growth was unevenly distributed across the different categories of retail, with general merchandise stores (GMS), electronics, apparel, and building materials/do-it-yourself (DIY) experiencing the highest rates.[1] During the same time period, the retail sector also experienced a significant increase in IT intensity.[2] The McKinsey Global Institute (MGI) examined the role of IT in enabling growth in these four subsectors in order to better understand how IT enabled growth in the overall sector.

In the four subsectors studied, IT played a critical enabling role in the strong labor productivity growth of the 1990s. Across each business process, from merchandise planning and management to store operations, IT systems enabled better operations. However, the exact role and nature of key IT systems varied greatly according to each subsector's characteristics and requirements and by business model across individual firms.

Across the four subsectors studied, retailers' IT investments could be described in terms of a four-tier value stack (Exhibit 1):

- **Cost of doing business**. The first level consists of IT investments required to move merchandise from suppliers to customers quickly and

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[1] Miscellaneous retail has the second highest labor productivity growth rate across subsectors, but the heterogeneous nature of this subsector makes it impossible to generalize the role of IT in enabling that growth.

[2] IT refers to software (prepackaged, own account, and custom software), hardware (PC, mainframes, servers), peripherals (storage devices, printers), and communication equipment. "IT intensity" refers to real IT capital stock per persons engaged in production (PEP).

Exhibit 1

IT INVESTMENTS CAN BE CATEGORIZED INTO A FOUR-LEVEL VALUE STACK

Source: MGI analysis

execute transactions efficiently. Most chain retailers have invested in these systems and have seen benefits from these investments.

- **Extended cost of doing business**. This level of investment is also required to move merchandise from suppliers to customers quickly and execute transactions efficiently. Larger retailers ($2 billion plus in annual revenues) need these investments due to their size and added complexity, and, to date, most of the bigger retailers have invested in these systems and have seen an acceptable level of benefits.
- **Differentiating**. These IT applications not only move the right merchandise to the right place, but also do it at the right time and at the right price. Only leading firms (MGI estimates this category to include less than 10 percent of all retailers) have invested and seen significant benefits from these IT systems.
- **Next frontier.** The fourth level of IT investments, besides moving the right merchandise to the right customer at the right price and at the right time, also targets providing the right experience. Leading firms are piloting technology solutions in this space with no significant impact to date; however, successful implementation with well-aligned strategies and business processes could push the performance frontier even further for leading retailers.

Each level of investment creates more value for retailers than the previous level when they are added sequentially. As in other sectors studied, key productivity-enhancing applications in the retail sector shared three characteristics: they were vertical applications with a focus on key business processes and they affected critical performance levers; they helped sequentially build capabilities and were part of a disciplined approach to ensuring that key IT capabilities were in place prior to the next level of IT investments; and they were deployed in concert with business process changes and managerial innovations.

Historically, by various metrics such as IT dollars spent per employee, IT spend as percent of sales, and real IT stock as percent of GDP, retail trade has been a low IT spender, though the sector (like the financial services sector) does spend a significant portion of its gross margin on IT. Many industry participants also characterize the sector's spend as suboptimal, in part due to a vicious cycle in which retailers are reluctant to buy "off-the-shelf" products that do not meet their needs, and vendors are reluctant to invest in what appears to be a "difficult" market. Going forward, optimum deployment of IT across key business levers, coupled with the managerial and business capabilities and well-aligned business processes, could help further increase retail sector labor productivity. Furthermore at a firm level, IT could help mainstream retailers differentiate themselves while helping leading retailers further improve their productivity.

IT vendors interested in participating in this space can facilitate this transition by breaking the vicious cycle. To break the cycle, IT vendors need to focus on four areas: understanding the unique requirements of the retail sector and recognizing key differences among the various retail subsectors; working closely with end users to reduce resistance to change; offering rich APIs[3] to promote seamless integration of the various IT solutions to facilitate end-to-end solutions; and scrutinizing the retailer's position on the "value stack" and offering them the right products and services to help retailers first consolidate their current abilities, then add capabilities and move up the stack when appropriate, versus adopting a "one-size-fits-all" strategy.

INTRODUCTION

The retail sector comprises a significant share of US GDP and, in the 1990s, experienced strong labor productivity and IT intensity growth (Exhibit 2). Retail trade is a transaction-intensive sector with a variety of formats and business models and multiple business process steps connecting suppliers with the end customers. IT in this sector is a critical enabler in moving the merchandise from the suppliers to the consumers and in facilitating the transactions. In this case, MGI found:

- The retail sector contributed significantly to economy-wide productivity growth and acceleration.
- IT played an enabling role in the sector; its role was significant but complex.
- Key IT applications that impacted performance in the retail sector shared three characteristics.
- Significant opportunities and challenges exist for retailers, and for IT vendors wanting to participate in this space.

Focus of current project

Even though the retail trade, in aggregate, experienced high labor productivity growth in the 1990s, wide variation existed across subsectors. The productivity growth rates varied from 12.8 percent to -0.4 percent with electronics, apparel, GMS, and building materials/DIY experiencing the highest productivity growth rates[4] (Exhibit 3). These four subsectors accounted for more than a quarter of

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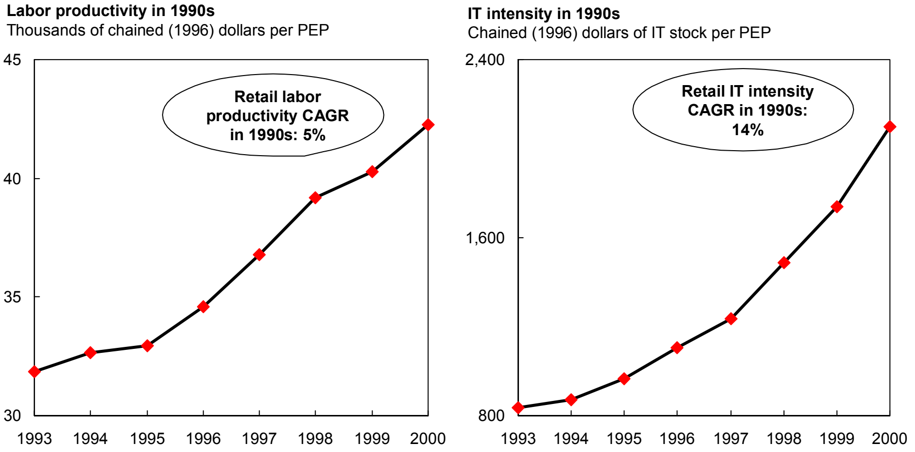
[3] An application programming interface (API) is a "hook" on an application to allow interoperability with other applications.

[4] Miscellaneous retail has the second highest labor productivity growth rate across subsectors, but the heterogeneous nature of this subsector makes it impossible to generalize about the role of IT in enabling that growth.

Exhibit 2

RETAIL SECTOR EXPERIENCED STRONG LABOR PRODUCTIVITY AND IT INTENSITY GROWTH IN THE 1990s



Labor productivity in 1990s
Thousands of chained (1996) dollars per PEP

Retail labor productivity CAGR in 1990s: 5%

IT intensity in 1990s
Chained (1996) dollars of IT stock per PEP

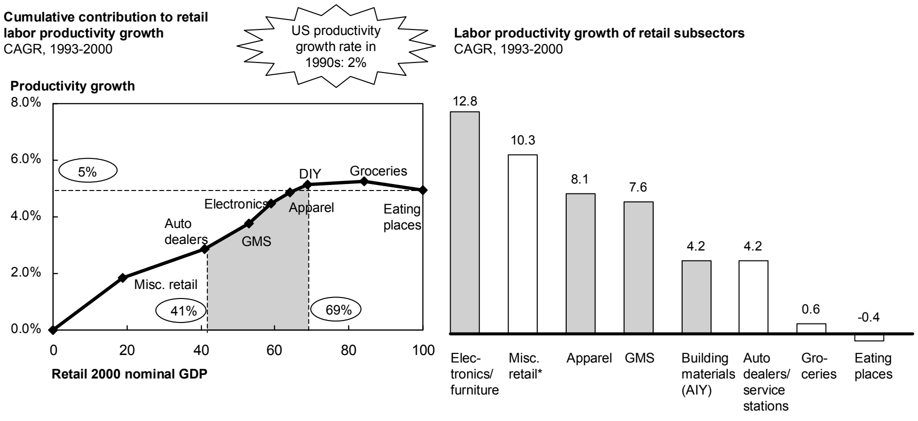
Retail IT intensity CAGR in 1990s: 14%

Source: Bureau of Economic Analysis; MGI analysis

Exhibit 3

RETAIL SECTOR EXPERIENCED HIGH PRODUCTIVITY GROWTH IN 1990s, BUT WIDE VARIATION AMONG SUBSECTORS

▨ Areas of focus



Cumulative contribution to retail labor productivity growth
CAGR, 1993-2000

US productivity growth rate in 1990s: 2%

Labor productivity growth of retail subsectors
CAGR, 1993-2000

* Miscellaneous retail has the second highest labor productivity growth rate across subsectors, but the heterogeneous nature of this subsector makes it impossible to generalize the role of IT in enabling that growth

Source: Bureau of Economic Analysis; Bureau of Labor Statistics; US Census Bureau; MGI analysis retail sales in 2000 (Exhibit 4). MGI focused on these subsectors to understand the role of IT in the productivity growth of the retail sector in the 1990s.

Definition and scope of IT for current project

This project focused on evaluating the role of IT as an input in enabling the productivity growth in the retail sector in the 1990s. MGI focused on “direct” IT, which includes hardware (mainframe computers, PCs, storage devices, and peripherals), software (prepackaged, custom, and own account software), and communication equipment. The study also considered “indirect” IT investments that had embedded IT systems (e.g., automation equipment in warehouses).

SECTOR PRODUCTIVITY

Retail trade was a significant contributor to the US economy’s labor productivity growth and productivity jump5 in the 1990s. Retail, along with semiconductors, wholesale, securities, computer manufacturing, and telecom, contributed to more than 75 percent of net US productivity growth and to more than 80 percent of the net jump in the 1990s.

Sector contribution to economy-wide productivity growth in the 1990s

Retail trade experienced strong labor productivity growth in the 1990s. The sector was the biggest contributor to the US GDP (contributing 13 percent of 1993 nominal GDP) and was the fourth largest contributor to the US labor productivity growth rate (after semiconductors, wholesale, and securities), contributing 11 percent of the growth (Exhibit 5).

Sector contribution to economy-wide productivity growth acceleration in the late 1990s

In MGI’s US Productivity Growth report,[6] retail trade was one of the six sectors that contributed 99 percent of the net economy-wide jump. In the GMS[7] subsector of retail, productivity acceleration was predominantly driven by real sales per hour. The casual factors for productivity acceleration in GMS were: increased consumer substitution toward higher-value goods, managerial and technological innovation leading to improvement in organization of functions and tasks (OFT),

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[5] Jump is defined as the difference between the productivity growth in two time periods.

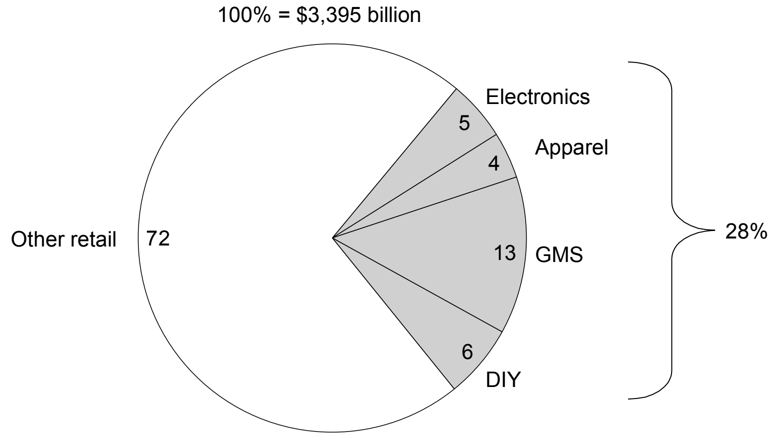
[6] MGI “US Productivity Growth 1995-2000, Understanding the Contribution of Information Technology Relative to Other Factors,” released in October 2001.

[7] GMS subsector includes retailers such as Wal-Mart, Target, Kmart, and Costco.

Exhibit 4

FOUR SUBSECTORS ACCOUNTED FOR MORE THAN ONE QUARTER OF 2000 RETAIL SALES

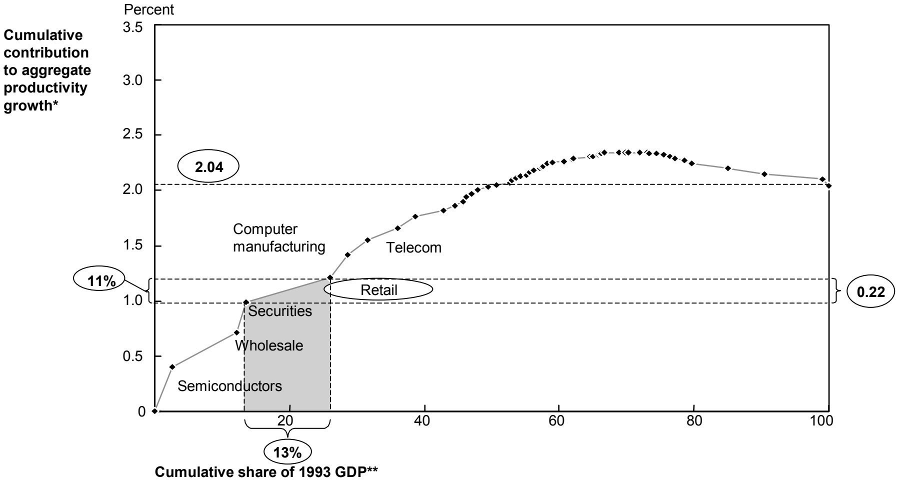
Nominal sales
Percent



Source: Bureau of Economic Analysis; MGI analysis

Exhibit 5

RETAIL SECTOR WAS THE FOURTH LARGEST CONTRIBUTOR TO US LABOR PRODUCTIVITY GROWTH IN 1990s



* CAGR from 1993-2000; does not include farm and government sectors; real estate and holdings contribution evenly divided among sectors excluding the top 6

** Does not include farm, government, holdings, and real estate sectors

Note: MGI's US Productivity Growth report identified semiconductors and computer manufacturing as the predominant (by contribution to growth) subsectors of electronic machinery and industrial machinery, thus the sector and the corresponding subsector are used interchangeably in this chart

Source: Bureau of Economic Analysis; MGI analysis

and heightened competitive intensity due to continued growth of Wal-Mart (Exhibit 6).

The findings remained unchanged when updated with 2000 economic numbers.[8] Retail continues to be a major contributor to the economy-wide acceleration in productivity growth. Retail contributed 12 percent of US nominal GDP in 1995 and 24 percent of the acceleration in productivity growth in 1995-2000. When 2000 data was added, retail replaced wholesale as the sector contributing the most to productivity acceleration, increasing its relative importance (Exhibits 7a and 7b). Furthermore, productivity acceleration in GMS continues to be driven by change in real sales per hour. Interestingly, with the release of new economic data, value added per unit of real sales is even less significant than it was in the original report (Exhibits 8a and 8b).

ENABLING ROLE OF IT

Retail is an extremely transaction- and information-intensive sector. The four target subsectors (GMS, electronics, apparel, and DIY), on average execute 45 million to 50 million transactions a day with an average basket size of $60,[9] compared to securities, which performs 3 million to 4 million daily transactions with an average transaction size of $25,000.[10] IT is required in retailing to manage the complexity created by these high transaction volumes and to coordinate a complicated, multi-tier supply chain. IT not only helps in automating the basic functions (e.g., inventory receiving, inventory control, price scans, checkout), it also offers the ability to optimize many of these processes, including supply chain management, merchandise management, and customer relationship management.

The exact benefit a retailer obtained from IT depended on that retailers' business model, as well as on their strategic choices and their execution. Good IT decisions did not, and will not, compensate for the effects of bad strategic choices; but good strategic decisions, supported by complementary, well-executed IT investments, helped retailers develop sustainable competitive advantage. For example, in the early 1990s, Target Corporation decided to adopt a differentiation strategy based on more trend-oriented merchandising to compete against Wal-Mart. To support its differentiation strategy, Target upgraded the IT systems across its entire group of stores (Target, Mervyn's, and Marshall Fields). The revamped IT system

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[8] See appendix to this report for more detail.

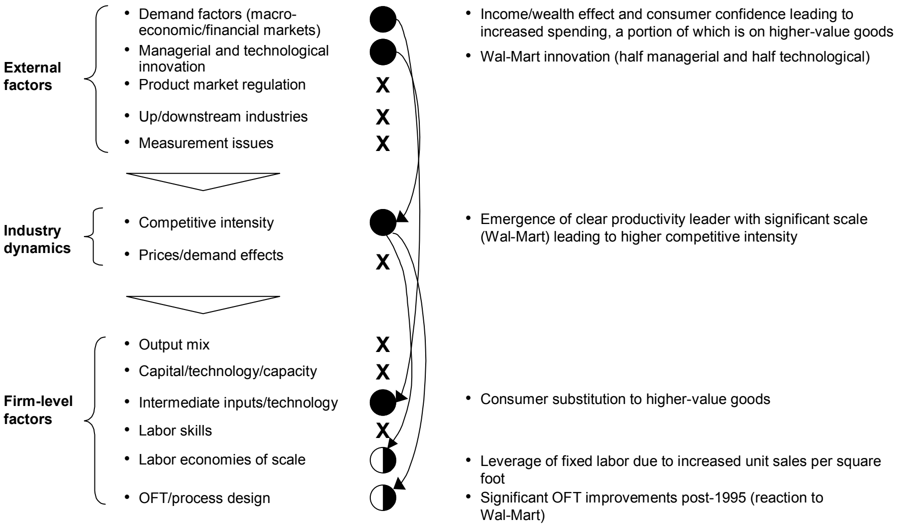
[9] Basket size extrapolated from National Retail Federation survey of apparel retailers and departmental stores in 1998; number of transactions determined by dividing 2000 sales for four subsectors by the average basket size.

[10] Based on transactions on the NYSE and NASDAQ in 2001.

Exhibit 6

SEVERAL FACTORS DROVE PRODUCTIVITY JUMP IN GENERAL MERCHANDISE IN 1995-2000

● Important (>50% of acceleration)
◑ Somewhat important (10-50% of acceleration)
X Not important (<10% of acceleration)

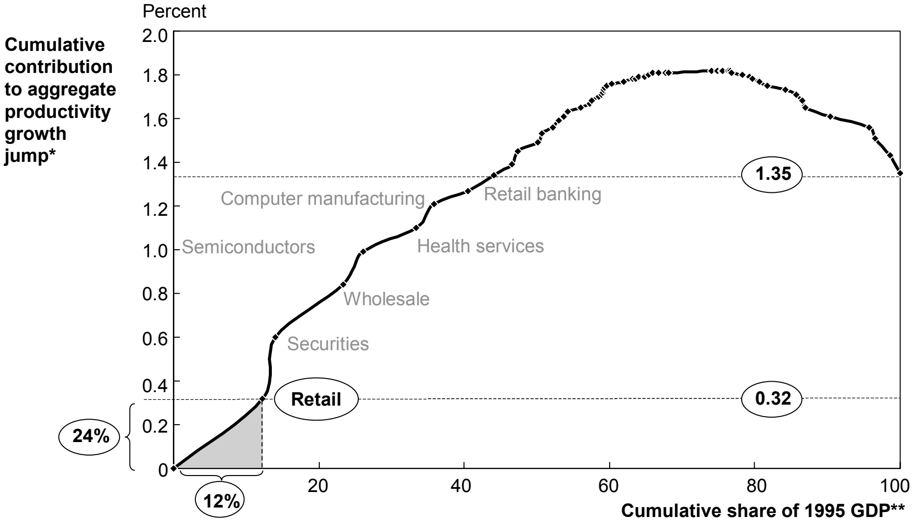


External factors	• Demand factors (macro-economic/financial markets)	●	• Income/wealth effect and consumer confidence leading to increased spending, a portion of which is on higher-value goods
	• Managerial and technological innovation	●	• Wal-Mart innovation (half managerial and half technological)
	• Product market regulation	X	
	• Up/downstream industries	X	
	• Measurement issues	X	
Industry dynamics	• Competitive intensity	●	• Emergence of clear productivity leader with significant scale (Wal-Mart) leading to higher competitive intensity
	• Prices/demand effects	X	
Firm-level factors	• Output mix	X	
	• Capital/technology/capacity	X	
	• Intermediate inputs/technology	●	• Consumer substitution to higher-value goods
	• Labor skills	X	
	• Labor economies of scale	◑	• Leverage of fixed labor due to increased unit sales per square foot
	• OFT/process design	◑	• Significant OFT improvements post-1995 (reaction to Wal-Mart)

Source: Interviews; MGI analysis

Exhibit 7a

RETAIL SECTOR MADE DISPROPORTIONATE CONTRIBUTION TO US LABOR PRODUCTIVITY JUMP IN 1995-2000



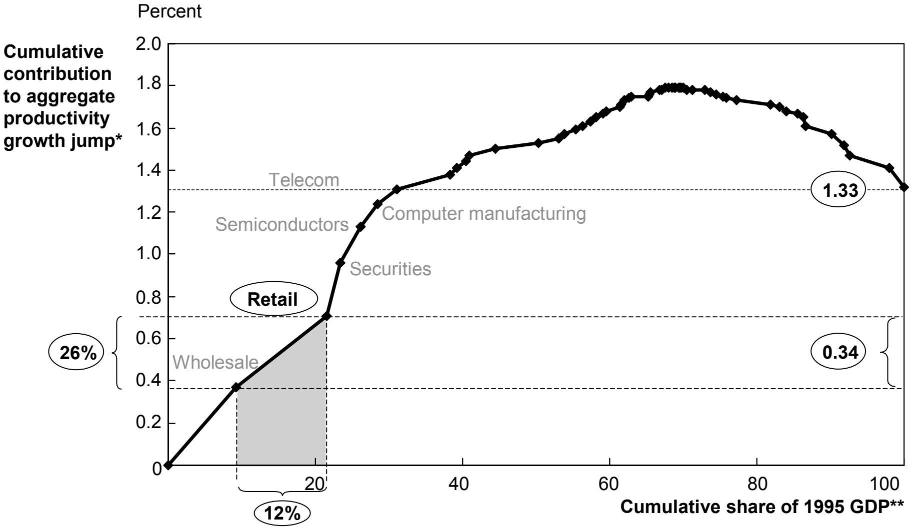
* Jump is defined as difference between 1995-2000 CAGR and 1987-95 CAGR; does not include farm and government sectors; real estate and holdings contribution evenly divided among sectors excluding the top 6

** Does not include farm, government, real estate, and holdings sectors

Source: Bureau of Economic Analysis; MGI analysis

Exhibit 7b

RETAIL SECTOR ALSO MADE DISPROPORTIONATE CONTRIBUTION TO CUMULATIVE PRODUCTIVITY JUMP IN 1995-99



* Jump is defined as difference between 1995-99 CAGR and 1987-95 CAGR; does not include farm and government sectors; real estate and holdings contribution evenly divided among sectors excluding the top 6

** Does not include farm, government, real estate, and holdings sectors

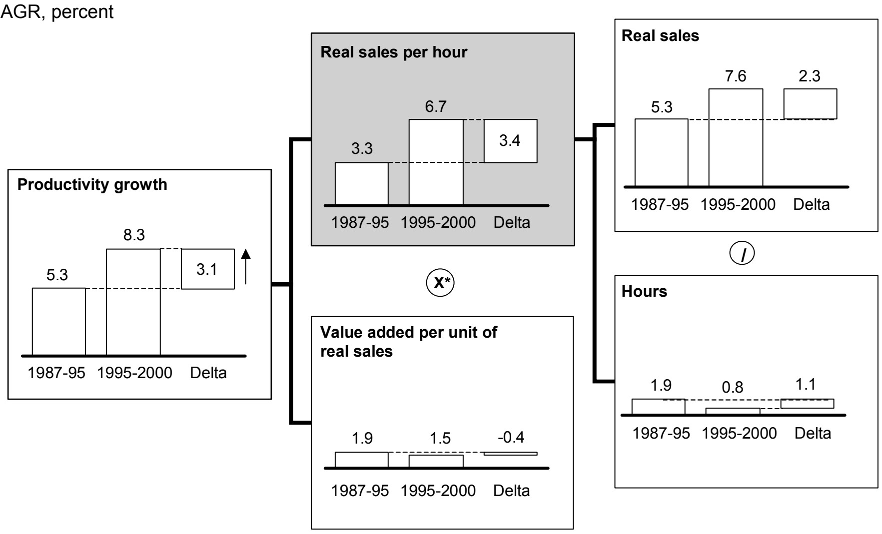
Source: Bureau of Economic Analysis; MGI analysis

Exhibit 8a

ACCELERATION OF REAL-SALES-PER-HOUR GROWTH DROVE PRODUCTIVITY GROWTH JUMP IN GMS IN 1995-2000

▨ Main driver

CAGR, percent



* Calculation is (1 + growth rate 1) x (1 + growth rate 2)

Note: Productivity growth data does not total due to rounding

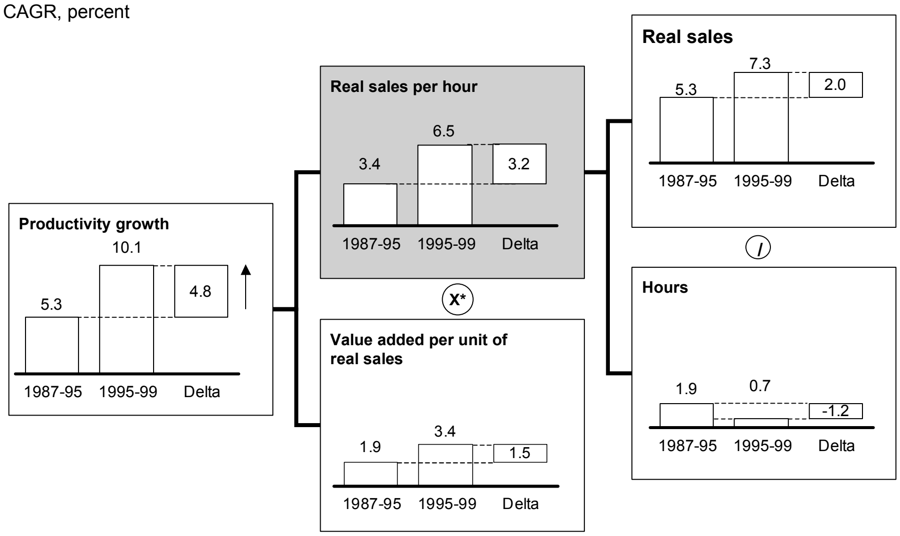
Source: Bureau of Economic Analysis; Bureau of Labor Statistics; US Census Bureau; MGI analysis

Exhibit 8b

ACCELERATION OF REAL-SALES-PER-HOUR GROWTH ALSO DROVE PRODUCTIVITY GROWTH JUMP IN GMS IN 1995-99

▨ Main driver

CAGR, percent



* Calculation is (1 + growth rate 1) * (1 + growth rate 2)

Note: The real sales per hour delta does not total due to rounding

Source: Bureau of Economic Analysis; Bureau of Labor Statistics; US Census Bureau; MGI analysis consisted of several modules including merchandise planning, inventory management, assortment planning, replenishment, pricing, collaborative planning, forecasting, and replenishment (CPFR®[11]), warehouse management systems/transport management systems (WMS/TMS), and included both hardware and software upgrades. The upgraded IT systems allowed the Target Corporation to monitor trends faster and react more quickly, enabling the execution of its differentiation strategy.

Overview of business processes and key IT components

The major IT systems can be determined by aligning the vertical applications along the retail business processes.

A typical retailer has five key business processes (Exhibit 9a):

¶ **Merchandise planning and management** involves determining the quantity and type of merchandise needed in the various stores along with the appropriate promotions, pricing, and markdowns to optimize the retailer's bottom line.

¶ **Manufacturing/sourcing** entails coordinating and collaborating with vendors to procure quality merchandise in a timely manner to supply the stores.

¶ **Distribution/logistics** includes managing the merchandise in a central location and transporting the merchandise from the suppliers to the warehouses/distribution centers (DCs) and from the DCs to the stores in a timely and cost-efficient manner.

¶ **Store operations** comprise various activities in the store needed to complete the sale to the customer. These activities include both back-end (such as receiving inventory, inventory control, and scheduling the sales associates) and front-end operations (such as check outs and store presentation).

¶ **Central functions** involve activities that provide support to the various business processes to ensure continuous operations of a retailer.

Mapping potential IT investments across these business processes indicates that IT investments can be grouped into four major sector-specific bundles (Exhibit 9b):

1. **Merchandise planning and management systems**: Encompasses demand forecasting tools, assortment and allocation planning applications, replenishment solutions, revenue management applications, functional and enterprise data warehouses and datamarts, and database mining tools.

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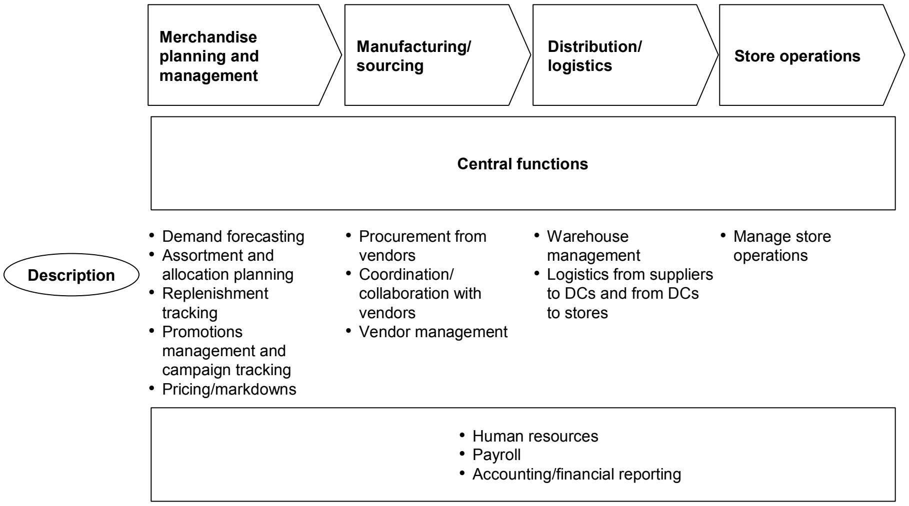
[11] CPFR is the registered trademark of VICS.

Exhibit 9a

TYPICAL RETAILER HAS FIVE BUSINESS PROCESSES



	Merchandise planning and management	Manufacturing/ sourcing	Distribution/ logistics	Store operations
Description	• Demand forecasting • Assortment and allocation planning • Replenishment tracking • Promotions management and campaign tracking • Pricing/markdowns	• Procurement from vendors • Coordination/ collaboration with vendors • Vendor management	• Warehouse management • Logistics from suppliers to DCs and from DCs to stores	• Manage store operations

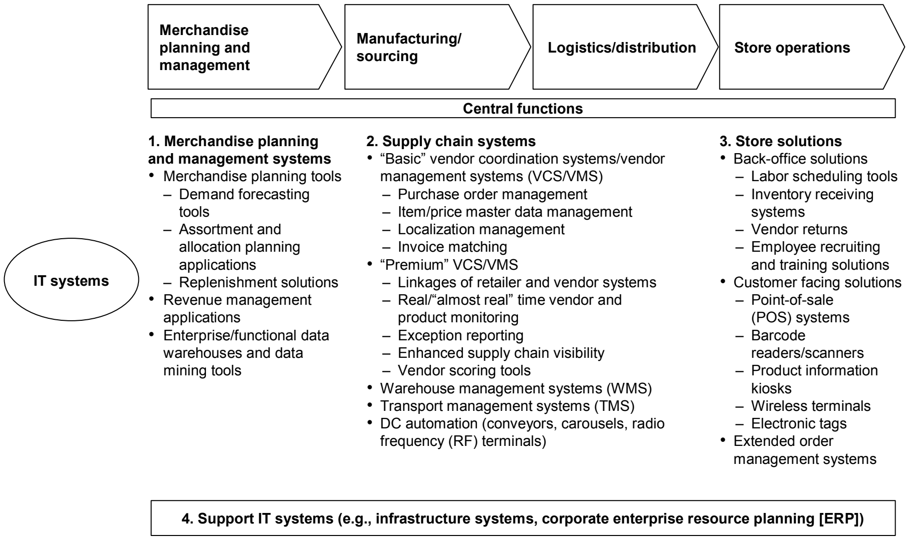
Central functions

- Human resources
- Payroll
- Accounting/financial reporting

Source: Interviews; MGI analysis

Exhibit 9b

RETAIL IT SYSTEMS CAN BE GROUPED INTO FOUR BUNDLES



1. Merchandise planning and management systems
- Merchandise planning tools
  - Demand forecasting tools
  - Assortment and allocation planning applications
  - Replenishment solutions
- Revenue management applications
- Enterprise/functional data warehouses and data mining tools

2. Supply chain systems
- “Basic” vendor coordination systems/vendor management systems (VCS/VMS)
  - Purchase order management
  - Item/price master data management
  - Localization management
  - Invoice matching
- “Premium” VCS/VMS
  - Linkages of retailer and vendor systems
  - Real/“almost real” time vendor and product monitoring
  - Exception reporting
  - Enhanced supply chain visibility
  - Vendor scoring tools
- Warehouse management systems (WMS)
- Transport management systems (TMS)
- DC automation (conveyors, carousels, radio frequency (RF) terminals)

3. Store solutions
- Back-office solutions
  - Labor scheduling tools
  - Inventory receiving systems
  - Vendor returns
  - Employee recruiting and training solutions
- Customer facing solutions
  - Point-of-sale (POS) systems
  - Barcode readers/scanners
  - Product information kiosks
  - Wireless terminals
  - Electronic tags
- Extended order management systems

4. Support IT systems (e.g., infrastructure systems, corporate enterprise resource planning [ERP])

Source: Interviews; MGI analysis

2. **Supply chain systems**: The major components are vendor coordination systems/vendor management systems (VCS/VMS), Electronic Data Interchange (EDI), warehouse management systems (WMS), and transportation management systems (TMS).
3. **Store solutions**: Includes various point solutions such as labor scheduling tools, inventory receiving systems, employee recruiting and training solutions, POS systems, bar code readers/scanners, self help kiosks, radio frequency (RF) terminals for replenishments, and extended order management systems.
4. **Support IT systems**: Primarily includes infrastructure systems (e.g., transactional databases, network management, security, storage systems) and corporate enterprise resource planning (ERP) (e.g., human resources module, payroll module, accounting and financial reporting applications).

Impact of key IT systems on productivity levers

Across most subsectors of retail, IT investments contributed to higher performance along several productivity dimensions, or levers (Exhibit 10). First, IT increased labor efficiency through process redesign. WMS increased labor efficiency by improving the stock picking process in DCs. Second, IT increased asset utilization. Retailer WMS increased DC utilization across all subsectors. Third, IT helped to deploy labor more effectively; labor-scheduling tools in stores enabled better matching of labor demand and supply (an important lever since sales and related labor accounted for 58 percent of the labor pool in retail). Finally, IT helped reduce nonlabor costs such as material handling costs and inventory holding and inventory obsolescence costs.

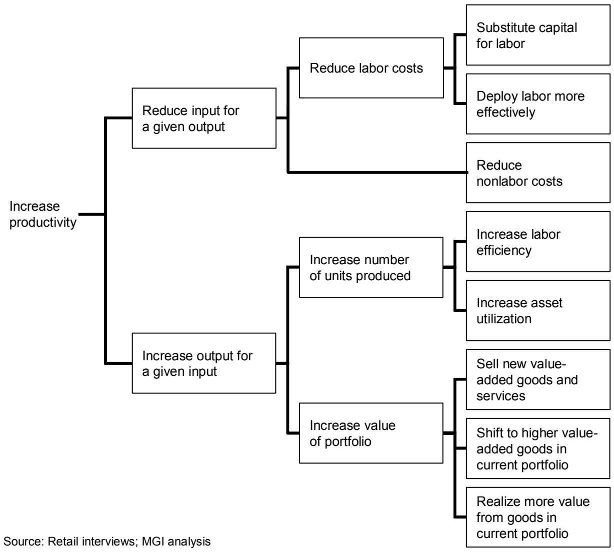
However across subsectors, critical IT systems impacted different productivity levers for three reasons. First, IT bundles and the components within each bundle had varying degrees of penetration. For example, Wal-Mart and Target, two leading players in GMS, have excellent VCS/VMS, while nonvertically integrated players in apparel such as May and Federated have only a moderately effective VCS/VMS. Second, implemented IT systems had different levels of sophistication. GMS and apparel retailers have implemented enterprise data warehouses, while electronic retailers continue to use functional data warehouses and datamarts. Third, subsectors have different characteristics and requirements. WMS, for instance, increased asset utilization in GMS while reducing nonlabor costs (inventory holding and inventory obsolescence costs) in apparel.

Furthermore, MGI's analysis indicates that at a firm level, the impact of critical IT systems on the performance levers depended on the level of usage by the end-users, the extent of sophistication, and the degree of integration of the IT systems within a retailer's organization; their alignment with the business strategy; the

Exhibit 10

PRODUCTIVITY LEVERS IMPACTED BY KEY IT INVESTMENTS VARIED BY SUBSECTORS

○ Low
◑ Moderate
● High



Sector average of impact of IT on productivity levers

Productivity levers	**GMS**	**Apparel**	**Electronics**	**DIY**
Substitute capital for labor	◑	◑	◑	○
Deploy labor more effectively	◑	◑	◑	◑
Reduce nonlabor costs	◑	◑	◑	◑
Increase labor efficiency	●	◑	●	●
Increase asset utilization	●	◑	●	◑
Sell new value-added goods and services	○	○	○	○
Shift to higher value-added goods in current portfolio	◑	◑	◑	○
Realize more value from goods in current portfolio	○	○	○	○

Source: Retail interviews; MGI analysis

degree of organizational and managerial capabilities in place; and the alignment of existing and redesigned business processes with the key IT investments.

Relationship between critical IT investments and subsector characteristics

The relative importance and impact of each IT bundle, and the investments within each bundle on key business processes depends on subsector characteristics and requirements (Exhibits 11a and 11b).

GMS

GMS is a low-margin/high-velocity sector with a high number of SKUs and a high proportion of staple goods.[12] Since the margin per staple item is extremely low, it is critical to increase the inventory turns. Also it is essential to reduce the cost structure by reducing the interaction costs[13] with their suppliers and by minimizing inventory while maintaining high in-stock levels.

Hence the key IT systems[14] in GMS are WMS/TMS, "premium" VCS/VMS, merchandise allocation and replenishment applications, and enterprise or functional data warehouses.

Apparel

The apparel subsector[15] has a high proportion of fashion products with relatively short shelf lives. For these fashion products, inventory levels are committed before the beginning of the season, the number of SKUs are high due to the wide number of variations for each product, and customer requirements are wide-ranging and can change rapidly. Furthermore these fashion products make a significant contribution to the retailer's profit. Hence it is critical to choose the "right" goods, allocate them effectively across stores, get them on store shelves quickly, and optimize markdowns when they are necessary.

These characteristics tend to highlight assortment and allocation planning applications, functional or enterprise data warehouses and data mining tools, "premium" VCS/VMS, revenue management applications, and WMS/TMS as critical IT investments.

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[12] Staple goods are relatively undifferentiated "necessary" items that require high in-stock level and are constantly replenished, e.g., light bulbs, paper towels, and toilet paper.

[13] Interaction costs refers to the cost of coordinating/collaborating with other individuals and firms.

[14] Refer to the glossary of this section for description of IT investments.

[15] Refers to retailers such as Gap, Limited, Federated, May, Saks, and Neiman Marcus; BEA classifies department stores (e.g., May and Federated) as GMS, but MGI has classified department stores as apparel, since these two subsectors share characteristics such as committed inventory levels and high fraction of fashion products.

Exhibit 11a

GMS AND APPAREL SUBSECTOR CHARACTERISTICS AND REQUIREMENTS DETERMINE CRITICAL IT INVESTMENTS

	GMS	Apparel
Sector characteristics and requirements	• Low-margin/high-velocity business with high number of SKUs and high proportion of staples • Sector requires high inventory turns and operational effectiveness	• High number of products with short shelf life, committed inventory levels, and heterogeneity in customer demand • Sector requires reduced time to market, optimized merchandise assortment and allocation, and enhanced revenue management
Key IT investments*	• WMS/TMS • “Premium” VCS/VMS (à la RetailLink) • Allocation planning systems • Replenishment solutions • Data warehouses/data mining tools	• Assortment planning tools • Allocation planning systems • Data warehouses • “Premium” vendor coordination systems • Revenue management applications • WMS • TMS

* Refer to glossary for description of key IT investments

Source: Interviews; MGI analysis

Exhibit 11b

ELECTRONICS AND DIY SUBSECTOR CHARACTERISTICS AND REQUIREMENTS DETERMINE CRITICAL IT INVESTMENTS

	Electronics	Home improvement (DIY)
Sector characteristics and requirements	• Portion of products have short shelf life and experience heterogeneous customer demand; sizeable proportion of products are staples • Relatively low assortment mix/low number of SKUs • Sizeable portion of products needs to be serviced after sale (e.g., warranties, home delivery, repairs) • Sector requires optimized merchandise allocation and pricing/markdowns for seasonal products, enhanced replenishments and in-store inventories for staples, and streamlined after-sales services in certain categories	• Relatively homogeneous and nonseasonal/ predictable customer demand; portion of merchandise are high turn, bulky products • Sector characteristics reduces criticality of merchandise allocation, warehouses management, and close coordination with suppliers • Sizeable portion of products needs to be serviced after sale (e.g., home delivery and installation, repairs); after-sales component has higher margins • Sector requires optimized in-store (back-end and customer-facing) solutions, “right” customer targeted marketing to differentiate and grow, and streamlined after-sales services in certain categories
Key IT investments*	• Allocation planning systems • Replenishment solutions • Functional data warehouses/datamarts • Revenue management applications • Extended order management systems • WMS • TMS	• Back-end in-store solutions • Customer-facing solutions • Extended order management systems • Customer data warehouses

* Refer to glossary for description of key IT investments

Source: Interviews; MGI analysis

Electronics

Electronics[16] typically has some “hot” products that have a short shelf life and varying customer demand, plus a sizeable percentage of staples. Also, electronics has a relatively low assortment mix, a low number of SKUs, and a sizeable portion of products that require service after sale (e.g., warranties, home delivery, repairs). Hence, the electronics subsector needs to maximize its revenues from the “hot” products while reducing the cost structure on its staples product line.

These traits tend to make allocation planning systems, replenishment solutions, functional data warehouses or datamarts, and revenue management applications the critical IT investments.

Building materials/DIY

The home improvement subsector[17] experiences relatively homogeneous and nonseasonal or seasonably predictable customer demand. Relatively large portions of its merchandise are high-turn, bulky products, and a sizeable portion of products needs to be serviced after sale (e.g., home delivery and installation, repairs). Typically, the after-sales component has higher margins.

These characteristics reduce the criticality of merchandise planning investments and increase the importance of in-store operations and after-sales management systems.

Relevance of IT bundle to business model

The relative importance and role of each IT “bundle” and investments within each bundle, depends not only on subsector characteristics and requirements but also on the retailer’s individual business model within a subsector.

GMS

For an “every day low price” (EDLP) retailer such as Wal-Mart, WMS/TMS and “premium” VCS/VMS play a critical role in improving the operational effectiveness and thereby in reducing the cost structure to enable the EDLP strategy. Conversely for a “high-low” retailer such as Sears or Kmart, promotions and campaign management tools are needed to determine the optimum promotions and to monitor the promotional effectiveness of each campaign. Also, causal-based forecasting applications to accurately determine the demand for “affinity products," and back-end in-store applications (for example, labor scheduling tools to match labor supply with peak demand) are critical technology investments to support their strategy.

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[16] Refers to retailers such as Circuit City, Best Buy, and CompUSA.

[17] Refers to retailers such as Home Depot, Lowe’s, and Ace Hardware.

Apparel

For a vertically integrated specialty apparel retailer such as Gap or Limited, VCS/VMS are critical IT investments to enable quick reaction to market trends, to reduce time to market, and to improve production and sourcing. On the other hand, for a nonvertically integrated discount apparel retailer such as Ross or Marshall's, revenue management applications (pricing and markdowns) can help drive the retailer's top line. Similarly, for a "nonstore" catalog player (such as J.Crew or Lands' End) or for a high-end retailer such as Saks or Neiman Marcus, CRM plays a critical role in identifying up-sell and cross-sell opportunities to maximize revenues.

Electronics

In a "brick and mortar" retailer such as Circuit City or Best Buy, store allocation and price optimization tools play a key role in increasing inventory turns and in reducing markdowns to increase the retailer's bottom line. However for an "e-tailer" such as Buy.com or Amazon.com, CRM is needed to identify cross-sell opportunities to maximize revenues.

Building materials/DIY

For a retailer such as Home Depot that has a relatively decentralized business model (i.e., each store is company-owned but to some extent makes its own merchandising and business decisions), in-store solutions and IT investments to link the stores to the corporate office in real time (such as thin clients[18] and broadband to the stores) are critical to operate efficiently and to be in "sync." However, for a DIY retailer such as TruServ, which is a cooperative, where individuals or third-party firms can buy the franchise and operate the store under the TruServ brand, supply chain systems play a key role in reducing the cost structure to allow the individual stores to compete on a level playing field against the chain retailers.

Impact of key IT systems on profitability

For the most part, we found that IT applications that favorably impact productivity also favorably impact profitability. For example, increased inventory turnover and, therefore, capital turnover were affected to a great degree by improved asset utilization in GMS and electronics (Exhibit 12). In addition, MGI's interviews with several retailers, IT vendors, and industry experts generally showed that the industry best practice players have leveraged IT to impact more productivity levers to a greater extent than average players, who have used IT to only

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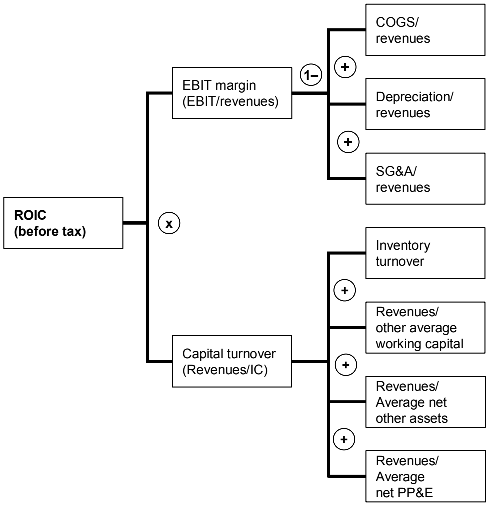
[18] Thin client is a suite of hardware and software products designed to access a server for all information and business-critical applications. The thin client processes the keyboard input and screen output, and the server performs all the application processing. PC terminal is an example of a thin client.

Exhibit 12

IT ALSO IMPACTED DIFFERENT PROFITABILITY LEVERS ACROSS SUBSECTORS

++ High impact
+ Medium impact
0 No impact



	Sector average of impact of IT on profitability levers			
Levers	GMS	Apparel	Electronics	DIY
COGS/ revenues	0	+	+	0
Depreciation/ revenues	0	0	0	0
SG&A/ revenues	+	+	+	+
Inventory turnover	++	+	++	+
Revenues/ other average working capital	0	0	0	0
Revenues/ Average net other assets	0	0	0	0
Revenues/ Average net PP&E	0	+	+	0

Source: Interviews; SEC filings; MGI analysis moderately impact a few productivity levers. However, even the industry's best practice players have not fully utilized IT to gain the maximum impact from all the productivity levers (Exhibit 13). Thus, industry best practice leaders have leveraged IT to affect more of their profitability levers to a greater extent, but have not exploited IT for maximum impact from all the profitability levers (Exhibit 14).

The large gap between industry average performance and best practice players' performance against the various productivity and profitability levers provides a significant challenge and an opportunity for the various stakeholders in this space to improve performance.

IT architecture in retail

Successful retailers developed their IT architecture by developing capabilities in a logical order – they initially built out basic capabilities such as support functions, supply chain management, and POS systems, and then on top layered more sophisticated merchandising and revenue management capabilities. When retailers tried to deploy more sophisticated applications out of sequence, they were generally not successful.

We segmented IT investments across the subsectors according to what the systems do and which retailers invested in them (Exhibit 15). These four tiers of investments, when added sequentially, approximate an ideal retail IT architecture.

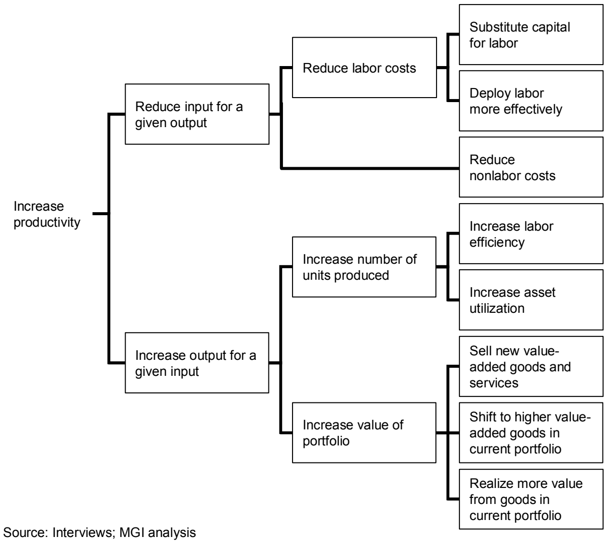
¶ **Cost of doing business.** Almost all chain retailers have invested in these systems and have seen at least an acceptable level of benefit. Although individual retailers' performance on these systems may vary, no one retailer gets a competitive advantage from these investments. These investments include corporate ERP (HR, payroll, and financials), infrastructure systems (e.g., network management, security, storage systems), perpetual inventory systems, WMS, and POS systems (scanners, barcode readers, and computer systems to capture data). These investments allow retailers to move merchandise rapidly from the suppliers to the customers.

¶ **Extended cost of doing business.** Almost all major chain retailers (greater than $2 billion in annual revenues) have invested in these systems and have reached, at a minimum, an acceptable threshold of performance. This additional level of investment is required because of the increased size and scale, and the additional complexity of operations that need to be managed. These investments include TMS, functional and enterprise level data warehouses, and data mining tools. Like the first group of investments, these investments help move merchandise rapidly from the suppliers to the customers.

Exhibit 13

NOT ALL PRODUCTIVITY LEVERS DELIVERED MAXIMUM IMPACT, EVEN FOR BEST PRACTICE PLAYERS

○ Low
◑ Moderate
● High



Productivity levels	GMS	Apparel	Electronics	DIY
Substitute capital for labor	●	●	●	◑
Deploy labor more effectively	●	◑	◑	●
Reduce nonlabor costs	●	●	●	◑
Increase labor efficiency	●	◑	●	●
Increase asset utilization	●	◑	●	◑
Sell new value-added goods and services	○	○	◑	◑
Shift to higher value-added goods in current portfolio	◑	●	◑	○
Realize more value from goods in current portfolio	◑	◑	◑	○

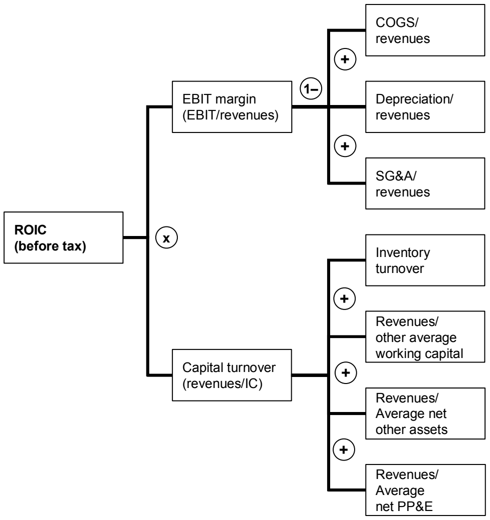
Best practices of impact of IT on productivity levers

Source: Interviews; MGI analysis

Exhibit 14

NOT ALL PROFITABILITY LEVERS DELIVERED MAXIMUM IMPACT, EVEN FOR BEST PRACTICE PLAYERS

++ High impact
\+ Medium impact
0 No impact



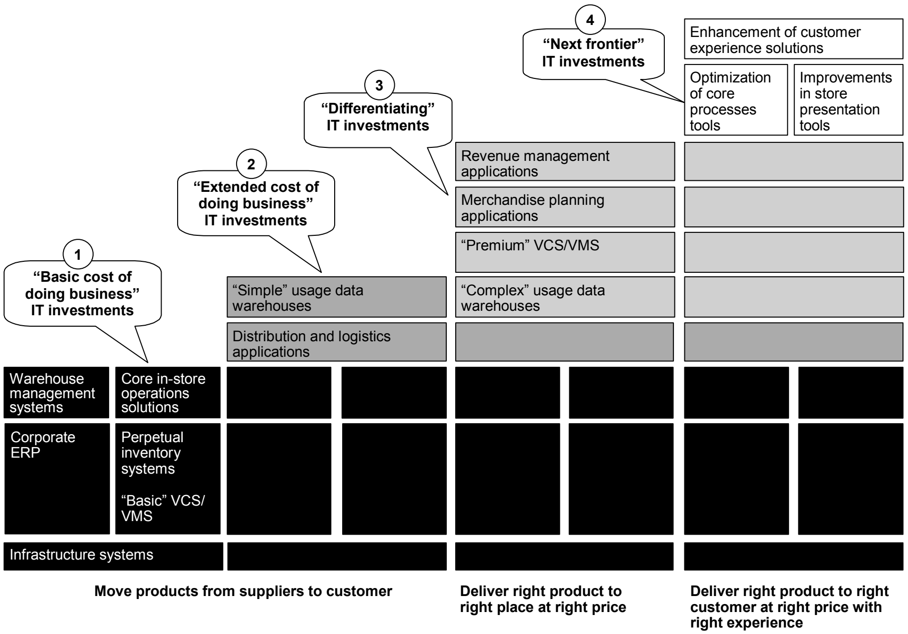
Levers	GMS	Apparel	Electronics	DIY
COGS/ revenues	+	++	++	0
Depreciation/ revenues	0	0	0	0
SG&A/ revenues	++	+	+	++
Inventory turnover	++	++	++	+
Revenues/ other average working capital	0	0	0	0
Revenues/ Average net other assets	0	0	0	0
Revenues/ Average net PP&E	++	++	++	+

Best practices of impact of IT on profitability levers

Source: Interviews; SEC filings; MGI analysis

Exhibit 15

IT INVESTMENTS CAN BE SEGMENTED INTO FOUR TIERS



Source: Interviews; MGI analysis

- **Differentiating**. Only leading retailers (MGI estimates this category to include less than 10 percent of all retailers) have invested at this tier, and they have seen a high level of impact from these systems. These investments have had disproportionate impact because the leading retailers have mastered the first two tiers and now have "one version of the truth" in the form of a reservoir of clean, accessible data that they can manipulate for enhanced decision support. Leading retailers have also invested in the required processes, capabilities, and organizational buy-in to leverage these investments into a competitive advantage. These investments include premium VCS/VMS, and merchandise planning and management systems (this includes assortment planning tools, allocation planning systems, replenishment solutions, and revenue management applications). Merchandise planning and management systems analyze historical and "like item" data at a very detailed level to arrive at planning decisions. The objective of the third group of investments is to get the right product to the right place at the right time and at the right price.

- **Next frontier.** A few select retailers are piloting some or all of investments in this bundle, but visible impact has been limited to date. Going forward, retailers who have invested in and built capabilities incrementally in the first three groups should both see the most benefits from these investments, and be able to use the systems to gain a strong competitive advantage. Investments in this tier include optimization of core processes, integration of decision support systems with planning systems, exception reporting systems, enhancement of customer experience through better store presentation, and targeted customer marketing. These investments get the right product to the right customer, at the right price, at the right time, and provide the right experience.

These four types of investments together form a value stack (Exhibit 16). Each level of investment creates more value than the previous level when they are added in sequence. It is important to note the following characteristics about the value stack:

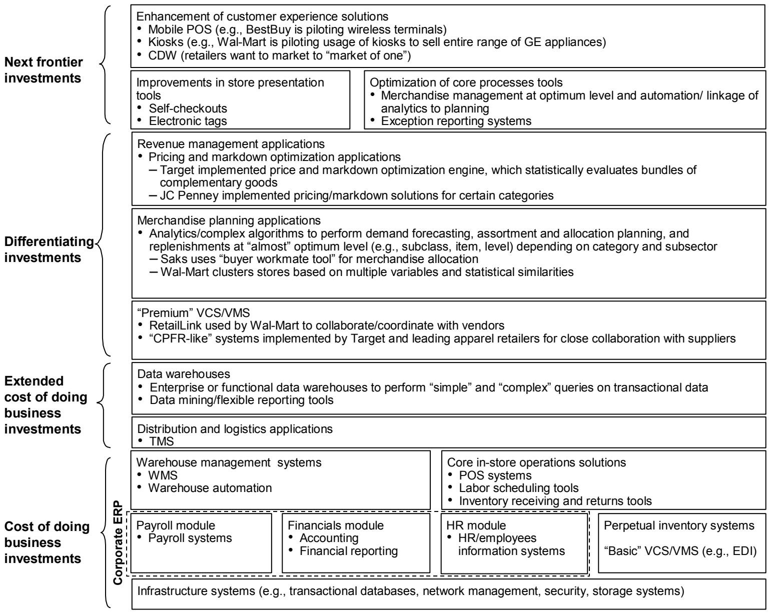
- Leading retailers have sequentially built capabilities and have a greater stack "height."

- Retailers capture more value and move closer to the customers as they move up the stack.

- "Out-of-step" stack investments reduce/eliminate value obtained from that particular IT investment. For example, Kmart invested in IT systems to improve promotions management, but the investment failed to deliver the desired impact due to the absence of effective supply chain systems

Exhibit 16

FOUR CATEGORIES OF IT INVESTMENTS FORM THE VALUE STACK



Next frontier investments

Enhancement of customer experience solutions
- Mobile POS (e.g., BestBuy is piloting wireless terminals)
- Kiosks (e.g., Wal-Mart is piloting usage of kiosks to sell entire range of GE appliances)
- CDW (retailers want to market to “market of one”)

Improvements in store presentation tools
- Self-checkouts
- Electronic tags

Optimization of core processes tools
- Merchandise management at optimum level and automation/ linkage of analytics to planning
- Exception reporting systems

Differentiating investments

Revenue management applications
- Pricing and markdown optimization applications
  - Target implemented price and markdown optimization engine, which statistically evaluates bundles of complementary goods
  - JC Penney implemented pricing/markdown solutions for certain categories

Merchandise planning applications
- Analytics/complex algorithms to perform demand forecasting, assortment and allocation planning, and replenishments at “almost” optimum level (e.g., subclass, item, level) depending on category and subsector
  - Saks uses “buyer workmate tool” for merchandise allocation
  - Wal-Mart clusters stores based on multiple variables and statistical similarities

“Premium” VCS/VMS
- RetailLink used by Wal-Mart to collaborate/coordinate with vendors
- “CPFR-like” systems implemented by Target and leading apparel retailers for close collaboration with suppliers

Extended cost of doing business investments

Data warehouses
- Enterprise or functional data warehouses to perform “simple” and “complex” queries on transactional data
- Data mining/flexible reporting tools

Distribution and logistics applications
- TMS

Cost of doing business investments

Warehouse management systems
- WMS
- Warehouse automation

Core in-store operations solutions
- POS systems
- Labor scheduling tools
- Inventory receiving and returns tools

Corporate ERP

Payroll module
- Payroll systems

Financials module
- Accounting
- Financial reporting

HR module
- HR/employees information systems

Perpetual inventory systems

“Basic” VCS/VMS (e.g., EDI)

Infrastructure systems (e.g., transactional databases, network management, security, storage systems)

Source: MGI analysis

that could handle the fluctuating sales volumes (especially premium VCS/VMS).

¶ The value stack is dynamic and it “settles” over time as differentiating applications diffuse throughout the sector and become cost-of-doing-business investments. As in most competitive arenas, the performance bar continually rises, and what it took to win gold a decade ago now only qualifies a player to be in the game. Leaders therefore need to continually invest and innovate to maintain their lead.

IT as a source of competitive advantage

In the 1990s, leading retailers beat mainstream retailers in three areas: parts of supply chain management (premium VCS/VMS), merchandise planning, and revenue management. Significantly, deriving value from these differentiating (third-tier) investments has come not only from leveraging IT capabilities but also from adapting the business processes to obtain the maximum impact.

The best supply chain managers had premium vendor coordination systems/vendor management systems – ones that link retailers’ systems to suppliers’ systems, creating a “glass pipeline”[19] for inventory visibility, better supply and demand visibility, and for enhanced collaboration between retailer and suppliers. Leading retailers have the organizational and system capability in place to create and maintain this “backbone” to gain a competitive advantage, while a lack of system capabilities and a lack of trust have historically prevented mainstream retailers from achieving close linkages with suppliers. Recent efforts such as CPFR®, public exchanges (e.g., WWRE), and private exchanges (e.g., hosted solutions offered by GNX) are moving mainstream players toward obtaining this capability, but a significant gap still exists between the leading and mainstream players.

Merchandise planning is comprised of three components – demand forecasting, assortment and allocation planning, and replenishment – and it involves planning along three dimensions – stores, products, and time (Exhibit 17). Planning on a micro level (e.g., one store, one item, one hour) eliminates the “averaging-out” effect that occurs when planning at a higher level (planning at a higher level implicitly assumes that all items in that group are homogeneous and their demand and supply characteristics equal the group’s average characteristics). Micro-level planning would ideally ensure perfect matching of supply to demand; however, physical barriers such as lead times from suppliers and distribution centers, noise at the granular level, and economic cost make it nearly impossible to achieve this objective.

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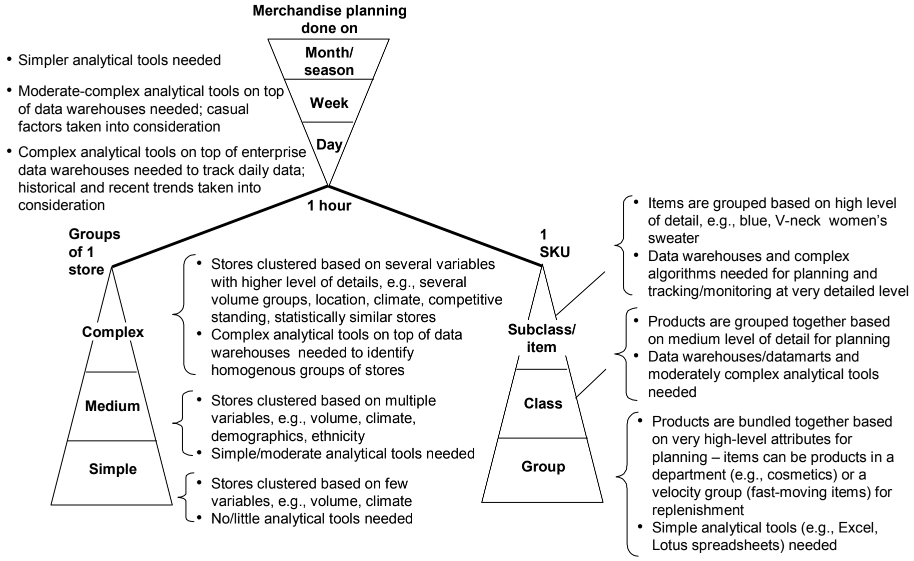
[19] Glass pipeline refers to the real-time visibility of inventory in the various parts of the supply chain to the retailer and its suppliers.

Exhibit 17

MERCHANDISE PLANNING INVOLVES PLANNING ALONG 3 DIMENSIONS: STORES, PRODUCTS, AND TIME, BUT LEVEL OF DETAIL CAN VARY



- Simpler analytical tools needed
- Moderate-complex analytical tools on top of data warehouses needed; casual factors taken into consideration
- Complex analytical tools on top of enterprise data warehouses needed to track daily data; historical and recent trends taken into consideration

- Stores clustered based on several variables with higher level of details, e.g., several volume groups, location, climate, competitive standing, statistically similar stores
- Complex analytical tools on top of data warehouses needed to identify homogenous groups of stores

- Stores clustered based on multiple variables, e.g., volume, climate, demographics, ethnicity
- Simple/moderate analytical tools needed

- Stores clustered based on few variables, e.g., volume, climate
- No/little analytical tools needed

- Items are grouped based on high level of detail, e.g., blue, V-neck women's sweater
- Data warehouses and complex algorithms needed for planning and tracking/monitoring at very detailed level

- Products are grouped together based on medium level of detail for planning
- Data warehouses/datamarts and moderately complex analytical tools needed

- Products are bundled together based on very high-level attributes for planning – items can be products in a department (e.g., cosmetics) or a velocity group (fast-moving items) for replenishment
- Simple analytical tools (e.g., Excel, Lotus spreadsheets) needed

Source: Retail interviews; MGI analysis

The optimum level of detail in planning along the three dimensions depends on product category, the subsector, and the retailer's business model and cost structure. Furthermore, the relative importance of individual components of merchandise planning varies depending on the product category and the retail subsector. For example, merchandise demand forecasting is critical to high-end fashion apparel, and assortment and allocation planning is important for "hot" apparel and electronics products, while replenishment is core for staple products in GMS, DIY, and electronics (Exhibit 18). Leading retailers leverage complex algorithms on transactional data in dedicated datamarts on top of functional or enterprise data warehouses,[20] to plan along these three dimensions to an "almost optimum" level. For example, Lowe's uses NCR Teradata enterprise data warehouse to determine the optimum time that Christmas ornaments and decorations need be on the store shelves. On the other hand, mainstream retailers are using simple analytical tools (e.g., MS-Excel on datamarts or transactional databases) and strong intuition to perform pre-season and in-season merchandise management in a more subjective, less precise way (Exhibit 19).

Revenue management involves pricing merchandise, including initial pricing and later markdowns, based on demand elasticity of customers, bundles of complementary goods, and substitutability and profit optimization. This is in contrast to more typical practices that base prices on competitive pricing or on a cost-plus basis. In addition, leading retailers used statistical analysis of historical data and data on "like" items to determine optimum pricing, while mainstream players used competitive pricing and natural instinct to determine pricing.

SUMMARY OF RELATIONSHIP BETWEEN KEY IT APPLICATIONS AND PRODUCTIVITY PERFORMANCE

The above discussion of the enabling role of IT in the retail sector, with its emphasis on understanding key business processes, subsector characteristics, particulars of individual business models, and IT architecture of average and best practice firms shows the complexity of the relationship between IT investments and productivity. Looking across the retail sector examples, we find that key productivity enhancing applications in the sector shared three characteristics:

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[20] Data warehouse, a relational database management system (RDBMS), is designed specifically for information retrieval and analysis, and has a multidimensional data model, in contrast to a transactional database that is also RDBMS but is designed for daily operations and has a normalized data model. Typically, data warehouses can handle multiple (several hundred) complex queries simultaneously per second, in contrast to transactional databases that are geared more toward transactional/operational handling and less toward enhanced analytics.

Exhibit 18

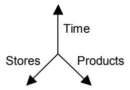
RELATIVE IMPORTANCE OF COMPONENTS OF MERCHANDISE PLANNING DEPENDS ON RETAIL SUBSECTOR AND PRODUCT CATEGORIES

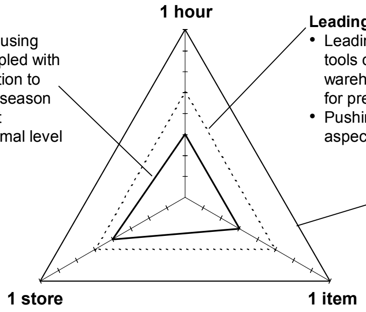
Critical in	Merchandise planning		
	Merchandise demand forecasting	**Assortment and allocation planning**	**Replenishment**
Subsegments	• High-end fashion apparel • Vertically-integrated segments/ retailers, e.g., apparel, private-label retailers, and private-label categories in groceries and GMS	• Fashion apparel • Electronics • GMS (nonstaples)	• GMS • DIY • Electronics (staples)
Product categories	• Long lead-time product • Short life-cycle, high obsolescence- cost products • High committed level of inventory	• Fashion products with heterogeneous demand • Products with big difference in margins	• Staples, nonseasonal products • Products with high in-stock level requirements (e.g., milk, toilet paper, light bulbs)
Required IT investments	• Analytical tools on top of data warehouse/datamart to – Identify “like”/complementary items – Use historical data trends for preseason planning to forecast demand at a department/class level – Determine sales lift due to promotions and affinity items promotion	• Complex queries/applications on enterprise data warehouses to – Identify optimum assortment mix during preseason and in-season planning – Cluster stores into “almost homogeneous” categories	• Analytical applications on top of enterprise/functional data warehouses to identify optimum in-store inventory levels at a detailed product and store level based on – Targeted in-stock levels – Lead times – Variability in demand and supply

Source: Interviews; MGI analysis

Exhibit 19

SIGNIFICANT GAP EXISTS BETWEEN LEADING RETAILERS AND MAINSTREAM RETAILERS IN EFFECTIVE MERCHANDISE PLANNING





Mainstream players
- "Mainstream" retailers are using simple analytical tools coupled with datamarts and strong intuition to perform preseason and in-season merchandise management
- Planning occurs at suboptimal level of detail

Leading players
- Leading retailers are using sophisticated analytical tools coupled with enterprise-level data warehouses for "almost optimum" level of grouping for preseason and in-season merchandise planning
- Pushing toward optimum level of detail in all aspects of merchandise management

"Final frontier"
- Using analytical tools to run complex algorithms on enterprise data warehouses to plan and track at an SKU, store, and hourly level
- Lead times from suppliers, noise at granular level, economics, and data integrity issues are barriers to reaching the "finish line"

“Holy grail” involves merchandise planning at the optimum (benefits > costs) level of detail along the 3 dimensions depending on
- **Product category**
- **Retail subsector**
- **Retailer’s cost structure and business model**

Note: The 3 axis represent grouping of stores, products, and time for merchandise planning; increasing number on scale represents increasing complexity in grouping resulting in increased number of groups/clusters and thus a more detailed level of planning

Source: Interviews; MGI analysis

1. They were vertical applications with a focus on key business processes, and they impacted critical performance levers

Across the four subsectors studied, vertical applications targeting critical business processes delivered the highest impact. For example, Wal-Mart's internally developed vendor management system, RetailLink, is credited for Wal-Mart's widely acclaimed efficient supply chain management. In a sector that is characterized by relatively low margins per item, RetailLink helps increase sourcing efficiency (by linking Wal-Mart's system with its vendors' system to enhance inventory visibility), reduces the "bullwhip effect"[21] and increases coordination with its suppliers; all of these factors have helped Wal-Mart achieve a low-cost structure.

Key technology investments played an enabling role in positively impacting the subsector-specific performance (productivity and profitability) levers. For example, Wal-Mart's portfolio of IT investments is said to have played a significant enabling role in improving its cost structure and its asset leverage. A comparison of Wal-Mart and Kmart's ROIC (return on invested capital) and ROIC levers, indicates that Wal-Mart had superior gross margins, operating margins, and inventory turnover, vis-à-vis Kmart over the past decade, in part due to IT (Exhibit 20).

2. They helped sequentially build capabilities and were a part of a disciplined approach to ensure that key IT capabilities were in place prior to new levels of IT investments

In retail, IT investments helped leading retailers obtain the required capabilities in phases. In the eighties and early nineties, IT investments such as POS upgrades and WMS helped move products from suppliers to customers rapidly. Later, IT investments such as enhanced bandwidth networks and functional or enterprise data warehouses helped retailers capture customer data and manipulate it in "almost real" time for planning purposes. Today, IT investments such as merchandise planning systems and revenue management applications are helping retailers optimize planning and deliver the right products to the right place, at the right time, and at the right price.

3. They were deployed in concert with business process changes and managerial innovations

Significant technology investments co-developed with changes in the business processes. For example in the 1990s when Home Depot expanded its stores aggressively, Home Depot implemented in-store kiosks (kiosks showed a video,

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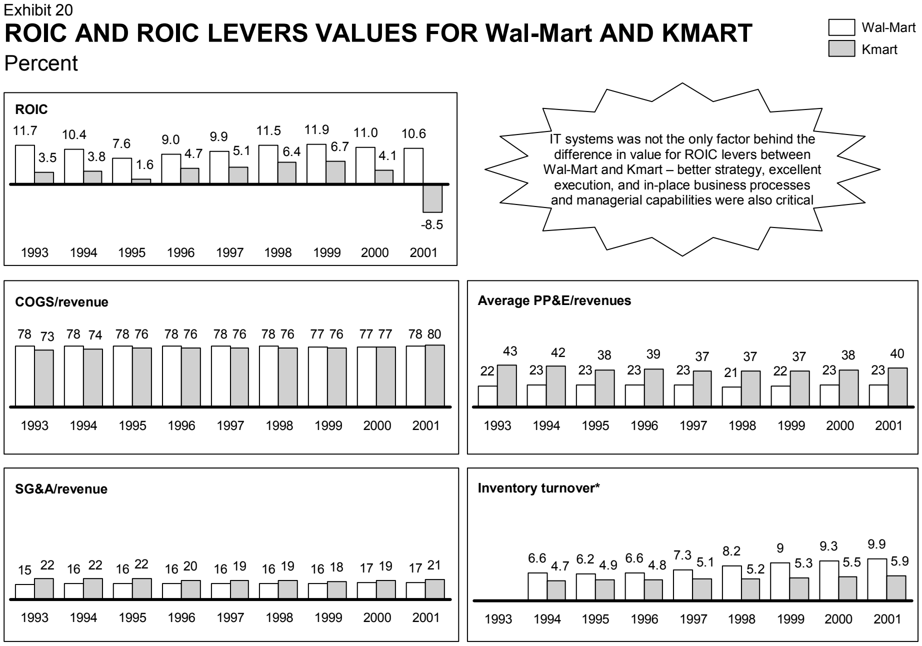
[21] "Bullwhip effect" refers to wide fluctuations in inventory levels in one part of supply chain due to a change in supply/demand in other parts of the supply chain.

Exhibit 20

ROIC AND ROIC LEVERS VALUES FOR Wal-Mart AND KMART

Percent



IT systems was not the only factor behind the difference in value for ROIC levers between Wal-Mart and Kmart – better strategy, excellent execution, and in-place business processes and managerial capabilities were also critical

* Inventory turnover represents ratio of revenues to inventory and is not in percentage terms

Source: Compustat; MGI analysis

administered a test, and passed on suitable candidates to the next level for interviewing) for new associate hiring, partially automating the human resource process and freeing up personnel time. At the same time, Home Depot “broadbanded” the stores and implemented thin clients at all the stores to improve coordination between the corporate office and its store network. Similarly, when a leading US apparel retailer decided to reduce the time to market for its new products by working more closely with their suppliers, they successfully developed and implemented extended inventory visibility systems, which reduced their interaction costs for working closely with their suppliers thus enabling a successful collaboration with their key vendors.

FUTURE OUTLOOK FOR IT INVESTMENTS

Going forward, most retailers are focused on improving communication both within the various groups inside a retailer’s organization and with external partners such as first- and second-tier suppliers, and on “catching up” with the industry leaders such as Wal-Mart and Target. During this evolution, retailers are planning to spend on various IT investments such as CPFR®, thin clients, and broadband to stores. Retailers are expecting these IT investments to help them improve their cost structure and to enable them to compete against industry leaders on a level playing field. Our interviews indicate a belief by retailers that these investments can have an impact if their IT solution providers focus on three areas during solution development:

- Understanding the retailer’s business requirements
- Customizing the product to the end-user’s requirements to increase acceptance and usage within the retailer organization
- Allowing integration with other applications to offer “plug-n-play” capabilities and to facilitate total solutions, instead of point solutions.

OPPORTUNITIES AND CHALLENGES FOR RETAILERS AND THEIR VENDORS

Our findings have an interesting set of implications for both retailers and vendors. For retailers, the results imply that all retailers do not need to follow the same IT strategy; instead, they need to benchmark their performance against the sector average and the sector best practices for all the performance levers, to evaluate options to maximize impact from several performance levers, and to make IT investments that are appropriate for their position in the value stack.

On the other hand, IT vendors interested in playing in this space need to break the vicious cycle that is responsible for the suboptimal spend and deployment in the sector. The cycle involves retailers who are reluctant to buy "off-the-shelf" products that do not meet their needs, and vendors who are reluctant to invest in what appears to be a "difficult" market.

Implications for retailers

As consumers become cost conscious in a slowing economy, retailers are struggling to maintain and increase their margins and profits. In this context, the MGI findings have four significant implications for retailers.

¶ **It is not always necessary to emulate leaders' IT spend to succeed and make profits in this industry.** Instead of "following the herd" of leaders (e.g., Wal-Mart, Target, Best Buy, Home Depot) to make their IT investments, retailers need to identify their own critical IT investments, which depend on their subsegment, their business model, and the retailer's current position in the value stack. For example, high-end apparel retailers such as Neiman Marcus and Saks may have opportunities to invest in customer data warehouses and data mining tools to segment their customer base, to identify the buying patterns of the most profitable customers, and to determine options to increase cross-sell potential for the most profitable segments and up-sell opportunities for the next tier of most profitable customers. However, discount apparel retailers such as Marshall's and Ross are more likely to benefit from investments in customer facing and backend in-store applications, as well as markdown optimization applications, to reduce their cost structure in the stores and to optimize their markdowns and pricing.

¶ **Benchmark productivity and profitability performance along the various levers vis-à-vis the sector average and the sector best practice, and invest accordingly.** For performance levers impacted by the "cost-of-doing-business" and "extended-cost-of-doing-business" IT investments, retailers need to ensure that their performance is at least on par with the sector average. This is a minimum requirement to survive and be a viable player in the market. If the firm's performance on these levers lags the sector average, the firm should consider reliable, low-cost ways of closing the gap, such as implementing standard off-the-shelf applications or outsourcing that particular business process, since these investments do not offer a competitive advantage. For example, if a retailer's WMS systems and DC operations' performance does not meet the sector average, the retailer should consider outsourcing new and existing DC management to a 3PL (third-party logistics) company – even Wal-Mart has outsourced its warehouse management to Tibbett & Britten in Canada.

¶ **For productivity levers impacted by subsector and business-model specific critical differentiating IT investments, retailers need to ensure that their performance meets industry best practice.** To do this, they need to accelerate the development/alignment of the required business processes and managerial capabilities and find the right technology partner – an independent software vendor (ISV), systems integrator, or the in-house IT department – to develop the required technical capabilities. For example in vertically integrated apparel retailers such as Gap and Limited, real-time communication and glass pipelines with suppliers are critical to enable them to quickly react to market trends and to keep their assortment "fresh," thus allowing them to differentiate themselves in the marketplace. These retailers need to work either with ISVs or with their own IT department to develop and implement the "best-in-class" VCS/VMS and extended inventory visibility systems to enable their realigned business processes to minimize nonlabor costs (inventory holding and inventory obsolescence costs).

¶ **Evaluate options to utilize productivity levers that are currently not being exploited.** For instance, in GMS and apparel, the "sell-new-value-added-goods-and-services" lever is currently not being significantly employed. Opportunities could exist for retailers in these subsegments to mine POS data in conjunction with primary surveys to identify goods and services that can satisfy an unmet demand and can command a higher premium. For example, apparel retailers could offer "self-design kiosks" to cater to individuals with odd sizes, requirements, and tastes and charge a higher margin for these customized products. Similarly in DIY the "realize-more-value-from-goods-in-current-portfolio" lever is not currently being significantly exploited suggesting that retailers in this subsegment should consider pricing optimization applications to price their products closer to the customer's reserve price, thereby increasing their bottom line.

¶ **Constantly monitor value stack positioning.** Leading retailers who are on the third segment of the value stack must focus on continuing to stay there, and they can do so by investing in critical technology that will differentiate their offerings, as today's investments become tomorrow's cost of doing business. Mainstream retailers need to make the required sequential "in-step" IT investments that align with their preexisting capabilities and help them move up the value stack. For example, companies like Wal-Mart and Target are likely to benefit most by focusing their IT investments on optimization of their core processes, on application integration of enhanced analytics with business planning, and on customer facing, in-store operations to enhance the customer's shopping experience. Companies like Kmart, on the other hand, may be better served by ensuring that their WMS/TMS delivers optimal performance and that they have access to clean transactional data; the next step would be implementing enhanced analytics on top of enterprise or functional data warehouses to perform merchandise planning and management at a more detailed level – to help deliver the merchandise at the right time to the right place, and at the right price.

Implications for IT vendors

Historically, retail trade, based on most metrics (IT dollars spent per employee, percent of sales, percent of GDP), has been a low IT spender (Exhibit 21), though the retail sector (like the financial services sector) does spend a significant portion of its gross margin on IT.[22] Many industry participants also characterize the sector's spend as suboptimal, in part due to a vicious cycle involving retailers and IT vendors (Exhibit 22). This cycle develops from a combination of several elements.

¶ **High level of in-house solutions**: Retailers were early IT investors, and they developed in-house solutions when commercial products were not available. Leaders such as Wal-Mart and Target used in-house IT extensively to gain competitive advantage while laggards followed similar strategies but failed to get an edge. Exacerbating this trend, retail is a low-margin industry, and mainstream, off-the shelf applications appeared overly expensive in the short run.

¶ **High sunk costs**: Huge past IT investments and implementation of "band-aid" IT solutions to compete with industry leaders have created a high percentage of legacy systems and high sunk costs. This, along with political resistance to shifting IT strategy and architecture data, created barriers to switch to newer solutions.

¶ **High level of customization**: Different business processes and multiple legacy systems required a high level of customization for each application. These customized applications needed significant services and created high ongoing maintenance costs.

¶ **Limited number of IT vendors**: A relatively small number of IT vendors specialize in retail, and the limited number of applications developed exclusively for the sector reduced the potential supply of IT. In addition, retailers appear unwilling to switch and adopt off-the-shelf standard applications, reducing the market potential for ISVs.

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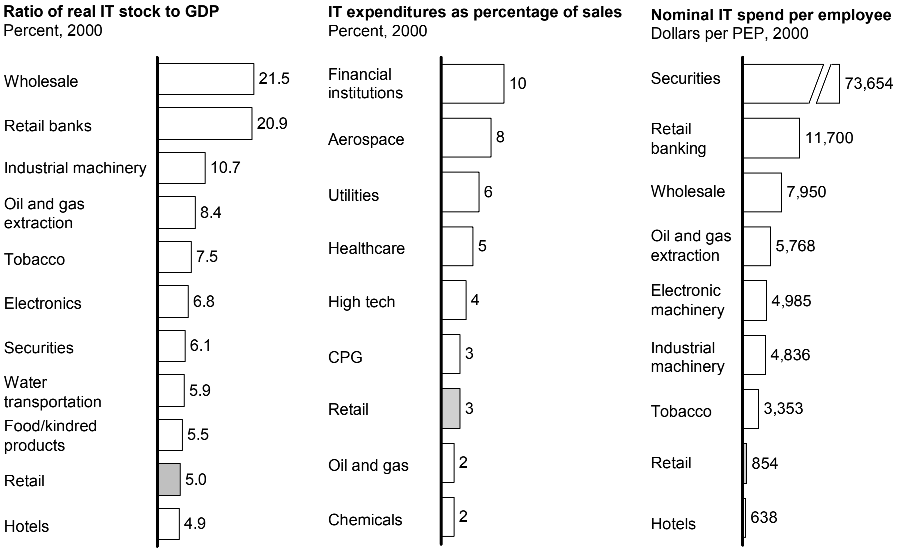
[22] In 2000, retail sector and financial services spent 44 percent and 38 percent of their gross margin on IT respectively.

Exhibit 21

RETAIL SECTOR IS LOW IT SPENDER



Ratio of real IT stock to GDP
Percent, 2000

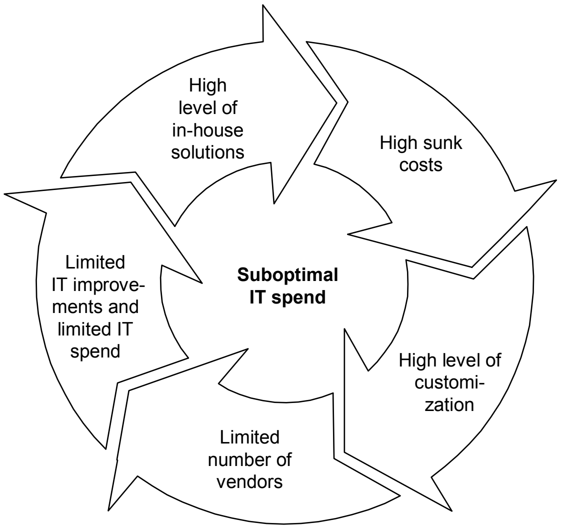
IT expenditures as percentage of sales
Percent, 2000

Nominal IT spend per employee
Dollars per PEP, 2000

Source: AMR; Bureau of Economic Analysis; *InformationWeek*; Compustat

Exhibit 22

VICIOUS CYCLE RESPONSIBLE FOR SUBOPTIMAL IT SPEND



Source: Interviews; MGI analysis

- **Limited IT improvements and limited IT spend**: The predominance of in-house solutions led, in some cases, to the creation of suboptimal IT systems, since IT is not the core competency of retailers. Furthermore, limited IT innovation diffusion meant multiple players were spending resources to develop the same functionality and skills, which reduced the potential for "step" IT improvements. In addition, limited external IT supply restricted IT investment opportunities for retailers.

IT vendors in this space can break this cycle by focusing on four priorities:

- Develop product functionalities that address the retail sector's unique requirements and complexities and contend with the wide differences among the retail subsegments.
- Understand the end-users' (e.g., buyers', merchandise planners') requirements and their level of technical competency to reduce resistance to change and to increase usage within the retailer.
- Rather than adopt a "one-size-fits-all" strategy, recognize the retailer's position in the value stack and offer the right products and services to help them move up the stack.
- Offer rich APIs on their products to promote end-to-end seamless integration of various IT solutions and to increase the number of options to retailers. These initiatives will offer retailers the capability to implement "best-of-breed" solutions and to implement new systems in modules without incurring the significant risk of replacing the entire IT system in one attempt.

Glossary of terms used in retail sector case

Term	**Definition**
Allocation planning systems	Applications to group stores into almost homogeneous groups based on volume sales, climatic conditions, location, demographics/ethnicity, competitive standing, and other variables.
API	Application programming interface; "hook" on a software application to allow interoperability with other applications.
Assortment planning tools	Statistical tools to determine optimum mix of product type and category, and their sources based on historical or "like item" data. Assortment planning and allocation planning are tightly linked.
Backend in-store solutions	Systems/applications to manage noncustomer facing in-store operations; includes labor scheduling, inventory receiving, returns, employee hiring and training, and inventory control.
"Basic" vendor coordination systems/vendor management systems (VCS/VMS)	Systems for purchase order management, item/price master data management, and localization management. Typically Electronic Data Interchange (EDI) is used for these tasks.
Bullwhip effect	Refers to wide fluctuations in inventory levels in one part of supply chain due to a change in supply/demand in other part of the supply chain.
Corporate enterprise resource planning (ERP)	Systems for central functions such as human resources, payroll, accounting and financial reporting.
CAGR	Cumulative annual growth rate.
CPFR®	Collaborative planning, forecasting, and replenishment.

Term	**Definition**
Data warehouses	Extracts, transforms and loads (ETL) data pulled from various operational databases to conduct complex queries on enterprise/functional level at various level of aggregation to assist various decisions; data warehouses can be used for functional purposes (e.g., customer data warehouse in marketing) or companies can have single enterprise level data warehouse (e.g., Wal-Mart has two EDWs, one for enterprise level decision support, and the other for back-up, disaster recovery). Typically all merchandise planning and management systems (demand forecasting, assortment and allocation planning, replenishment, and revenue management systems) use POS and related data in a dedicated datamart on top of an enterprise or functional data warehouse.
DC	Distribution center also referred as warehouses.
Direct IT	Includes hardware (mainframe computers, PCs, storage devices, and peripherals), software (prepackaged, custom, and own account software), and communication equipment.
DIY	Do-it-yourself; autonym for building materials sector, a subsegment of retail trade.
Extended order management systems	Systems for tracking and scheduling the after-sales requirements (e.g., delivery, warranties, repair, return to vendors etc); can also be used to determine potential up-sell and cross-sell opportunities.
GMS	General merchandise stores; subsegment of retail trade.
Glass pipeline	Refers to the real-time visibility of inventory in the various parts of the supply chain to the retailers and its suppliers.
Indirect IT	Includes software and hardware that are embedded or bundled as a part of a system. Typically these investments are captured in the BEA instruments category.
IT	Includes software (prepackaged, own account, and custom software), hardware (PC, mainframes, servers), peripherals (storage devices, printers), and communication equipment.
IT intensity	Real IT capital stock per people employed in production.

Term	**Definition**
POS systems	Point-of-sale systems; systems to conduct and capture customer transactions; includes scanners, bar code readers, and computer systems to capture data and update systems.
“Premium” vendor coordination systems/vendor management systems (VCS/VMS)	Systems to interface with vendors for vendor communication and collaboration, vendor and product performance monitoring in real to “almost real” time, exception reporting, and linkages of retailer and vendor systems for enhanced supply chain visibility (e.g., Wal-Mart’s RetailLink).
Replenishment solutions	Complex algorithms to determine optimum replenishment quantity based on demand, supply and targeted in-stock levels. Sophisticated solutions considers variability in multiple levels of the supply chain (multi-epsilon replenishment planning), and help plan replenishment at a more detailed store and product classification level instead of aggregating multiple product categories and stores into a single group.
Revenue management applications	Complex algorithms on historical or “like item” data to determine demand elasticity of customers, which takes into consideration the complementary nature of goods, substitutability of items, and price and quantity constraints to determine optimum price (initial pricing and markdowns).
RF terminals	Radio frequency terminals; refers to wireless terminals.
Sales forecasting systems	Systems to forecast demand based on historical data and casual factors such as promotions, special occasions, and incremental lift due to “halo effect” (i.e., promotions of affinity items).
Staples	Relatively undifferentiated “necessary” items that require high in-stock levels and are constantly replenished, e.g., light bulbs, paper towels, and toilet paper.
TMS	Transport management systems; software applications to optimize transportation of merchandise within the network of suppliers and DCs (includes best mode and route optimization, load configuration, and dead-end reduction in backhaul).

Term	**Definition**
WMS	Warehouse management systems; software applications and associated automation (carousels, conveyors, pick to light systems) to direct flow and storage of products within warehouses.

IT and productivity growth in the retail banking sector

SUMMARY

Retail banking is an IT-intensive sector, with many firms spending 10 percent or more of their revenues on IT-related activities. The McKinsey Global Institute's (MGI's) US Productivity Growth[1] report found retail banking to be an IT paradox in that, despite substantial growth in IT spending, labor productivity growth rates decreased during 1995-1999. However, while growth rates in the sector decreased, the retail banking sector did see a high baseline of productivity growth when compared with the US economy.

In this report, MGI sought to better understand both the role played by IT in enabling productivity growth, and the explanation for dissatisfaction on the part of banks with the benefits derived from some of their IT investments. We found that in general, IT investments related to increased automation (e.g., lending systems, voice response units), creation of and support for alternate channels (e.g., call centers), and scale enablement (e.g., realizing merger synergies enabled by IT) had higher impact on productivity, though not always on profitability, than those related to decision support (e.g., customer relationship management software or CRM) and core back-end and front-end infrastructure (e.g., core banking systems, branch automation, PCs).

The impact of increased merger activity on productivity in the 1990s came largely from synergies and scale benefits, including reductions in clerical and administrative labor and consolidation of channel operations such as call centers and branches. IT played a critical role in enabling these synergies, but the overall impact from IT was diluted by poor execution of merger projects, increased complexity costs from large IT environments, and limited incremental scale benefits due to some operations already being at efficient scale. IT is likely to play a stronger role in cost reduction efforts in merged entities as banks continue to respond to competitive pressure in the current economic environment.

IT architecture in banks is evolving from a product-centric and accounting-centric focus to an increased focus on delivery channels and the needs of the customer.

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[1] MGI "US Productivity Growth 1995-2000, Understanding the Contribution of Information Technology Relative to Other Factors," released October 2001.

Banks' ability to leverage their IT investments depends on the limitations of their IT architecture, which often cannot meet the demands imposed by the new customer-centric business requirements. Gaps in IT architecture between the average retail bank and best practices can be attributed in part to the difficulties inherent in this evolutionary process. As banks adapt their IT systems to the customer-centric architecture, they face challenges such as effective channel integration, targeted customer profitability management, faster time-to-market for new products, and efficient IT management.

In addition, banks' efforts to consistently translate productivity gains from IT into profitability improvements had mixed results. Some of the key trends contributing to limited success include product and channel proliferation, an increase in the capture of surplus by consumers, and the execution issues banks experience in managing large, complex IT environments.

Banks have found it difficult to derive competitive advantage through deploying IT innovations alone. The nature of the industry, including onerous regulatory reporting requirements, necessary inter-bank information and funds transfers, and reliance on vendors, has caused IT-enabled innovations to diffuse rapidly through the sector. Thus banks find it difficult to sustain competitive advantage from innovating (or adopting an innovation) for a significant period of time. Where banks have been successful in deriving value from IT, their investments were vertical applications tailored to key business processes that co-evolved with the necessary changes in business processes and were coupled with managerial innovation. They were also part of a disciplined approach to ensuring that key IT capabilities (e.g., access to accurate, reliable customer data) were in place prior to new IT investments in the evolution toward a customer-centric architecture.

Going forward, the retail banking industry is likely to see another phase of productivity growth driven by pressures to reduce costs, a focus on increasing revenues through multichannel management, and the transition toward electronic forms of payment driven by changes in consumer behavior. While most banks are unlikely to make "big-bets" in IT spending in the short-term, large investments made in the 1990s mean that banks now have significant IT capital resources on which to build. The trick will be for banks to leverage existing systems and resources effectively while making high-value incremental investments to close any gaps with respect to other banks in the sector, and to improve business process efficiency.

INTRODUCTION

Retail banking is an IT-intensive sector, with many firms spending 10 percent or more of their revenues on IT-related activities. MGI's US Productivity Growth report[2] found retail banking to be an IT paradox in that, despite substantial growth in IT spending, labor productivity growth rates decreased during 1995-1999. However, the sector did experience a high baseline of productivity growth when compared with the US economy. IT is a critical enabler of products, services, transactions, and overall operations in retail banking. In this case, MGI found:

- Retail banking experienced a high baseline of labor productivity growth, but the productivity growth rate slowed down in the late 1990s.
- The enabling role of IT in retail banking was significant, but key IT investments had varying impact on productivity.
- Key IT applications that impacted performance in retail banking shared three general characteristics.
- Significant opportunities and challenges exist for retail banks and IT vendors wanting to participate in this space.

Focus of current project

Retail banking, as defined by MGI, includes the retail portion of commercial banks, savings institutions, and credit unions. Services to medium and large businesses (e.g., wholesale banking, commercial loans) are not included in MGI's retail banking measure (Exhibit 1).

This study focuses on the role of IT in enabling productivity in commercial banks. Commercial banks vary from being large, national and sometimes global players (e.g., Bank of America, Citibank, JPMorgan Chase, Wells Fargo), to regional players (e.g., Huntington Bank, Union Bank of California, and PNC Bank), to small local players. Nonbranch based commercial financial services, such as credit card "monolines" (e.g., MBNA Corp.), are not specifically addressed in this study.

Definition and scope of IT for current project

Banks have deployed IT solutions in almost every aspect of their business processes. For the purposes of this study, MGI looked at the major IT investments made in the 1990s. These include hardware such as PCs, servers, data centers,

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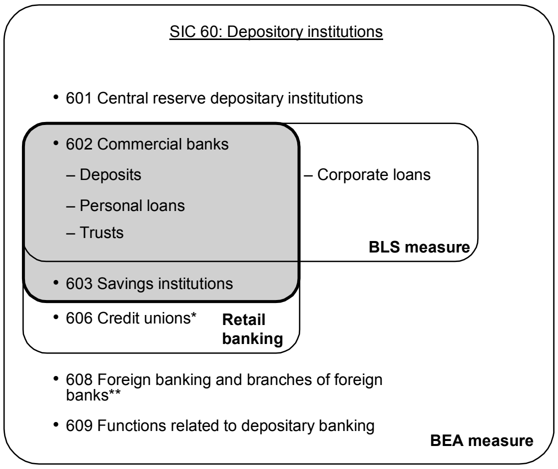
[2] MGI "US Productivity Growth 1995-2000, Understanding the Contribution of Information Technology Relative to Other Factors," released in October 2001.

Exhibit 1

MGI MEASURE OF RETAIL BANKING INCLUDES COMMERCIAL BANKS AND SAVINGS INSTITUTIONS

▨ MGI focus



* While credit unions are part of the retail banking sector definition, they are not included in the MGI measure because available data is limited

** Foreign banks accepting retail deposits from the general public are classified under SIC 602 Commercial banks

Source: SIC index; MGI analysis

networking equipment, imaging systems, and call center equipment (e.g., ACD or Automatic Call Dialers), and software such as customer relationship management (CRM) applications, core banking platforms, enterprise resource planning (ERP), and lending and risk management systems. Other peripheral electromechanical equipment such as proofing and sorting machines were not included, although software did play a role in the control and operation of such equipment.

SECTOR PRODUCTIVITY

The retail banking sector experienced strong labor productivity growth in the 1990s – more than twice the growth rate of the overall US economy. Banks observed a slowdown in productivity growth in the sector, even as IT intensity accelerated during this period. Given the IT-intensive nature of the retail banking sector, understanding which IT investments did enable productivity improvements (and which did not) is critical to understanding how IT enabled economy-wide labor productivity growth.

IT is an integral part of business processes within the sector, directly or indirectly impacting key productivity and profitability levers. The ability to capture value from IT operations and investments is influenced by banks' overall business strategy, organization structures, underlying IT architectures, and performance management capabilities. These factors, combined with forces in the external environment such as regulatory changes and consumer behavior, make for significant challenges as banks look to leverage IT to enable future productivity improvements.

Sector contribution to economy-wide labor productivity growth in the 1990s

Retail banking accounted for 5.4 percent of productivity growth in the US economy from 1993 to 2000, while constituting 4.4 percent of 1993 GDP (Exhibit 2). Furthermore, the labor productivity growth rate was higher than that of the US economy in the 1990s. Retail banking saw a 5.2 percent CAGR as compared with 2 percent CAGR for the US economy overall during 1993-2000.[3] Finally, retail banking had relatively strong baseline growth yet experienced a slowdown in the growth rate in the 1990s, just when productivity growth in the US economy as a whole was accelerating. This makes retail banking an interesting case study; examining this sector gives us the opportunity to look closely at how IT did and did not affect productivity in the 1990s.

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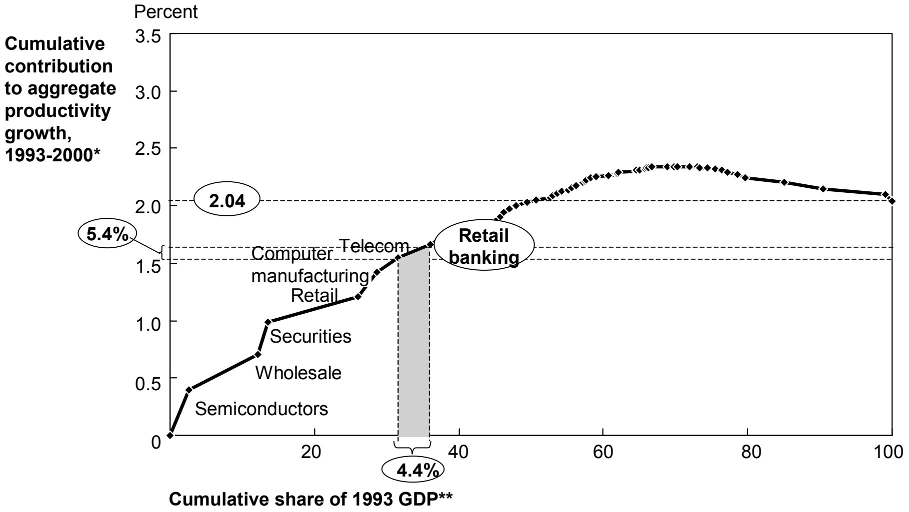
[3] Retail banking productivity calculated per MGI methodology; see appendix for details. US economy productivity based on data from BEA.

Exhibit 2

RETAIL BANKING CONTRIBUTED 5.4% OF ECONOMY-WIDE PRODUCTIVITY GROWTH DURING THE 1990S



* CAGR 1993-2000. Does not include farm and government sectors; real estate and holdings contribution evenly divided among sectors excluding the top 6

** Does not include farm, government, holdings, and real estate sectors

Source: Bureau of Economic Analysis (BEA); MGI analysis

Sector contribution to economy-wide productivity growth acceleration in the late 1990s

As detailed in MGI's US Productivity Growth report, from 1995-1999 retail banking represented a paradox. Despite a substantial acceleration in IT capital intensity growth, labor productivity growth rates decreased slightly. This story remains unchanged when updated with 2000 economic results. IT capital intensity growth in the retail banking sector accelerated at a CAGR of 18.1 percent during 1995-2000 from 11.4 percent during 1987-1995, and labor productivity slowed to a CAGR of 4.8 percent during 1995-2000 as compared with 5.5 percent CAGR in 1987-1995 (Exhibit 3).[4] Labor productivity grew at a significantly higher rate during 1999-2000 (7.4 percent) than during the periods 1995-1999 (4.1 percent) or 1987-1995 (5.5 percent). However, productivity growth for the overall period 1995-2000 remained lower than that for 1987-1995.[5]

Key trends in productivity measures in the 1990s[6]

The strong baseline productivity growth in banks during the 1990s was driven by significant growth in the total number of transactions processed (5.2 percent CAGR), even as the labor hours declined by 1.9 percent. These included information transactions (e.g., telephone inquiries, ATM inquiries, and on-line inquiries) as well as payment transactions via checks, credit cards, debit cards, ATMs, and ACH[7] transfers (Exhibit 4).

Information transactions grew at a significantly higher rate (14.3 percent) than other physical output measures, driven in large part by the convenience of remote channels such as ATMs, call centers, and the Internet. In payment transactions, the number of checks processed as a fraction of total payment transactions decreased from 82 percent in 1990 to 63 percent in 2000. Growth in checks processed slowed from a 2.2 percent CAGR during 1990-1995, to 1.4 percent CAGR during 1995-2000. In fact, recent reports from the Federal Reserve suggest that the number of checks written may have peaked in the mid-1990s.[8] The decrease in labor hours in the 1990s was driven in part by merger and consolidation activity in the sector. Banks also began to increase their use of

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[4] For detailed discussion on comparison between MGI methodology and BEA productivity data, refer to MGI's US Productivity Growth report.

[5] See appendix for complete discussion on retail banking labor productivity update for 2000.

[6] See appendix for discussion of productivity measures and trends during 1990-2000.

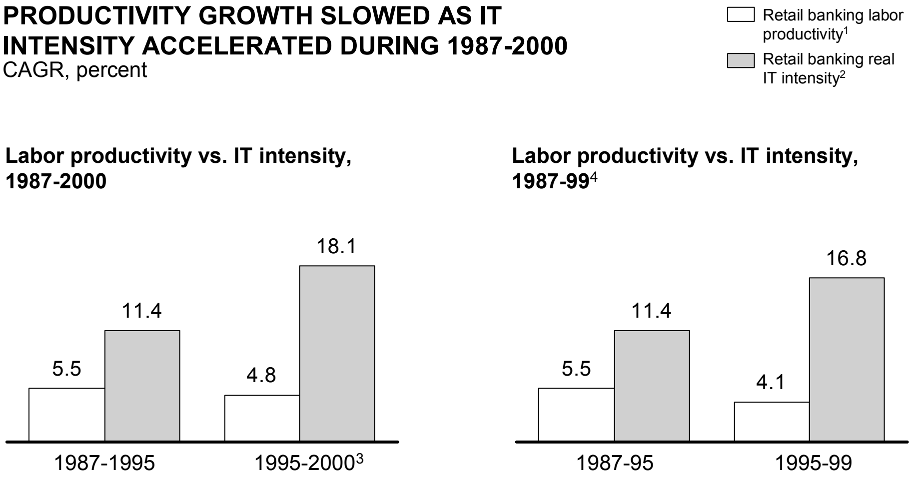
[7] Automated clearing house.

[8] Based on NACHA press release, "Federal Reserve Check Volume Declines for Second Consecutive Year," *August 15, 2002.*

Exhibit 3

PRODUCTIVITY GROWTH SLOWED AS IT INTENSITY ACCELERATED DURING 1987-2000

CAGR, percent



[1] Labor productivity measured per MGI methodology as real output (transactions plus loans plus fiduciary activities), divided by hours worked; index 1987 = 100

[2] Real IT intensity measured as real IT capital stock, divided by persons engaged in production (PEP). Estimate based on BEA depository institutions data

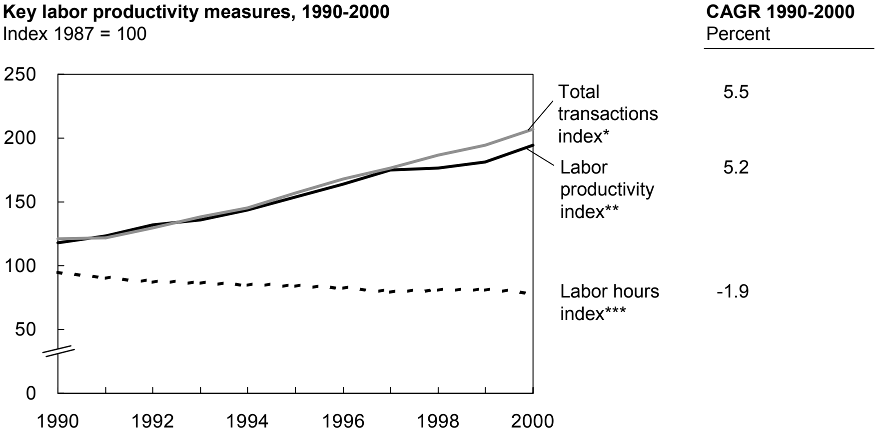
[3] Productivity grew 7.4% from 1999 to 2000, but overall productivity growth for 1995-2000 was at 4.8% compared with 5.5% for the period 1987-95

[4] As reported in MGI's "US Productivity Growth 1995-2000" report, October 2001

Source: Bureau of Economic Analysis (BEA); MGI analysis

Exhibit 4

LABOR PRODUCTIVITY GREW AT 5.2% CAGR DURING 1990s, DRIVEN BY GROWTH IN TOTAL TRANSACTIONS AND DECLINE IN LABOR HOURS



* Total transactions include payment transactions (checks, credit cards, debit cards, ATM, and ACH transfers) and information transactions (telephone, on-line, and ATM inquiries); index 1987 = 100; total transactions in 1990 estimated at 69.9 billion

** Labor productivity measured per MGI methodology as real output (transactions plus loans plus fiduciary activities), divided by hours worked; index 1987 = 100

*** Labor hours include internal and outsourced labor hours; index 1987 = 100; total labor hours in 1990 estimated at 3,086 million

Source: Bureau of Labor Statistics (BLS); MGI analysis outsourced[9] labor in the 1990s, although this remained a small fraction of overall hours (3 percent).

Productivity and the IT paradox in retail banking in the late 1990s

As outlined in MGI's US Productivity Growth report, the IT paradox in retail banking was driven by several operational, industry-level, and external factors (Exhibit 5). Firm-level factors included organizational constraints that resulted in uncoordinated IT decisions by individual line-of-business (LOB) units, lack of experience in executing large-scale IT projects, and the existence of fragmented IT platforms that did not scale easily. The result was excessive and unnecessary investments in hardware and software that did not yield expected benefits (e.g., PCs, CRM software, merger integration projects), and additional IT reinvestments in order to "clean up" the basic technology platform. In addition, there were unmeasured benefits to customers from the race to deploy on-line banking and call centers on the part of banks.

Industry dynamics contributed to the IT paradox as well. Increased consolidation may have reduced competitive intensity, and high levels of profitability in the late 1990s temporarily disguised excess IT spending by banks.

Finally, contributing external factors included buoyant capital markets that made resources available for large IT investments and product market regulation that spurred merger activity. In addition, the full benefits to consumers of new channels such as on-line banking and automated call centers are difficult to measure and are probably not fully accounted for in either BEA or MGI productivity measures.

ENABLING ROLE OF IT

Retail banks have historically spent up to 10 percent of their gross revenues on IT, and IT comprises nearly 15 percent of noninterest expense in commercial banks.[10] In the 1990s, banks invested in several major IT initiatives, including CRM (e.g., customer support, branch automation, call management systems, analytic and sales tools, and other CRM tools), customer data and systems integration, on-line

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[9] Outsourced labor includes contractors, consultants, and other third parties who work at commercial banks but are not directly employed by commercial banks.

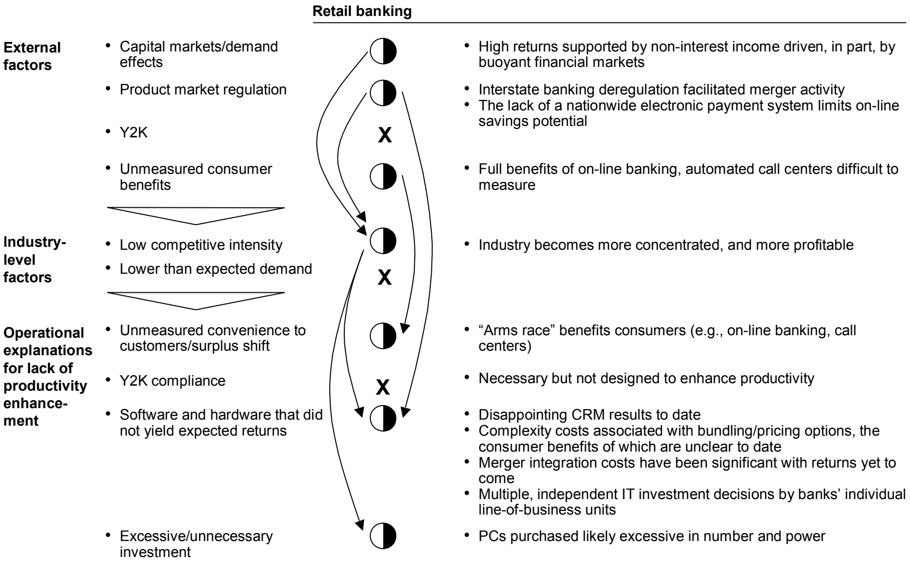
[10] Based on data from Tower Group and FDIC.

Exhibit 5

SEVERAL FACTORS DROVE RETAIL BANKING IT PARADOX

◑ **Somewhat important** (10-50% of investment)

X **Not important** (<10% of investment)



		Retail banking	
External factors	Capital markets/demand effects	◑	High returns supported by non-interest income driven, in part, by buoyant financial markets
	Product market regulation	◑	Interstate banking deregulation facilitated merger activity The lack of a nationwide electronic payment system limits on-line savings potential
	Y2K	X	
	Unmeasured consumer benefits	◑	Full benefits of on-line banking, automated call centers difficult to measure
Industry-level factors	Low competitive intensity	◑	Industry becomes more concentrated, and more profitable
	Lower than expected demand	X	
Operational explanations for lack of productivity enhancement	Unmeasured convenience to customers/surplus shift	◑	"Arms race" benefits consumers (e.g., on-line banking, call centers)
	Y2K compliance	X	Necessary but not designed to enhance productivity
	Software and hardware that did not yield expected returns	◑	Disappointing CRM results to date Complexity costs associated with bundling/pricing options, the consumer benefits of which are unclear to date Merger integration costs have been significant with returns yet to come Multiple, independent IT investment decisions by banks' individual line-of-business units
	Excessive/unnecessary investment	◑	PCs purchased likely excessive in number and power

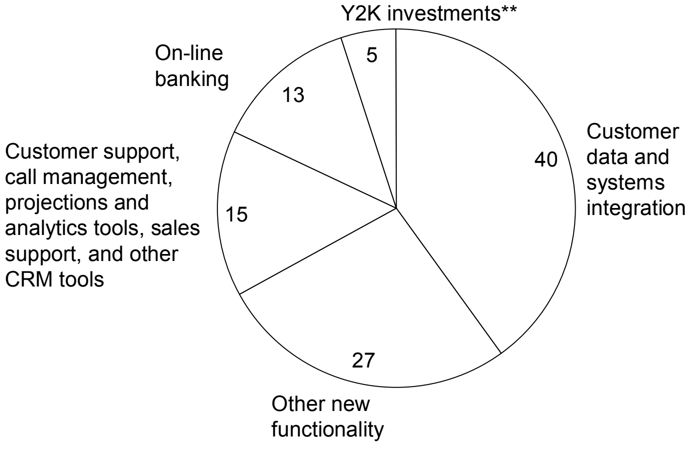
Source: MGI's "US Productivity Growth 1995-2000" report, October 2001

Exhibit 6

THERE WERE 5 KEY IT INITIATIVES IN RETAIL BANKS DURING THE 1990s

CIO allocation of IT investment dollars during 1995-2000

Percent, 100% = average retail bank spend on IT initiatives*



* Estimates of major IT initiatives include direct/indirect IT investments in hardware, software, and communication equipment, excluding expenses

** Y2K investment represents only half of total Y2K costs; the remaining half was an expense

Source: Information Week 500; Tower Group; retail banking CIO/management interviews; IDC; MGI analysis banking, product proliferation, and Y2K[11] (Exhibit 6). These initiatives had significant productivity benefits but also increased systems complexity. The complexity was further exacerbated by trends in merger activity and the evolution of IT architecture.

To understand the impact of these IT investments, MGI looked at the key business processes in retail banking along with the key IT components deployed against them. We examined how and why IT impacted productivity and profitability, including how it did (or did not) create value; IT's role in merger activity; and the impact of banks' underlying IT architecture. Finally, we examined IT as a source of competitive advantage in the sector.

Overview of business processes and key IT components

The main services provided by retail banks to their customers are payment transactions, deposits, consumer loans, and trust management. Banks support these services with a complex network of channels, including physical branches, ATMs, call centers, and the Internet. The typical bank is organized into businesses or line-of-business units consisting of a combination of products, channels, and customers; shared resources such as operations, IT/systems, and human resources; and the corporate center, which is responsible for strategic direction, investment and risk policy, and management control of different units.

The key business processes that enable these operations include sales and marketing, including product design and development; channel management; depository operations; lending operations; IT operations; and other administrative and corporate functions, including human resources and payroll (Exhibit 7). IT is an integral part of managing the information flow in these business processes (Exhibit 8).

¶ **Sales and marketing.** This includes sales, marketing, product design, and development of various retail products and services. Activities include customer acquisition and retention, research, marketing campaigns, and product development. Key IT components include CRM (e.g., sales force automation, marketing and service automation), customer information systems (CIS), data warehouse, and product factory modules in core banking systems.

¶ **Channel management.** Channel management involves customer or account management and servicing through branches (e.g., tellers), and

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[11] Refers to the year 2000 compliance investments.

Exhibit 7

THERE ARE 6 HIGH-LEVEL BUSINESS PROCESSES IN RETAIL BANKING

High-level processes at a retail bank	Description	Key subactivities
Sales and marketing	• Sales, marketing, and product design and development of products and services	• Customer acquisition • Customer profile creation, maintenance, and research • Marketing campaigns • Product development
Channel management	• Customer/account management and servicing via multiple channels	• Branch operations – ATM operations – Teller operations • On-line banking • Customer service (call centers)
Depository operations	• Savings, checking, cash, and credit card management	• Cash management • Items processing • Check processing • Interest, fee, tax calculations • Settlement and payment clearing
Lending operations	• Credit/loan processing and collections	• Credit-related processing • Credit origination and administration • Risk management
IT operations	• IT and infrastructure support for all operations	• Data processing software development • Infrastructure management • Technical support
Corporate and administrative	• Administrative support for all operations • Financial management • Treasury operations • Regulatory reporting	• Purchasing • Payroll services • Administrative services • Treasury operations • Enterprise-wide risk management • Compliance processing/regulatory reporting • Asset management

Source: Interviews; MGI analysis

Exhibit 8

KEY IT COMPONENTS OF RETAIL BANKING BUSINESS PROCESSES

▨ Elements of core banking system

High-level processes at a retail bank	Key IT systems and components
Sales and marketing	• CRM (sales force automation, marketing) • Data warehouse ▨ • Customer information file/system (CIF/CIS) ▨ • Product factory (checking, savings, time deposits, line of credit, mortgages, etc.)
Channel management	• VRU, IVR, CTI, and other call center technologies • CRM (customer service modules) • Middleware • Web-enabled applications (on-line banking) • Branch automation, including PCs, teller platform • ATM, ATM network ▨ • Customer information file/system (CIF/CIS)
Depository operations	• Check imaging technologies (image capture, storage, retrieval) • Check processing (readers, sorters, processing application software) • Magnetic ink character recognition (MICR) encoders/decoders • ATM operations ▨ • Deposit processing system
Lending operations	• Lending systems (credit scoring software, straight-through processing, underwriting software modules) • Credit/debit card transaction processing systems • Collection system (e.g., predictive dialer) • Workflow/document management ▨ • Loan accounting and servicing system
IT operations	• Management Information Systems (MIS) • Network/communications infrastructure and support • Database management • Middleware/enterprise application integration
Corporate and administrative	• Procurement software • Statement production and notice/letter generation • Reporting tools • Treasury applications (risk management) • Securitization ▨ • General ledger system (regulatory reporting, reconciliation, budgeting, financial planning, etc.)

Source: Interviews; MGI analysis

remote channels such as ATMs, call centers, on-line banking, and wireless devices. Key IT components in channel operations include ATM networks, voice response units (VRUs) and other call center technologies,[12] on-line banking, branch automation (including PCs), and middleware technologies.

¶ **Depository operations.** These include savings, checking, and cash and debit card management. Activities such as items processing, check processing, cash and lock-box management, interest and fee calculations, and settlements are supported by IT components such as ATM networks, check imaging, and demand deposit application (DDA) systems.

¶ **Lending operations.** This process includes credit and loan origination, application verification and processing for loan products (e.g., credit cards, student loans, mortgages, auto financing), and collections. These and other activities such as credit administration, risk management, and asset management are supported by IT applications such as lending systems (e.g., credit scoring software, underwriting modules) and collection systems (e.g., predictive dialers).

¶ **IT operations.** IT operations include the IT and infrastructure support for all banking activities, including data processing, software maintenance and development, infrastructure management, network and information security, management information systems (MIS), and technical support.

¶ **Administrative and corporate functions.** These include administrative and support functions such as procurement and purchasing, payroll services, compliance processing, regulatory reporting, HR, accounting, auditing, treasury operations, and corporate risk management. Key IT components include the general ledger system, software for purchasing, payroll, accounting, (e.g., enterprise resource planning (ERP) software), treasury applications, and risk management systems.

Impact of IT on productivity and profitability

MGI focused its analysis on key IT investments banks made during the 1990s in sales and marketing, channel management, depository operations, and lending operations. These investments included VRUs and associated call center

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[12] Call center technologies also include automatic call dialers (ACD), integrated voice response systems (IVR), computer telephony integration (CTI), and other associated software.

technologies, lending systems, core banking systems, check imaging, on-line banking, CRM, and branch automation.[13]

IT applications that targeted the improvement of lending operations and select channel operations, such as call centers, had higher impact than those targeting depository operations, sales and marketing, and product design and development. In general, IT investments related to increased automation, development and support for alternate channels (e.g., lending systems, VRUs) and scale enablement (e.g., realizing merger synergies enabled by IT) had higher impact than those related to decision support (e.g., CRM) and core back-end and front-end infrastructure (e.g., back-end systems such as core banking software and front-end systems such as branch automation) (Exhibit 9).

Impact of key IT investments on productivity levers

Across the eight productivity levers, these IT investments had varying impact. The key determinants of impact were the business process affected and the functional nature of the IT application (Exhibits 10 and 11).

VRUs and call center technology. VRUs and call center technologies lowered personnel costs in handling call inquiries and improved asset utilization by enabling the handling of peak call volumes without requiring additional customer service representatives. For instance, VRUs and other call center technologies reduced labor costs through automation of customer service functions in channel operations. The number of telephone banking transactions increased between 1994 and 1998 (21 percent CAGR), at a rate higher than the increase in the number of call center agents during the same period (13 percent CAGR) (Exhibit 12).

Furthermore, call center operations underwent significant innovations that enabled increased diversion of calls to VRUs as opposed to live customer service agents, intelligent skill-based routing of calls based on product expertise and customer need or priority, and use of CTI and screen-pops for efficient call handling. Finally, availability and access to reliable customer data and the ability to link information across product and channel systems to the customer service representative’s (CSR’s) desktop were critical to the effective and efficient use of VRU and IVR systems in call center operations. The result was improved service quality, first-call resolution, and the ability to handle more calls per CSR.

Lending systems. Lending systems reduced labor costs in processing loan applications while increasing the number and quality of loans processed through

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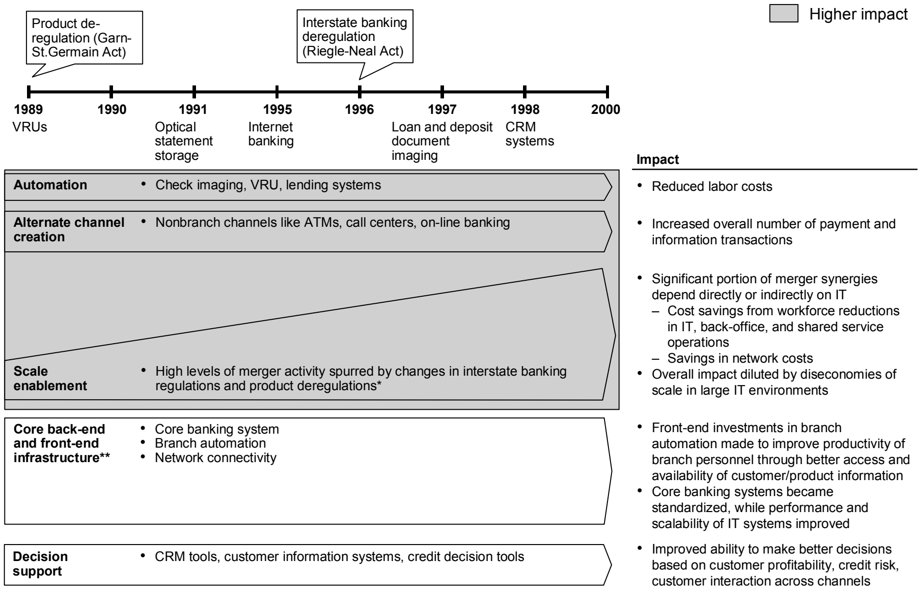
[13] ATMs are not included because the majority of investment in ATM networks occurred before 1990. Investments related to Y2K and security are not included as they were not designed for productivity improvement.

Exhibit 9

THROUGH THE 1990s, IT HAD IMPACT ON PRODUCTIVITY IN 5 WAYS



▨ Higher impact

Product de-regulation (Garn-St.Germain Act)

Interstate banking deregulation (Riegle-Neal Act)

1989	1990	1991	1995	1996	1997	1998	2000
VRUs		Optical statement storage	Internet banking		Loan and deposit document imaging	CRM systems	

		Impact
Automation	• Check imaging, VRU, lending systems	• Reduced labor costs
Alternate channel creation	• Nonbranch channels like ATMs, call centers, on-line banking	• Increased overall number of payment and information transactions
Scale enablement	• High levels of merger activity spurred by changes in interstate banking regulations and product deregulations*	• Significant portion of merger synergies depend directly or indirectly on IT – Cost savings from workforce reductions in IT, back-office, and shared service operations – Savings in network costs • Overall impact diluted by diseconomies of scale in large IT environments
Core back-end and front-end infrastructure**	• Core banking system • Branch automation • Network connectivity	• Front-end investments in branch automation made to improve productivity of branch personnel through better access and availability of customer/product information • Core banking systems became standardized, while performance and scalability of IT systems improved
Decision support	• CRM tools, customer information systems, credit decision tools	• Improved ability to make better decisions based on customer profitability, credit risk, customer interaction across channels

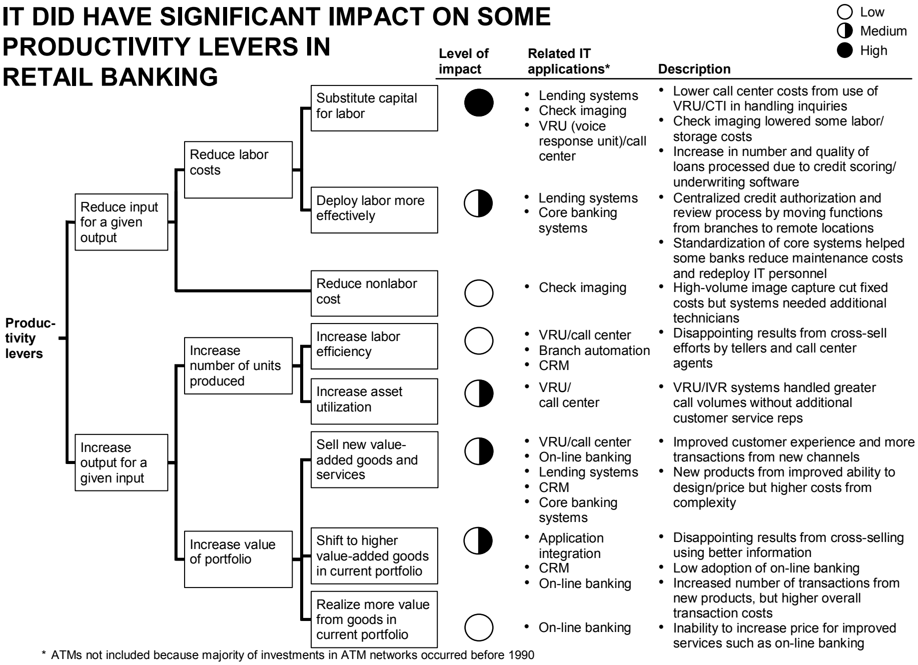
* 371 mergers from 1997-99 compared with 83 during 1993-96

** Reduced costs from software development and maintenance occurred mostly at smaller banks; large banks did not see significant impact

Source: Interviews; MGI analysis

Exhibit 10

IT DID HAVE SIGNIFICANT IMPACT ON SOME PRODUCTIVITY LEVERS IN RETAIL BANKING



○ Low
◑ Medium
● High

- **Productivity levers**
  - Reduce input for a given output
    - Reduce labor costs
      - Substitute capital for labor
      - Deploy labor more effectively
    - Reduce nonlabor cost
  - Increase output for a given input
    - Increase number of units produced
      - Increase labor efficiency
      - Increase asset utilization
    - Increase value of portfolio
      - Sell new value-added goods and services
      - Shift to higher value-added goods in current portfolio
      - Realize more value from goods in current portfolio

	Level of impact	Related IT applications*	Description
Substitute capital for labor	●	• Lending systems • Check imaging • VRU (voice response unit)/call center	• Lower call center costs from use of VRU/CTI in handling inquiries • Check imaging lowered some labor/storage costs • Increase in number and quality of loans processed due to credit scoring/underwriting software
Deploy labor more effectively	◑	• Lending systems • Core banking systems	• Centralized credit authorization and review process by moving functions from branches to remote locations • Standardization of core systems helped some banks reduce maintenance costs and redeploy IT personnel
Reduce nonlabor cost	○	• Check imaging	• High-volume image capture cut fixed costs but systems needed additional technicians
Increase labor efficiency	○	• VRU/call center • Branch automation • CRM	• Disappointing results from cross-sell efforts by tellers and call center agents
Increase asset utilization	◑	• VRU/ call center	• VRU/IVR systems handled greater call volumes without additional customer service reps
Sell new value-added goods and services	◑	• VRU/call center • On-line banking • Lending systems • CRM • Core banking systems	• Improved customer experience and more transactions from new channels • New products from improved ability to design/price but higher costs from complexity
Shift to higher value-added goods in current portfolio	◑	• Application integration • CRM • On-line banking	• Disappointing results from cross-selling using better information • Low adoption of on-line banking • Increased number of transactions from new products, but higher overall transaction costs
Realize more value from goods in current portfolio	○	• On-line banking	• Inability to increase price for improved services such as on-line banking

* ATMs not included because majority of investments in ATM networks occurred before 1990

Source: Interviews; MGI analysis

Exhibit 11

IT INVESTMENTS WITH HIGHEST PRODUCTIVITY IMPACT WERE VRUs AND LENDING SYSTEMS

○ Low
◑ Medium
● High

Key applications*	Impact*** on productivity	Rationale Pros	 Cons
VRU/call center technology**	●	• Reduced labor costs with improved functionality replacing branch employees, customer service reps • Increased number of information transactions • Unmeasured consumer benefits	• Limited success in increasing sales through outbound calls
Lending systems	●	• Automation of selected credit processes (reduced labor costs) • Increased number and quality of loans processed	• Need for further optimization between manual and automated processes
CRM	○	• Perception of strong potential for cross-sell and customer profitability management drove initial investments	• Limited demonstrated revenue increase • Additional employees required for implementation • Existing organizational skills not adequate to exploit, e.g., cross-selling, improved asset management • High cost of consulting and integration services
Check imaging	◑	• Reduced storage and labor costs in archiving and retrieval-related activities • Improved customer service	• Limited reduction in check processing costs due to low usage of branch-based imaging • Minimum efficient scale for check processing not attained by several smaller banks
On-line banking	○	• Unmeasured consumer benefits from increased convenience • Improves customer retention, thereby reducing labor and other costs	• Overall costs and number of transactions have increased due to channel proliferation • Minimal actual reduction in branch labor costs • Limited adoption by customers
Core banking systems	◑	• Reduced software development and maintenance costs through standardization (in smaller banks) • Reduced labor and IT costs from back-office automation and outsourcing	• IT spend on integration across core banking software modules continue to exist • Large banks continue to have multiple core banking platforms
Branch automation	○	• Perception of increased functionality and necessary process needed to support customer information management and sales automation tools drove investments	• Many banks did not fully utilize improved functionality, as accessibility and availability of accurate customer information was limited • Limited demonstrated increase from cross-sell

* ATMs not included because majority of investments in ATM networks occurred before 1990; Y2K and security-related investments were not designed for productivity improvement and are not included

** Includes CTI, auto-dialer, and other call center technologies

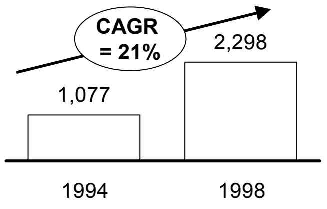
*** Impact at the sector level

Source: MGI; retail banking CIO/management interviews; interviews with McKinsey experts in Retail Banking/Consumer Credit practice and Business Technology Office

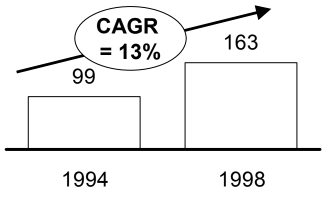
Exhibit 12

INVESTMENTS IN CALL CENTER TECHNOLOGY RESULTED IN GREATER NUMBER OF CALL INQUIRIES HANDLED PER EMPLOYEE

Number of call inquiries, 1994-98
Millions



Number of retail banking call center agents,* 1994-98
Thousands



> "VRUs and call center technology have had great impact by allowing us to handle the growing number of customer inquires efficiently."
>
> – Senior retail banking executive

* Includes call center employees in retail banks only, and assumes that large banks operate 24 hours per day; does not include call center agents in other "monoline" financial services

Source: American Bankers Association; Datamonitor; Tower Group; MGI Analysis use of credit scoring software and underwriting modules. These systems automated various manual steps associated with credit verification and authorization in lending operations and eased time-consuming bottlenecks at the credit-service bureau, leading to more applications processed per employee. They also enhanced decision making and improved the quality of loans approved (Exhibit 13).

Credit card operations significantly reduced fraud by using software that employs artificial intelligence and neural network technology. Banks used their extensive knowledge of consumer's credit card usage needs to extract behavior patterns from databases and customer transaction histories and reduced transaction fraud (Exhibit 14). After large banks optimized their credit card operations, they applied the learnings and process changes across their mortgage, student loan, and other related businesses, while integrating the customer information systems in the process.

Core banking systems. Use of standardized core banking systems, primarily in smaller regional banks, reduced software development and maintenance costs. However, large banks continued to see significant maintenance and development costs associated with supporting multiple core banking platforms (Exhibit 15). These costs, which arose from legacy systems, merger integration efforts, and independent LOB investment decisions, have resulted in high maintenance and development costs at an enterprise level.

In addition, these systems had limited flexibility in developing new products. In many cases, the product factory within the core banking system was not flexible enough, making it difficult for banks to develop new products faster. For example, a bank's ability to offer different checking and savings account features such as sweep or overdraft protection may have been constrained by the product factory's inability to link a customer's existing accounts and develop such a customized product offering. This represented a bottleneck that restricted banks' ability to move toward best-practice IT architecture.

Check imaging. Check imaging lowered some labor and storage costs related to archiving, retrieval, and proofing operations. However, additional labor was required to operate the new machines, and banks were unable to change business processes to deploy imaging technology at the branch and reduce overall paper-based processing costs. Thus the impact of check imaging was limited (Exhibit 16).

On-line banking. On-line banking had limited impact due to low adoption rates[14]

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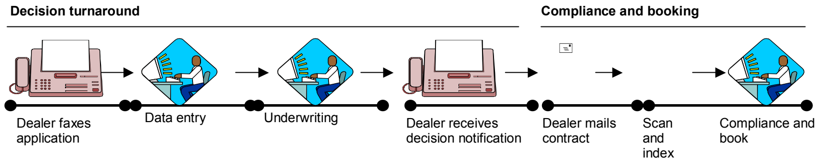
[14] Based on *Online Banking Report* data up to 2000; adoption and use of on-line banking continued to increase in 2001-2002.

Exhibit 13

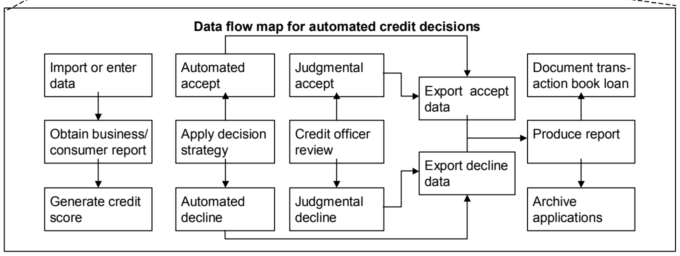
CREDIT SCORING AND AUTO-DECISIONING IMPROVED PRODUCTIVITY IN LENDING OPERATIONS

▨ Key IT investment areas



	Dealer faxes application	Data entry	Underwriting	Dealer receives decision notification	Dealer mails contract	Scan and index	Compliance and book
Today's technology	Fax server technology places image on screen	Work flow system manages electronic flow of information	Use decision engine for auto-decisioning (e.g., AMS's Strata)	Reply by fax server from underwriter desktop or decision engine	n/a	Use work flow system and provide interface to image archive and loan accounting systems (e.g., Hogan, Lemans)	

> "We have seen an 80% reduction in paper work in the lending process. Lending systems have reduced the time to process applications – on the back end, entries are processed automatically in the credit bureau, and the ranking and profiling of applications is done through IT"
>
> – Senior retail banking executive


Data flow map for automated credit decisions

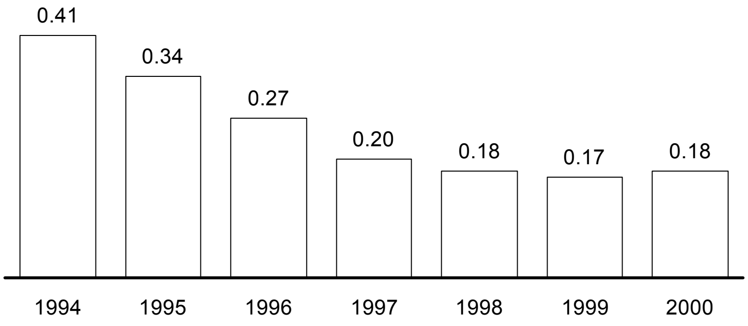
Source: Retail banking CIOs/interviews; industry analysts; MGI analysis

Exhibit 14

CREDIT CARD OPERATIONS REDUCED FRAUD LOSSES THROUGH USE OF IT

Credit card fraud losses as fraction of gross receivables,* 1994-2000

Percent monthly average



> "Losses from credit card transaction fraud are much less today than what they used to be – advances in neural network technology have helped determine whether a particular transaction makes sense for a given consumer."
>
> – Retail bank executive

* Includes all bank credit cards in US

Source: CardData; CIO and management interviews

Exhibit 15

INVESTMENTS IN CORE BANKING SYSTEM IMPROVEMENTS WERE MIXED

> "We have over 40 different DDA platforms worldwide."
> – Former global retail banking executive
>
> "Even though we adopted standard platforms, we began customizing them, and pretty soon, these become complex legacy systems."
> – Head of IT strategy at global retail bank
>
> "Bank One had been wasting $300,000-500,000 per day because the technology platforms inherited from the banks it acquired did not mesh with one another."
> – *American Banker,* attributing quote to Jamie Dimon, CEO of Bank One*
>
> "Our efficiency ratios continue to be low because we standardized on one single platform despite making acquisitions."
> – EVP, Information Services at regional bank

- Large banks continue to have multiple core banking platforms with high maintenance and development costs
- Some smaller, regional banks saw impact from lower maintenance and development costs from standardization

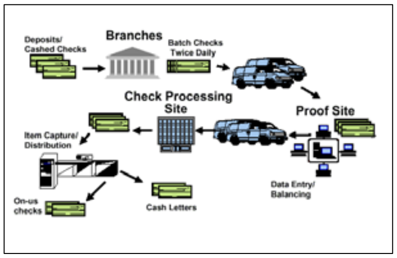
* Bank One projects savings of $200 million in 2003 from integrating its core banking platforms

Source: Retail banking CIO/management interviews; American Banker

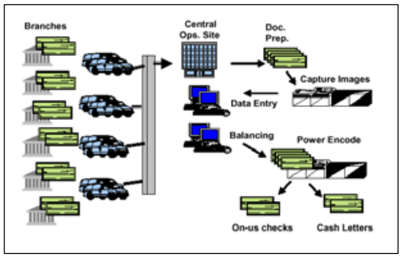
Exhibit 16

CHECK IMAGING HAD LIMITED IMPACT ON PRODUCTIVITY

Conventional check processing workflow



Check processing workflow with central image capture using image-based proof-of deposit (POD) technology



Advantages of check imaging

- Reduced personnel requirements at proof sites (e.g., proof operators)
- Lower costs of data entry, storage, archiving, and retrieval of checks and check information
- Reduced fine sorting and postage costs from use of image statements
- Faster resolution of customer inquires without requesting microfilm copies

Disadvantages of check imaging

- Increased maintenance requirements including additional labor for preparation of documents for subsequent processing
- Branches still need to ship payment documents to central image capture locations
- Slower capture rate on certain sorter types reduce processing efficiency
- Significant capital investments in communications required since image capture was not deployed at the branch*

* High costs of branch-based image capture was a key factor

Source: Tower Group; MGI analysis

and the inability of banks to reduce overall transaction costs by fully migrating customers to the Web. However, banks have found that although adoption of the Internet channel has been limited, retention rates tend to be high for customers who use on-line banking services (Exhibit 17).

Customer relationship management. Investments in software for automation of sales force, marketing, and service functions had disappointing results as banks were unable to use the new decision tools to increase revenues through cross-selling. Often, these CRM investments were made before customer data and customer information systems were well integrated across different products and channels. The resulting lack of data integrity and constraints in access to consistent and accurate data limited the effectiveness of CRM in cross-sell efforts.

Also, execution was inconsistent. Projects were often over ambitious, leading to lengthy implementation delays, and staff was often inadequately trained in the effective use of CRM tools. Nor did many banks make appropriate changes in the sales and marketing process needed to use the CRM tools effectively. The focus of banks' business units around products and specific customer groups as well as existing incentive structures for sales personnel further limited the impact of CRM in cross-selling.

Changing customer behavior proved difficult, too. Banks attempted to capture a greater share of customers' spend on alternate products like life insurance and brokerage accounts, but despite significant increases in IT spend on CRM technologies, the average number of products held by households at their primary bank has barely increased (1 percent CAGR) during 1998-2001 (Exhibit 18).

Branch automation. Banks over-invested in PCs, particularly in branch operations (Exhibit 19).[15] The needs of high-end users drove the standards for PC functionality, and lack of enterprise-wide control of PC purchases led to independent purchasing decisions being made at the department/division level. Further, these PCs were designed to support banks' planned additional front-end functionality such as sales automation and service capability. However, branch personnel were unable to utilize new PCs effectively because much of the new, user-friendly functionality needed to cross-sell and access and/or process customer information was not yet in place.

Impact of key IT investments on profitability

Measuring the impact of specific IT investments on profitability is difficult given

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[15] For additional details, refer to MGI's US Productivity Growth report.

Exhibit 17

ON-LINE BANKING HAD LIMITED IMPACT ON PRODUCTIVITY IN THE 1990s BUT OUTLOOK IS POSITIVE

"Customers have not really originated a lot of new products on-line."
– Major IT vendor

"On-line banking has actually increased the call volume in our call centers, as customers call to get additional assistance."
– Former CTO of large regional bank

"Customers continue to use the old channels, even though banks introduce convenient, low-cost channels."
– Industry analyst

"Customers on-line are less likely to move, have higher balances, and buy more products."
– Head of IT strategy at global retail bank

"On-line bill payment is one of our stickiest products – customer attrition reduced and overall profit margin increased."
– Former global retail bank executive

1990s

- Overall transaction costs continued to increase
- Customers did not completely migrate on-line and continued to use all channels

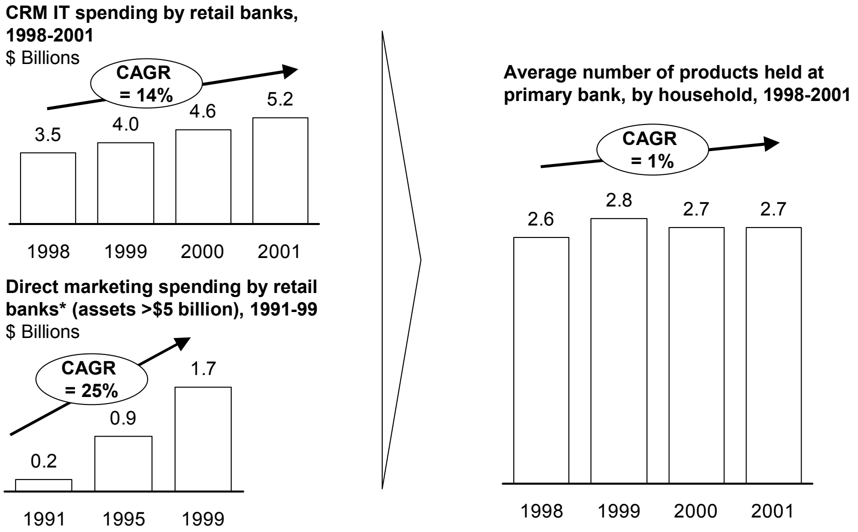
Going forward

- Customer using on-line banking may have better retention and may be more profitable

Source: Retail banking CIO/management interviews; industry analysts

Exhibit 18

CROSS-SELL RATES REMAIN LARGELY UNCHANGED DESPITE SIGNIFICANT INVESTMENTS IN TECHNOLOGY AND DIRECT MARKETING



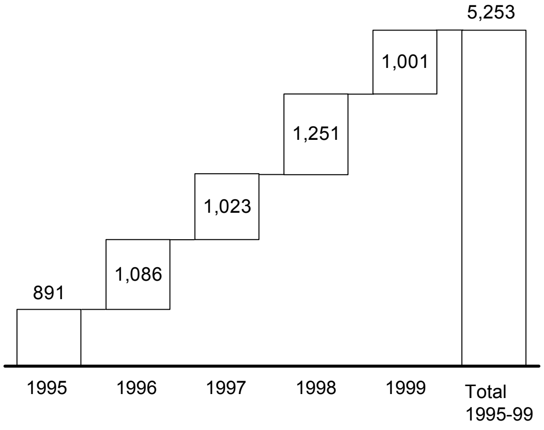
* Direct marketing includes direct mail literature, lists, postage, stuffers, and telemarketing

Source: Performance Solutions International (PSI) (2001); Tower Group (2001); ABA/BMA Bank Marketing Surveys (1992-2000)

Exhibit 19

BANKS* PURCHASED ON AVERAGE 2 PCs PER EMPLOYEE DURING 1995-99 AND MAY NOT BE FULLY UTILIZING PC-BASED FUNCTIONALITY

PC investment per employee
Nominal dollars



Interviewee quotes

"Although I am very pleased with the technology we deployed, we have not used all the capacity."

"If there is any place where there is excess capacity, it is damn sure on the desktop. You have a tremendous amount of power that you are using only 1% of."

"You can have new PCs sitting in the branches, but without good connectivity and fast access to reliable customer information, the new functionality cannot be used."

"Sure we had powerful PCs, but we also had to remember all these codes to access each product and enter data on multiple screens in the process – it was a frustrating experience for tellers."

* Data for depository institutions

Source: Bureau of Economic Analysis (BEA); retail banking CIOs/management/teller interviews; MGI analysis the range of IT and non-IT factors that can ultimately influence profitability. When IT investments have a positive impact on productivity, the associated process improvements in turn influence profitability. This impact on profitability can be broadly understood by looking at the key levers that influenced banks' return on assets (Exhibit 20).

IT investments targeting revenue enhancements had lower impact compared to those aimed at cost reduction. Net interest income, which represents the most significant portion of overall banks' income, is governed primarily by macro-economic variables such as interest rates and less by specific IT applications.[16] On the other hand, net fee and other noninterest income did not see significant impact from IT investments in CRM[17] and on-line banking. Banks were unable to either significantly increase cross-selling or to charge customers adequately for the increased convenience from use of remote channels.

Efficiency ratios,[18] which represent a bank's ability to cost-effectively acquire revenue, did not experience a significant improvement overall during the 1990s. Furthermore, significant gaps existed in efficiency ratios between best practice and the sector average (Exhibit 21). While many IT and non-IT factors can contribute to the efficiency ratio, IT investments impacted banks' income and the overall operational expenses.

Some IT investments positively impacted the ratio, while others had mixed or no impact. For example, lending systems reduced the loan loss provision through improved fraud detection and better loan quality for some banks. It must be noted, however, that while credit scoring did improve productivity by enabling the processing of more applications and improved credit risk evaluation, some banks did not adequately manage the risk associated with subprime lending. As a result, subprime lending activities, which now comprise nearly 37 percent of all credit card loans,[19] resulted in significant losses for some banks.

While VRUs did reduce salary expenses through substitution of capital for labor, an increase in transactions and overall transaction costs from channel proliferation diluted overall impact.

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[16] IT has played a limited role in aggregating and securitizing loans such as mortgage loans, and thus has had some impact on net interest income.

[17] While CRM can increase net fee income from sales of additional products/services, and increased "share of wallet," the overall increase in ROA will depend on the relative profitability of the additional products sold.

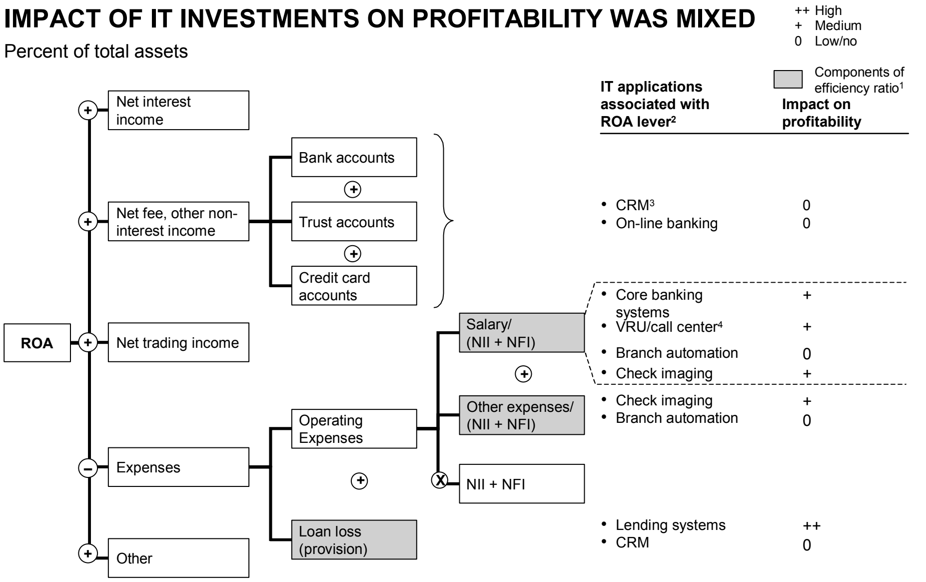
[18] Efficiency ratio is defined as (total noninterest expense)/(net interest income + total noninterest income).

[19] Based on a *Wall Street Journal* report in August, 2002; regulatory changes proposed by the Federal Financial Institutions Examination Council now require banks to increase their reserves for loan losses from subprime lending and have toughened accounting and lending standards involving subprime lending.

Exhibit 20

IMPACT OF IT INVESTMENTS ON PROFITABILITY WAS MIXED

Percent of total assets

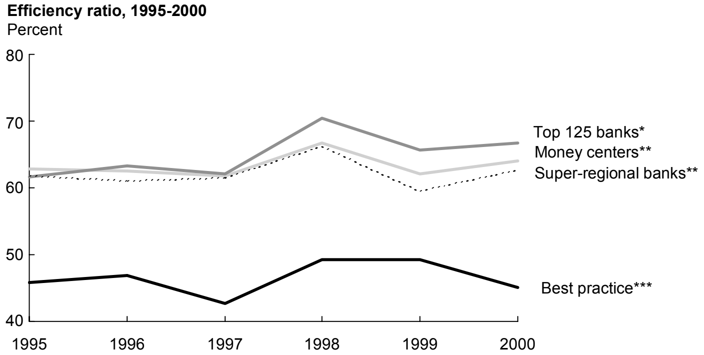


1 Efficiency ratio is defined as total noninterest expense/(net interest income and total noninterest income)
2 IT applications that have impacted net interest income to some extent are not included, e.g., technology to aggregate and securitize mortgage loans
3 CRM can have a positive impact on net fee income through sales of additional products and services; however, the impact on ROA depends on the relative return on assets for the new product/service; CRM may also impact ROA through improved customer profitability management
4 Salary reduction through VRUs occurred when VRU system was first installed (replacing clerical staff), and also when call centers were consolidated
Note: NII = net interest income; NFI = net fee income and other operating income
Source: Interviews; MGI analysis

Exhibit 21

EFFICIENCY RATIOS IN RETAIL BANKS REMAINED RELATIVELY CONSTANT IN THE LATE 1990s, WITH SIGNIFICANT GAP BETWEEN SECTOR AND BEST PRACTICE

$$\text{Efficiency ratio} = \frac{\text{Total noninterest expense}}{\text{(Net interest income + total noninterest income)}}$$



* Based on weighted average for top 125 commercial bank holding companies
** Money center data based on weighted average for Bank of New York, CitiGroup, FleetBoston Financial corporation, HSBC North America, JPMorgan Chase, and Taunus Corporation; data on super-regional banks based on weighted average for banks with more than $70 billion in assets
*** Based on data for Fifth Third Bank
Source: FDIC; MGI analysis

Although some regional banks experienced lower maintenance and development costs through standardization of their core banking systems and efficient IT operations, most large banks continue to experience high costs from supporting multiple core banking platforms. This problem is exacerbated by merger projects, where many banks have experienced difficulty in converting the merged entities into a single platform.

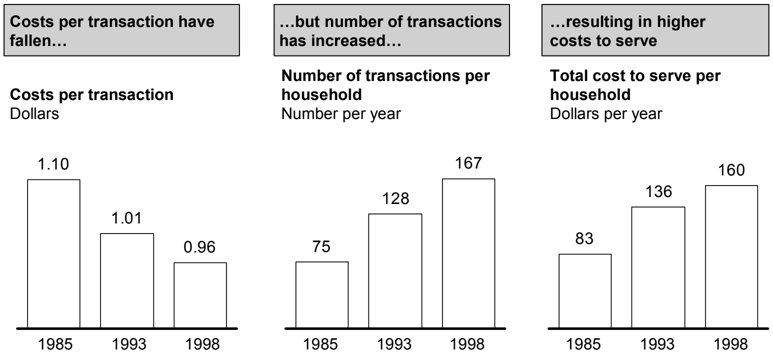
Finally, check imaging reduced some labor costs in check processing, but overall impact was limited because of the additional labor costs involved in handling the new equipment and low use of branch-based image capture.

Generally, retail banks' ability to translate some of their IT investments into profitability gains has been limited by four trends:

- **Product proliferation.** Banks were able to develop new products such as different credit card packages, loan products, and savings products, but the increased complexity (both IT and non-IT) from maintaining, supporting, and servicing these products created high costs.
- **Channel proliferation.** Although banks introduced new, more convenient, and lower-cost channels (e.g., on-line banking, telephone banking), customers continued to use all channels, including the higher-cost branches. This resulted in an increase not only in the total number of transactions but also in overall transaction costs (Exhibit 22).
- **Capture of surplus by consumers.** As customers captured surplus benefits, banks' profits were further limited. In particular, because of the high cost of customer acquisition and the resulting drive to retain customers at all costs, an "arms race" mentality led to investments that helped improve productivity but resulted in neither a significant reduction in cost nor an ability to increase price. In the case of on-line banking for example, since banks were largely unable to charge for the increase in information availability, consumers captured the bulk of the benefits through increased convenience.
- **Execution issues**. Performance management is critical to successful execution of projects in large and complex IT environments. Three execution shortfalls have hindered banks from extracting value from their IT investments: the lack of alignment between IT and business strategy (e.g., limitations in existing organization and governance structure), inadequate transparency in costs and performance of IT projects, and the lack of adequate capabilities to efficiently execute and complete large-scale projects (e.g., CRM deployments, data warehouse projects, and merger integration).

Exhibit 22

OVERALL TRANSACTION COSTS HAVE INCREASED AS CUSTOMERS CONTINUE TO USE ALL CHANNELS



"50% of customers who use the Web follow it up with a call to the call center."
– Gartner Group

"92.9% of US households with e-mail access prefer to receive both postal mail and e-mail when receiving bills, bank statements, and other financial reports."
– Pitney Bowes survey, quoted in Telephony

Source: Gartner Group; Telephony magazine; MGI analysis

Impact of IT on major segments

The impact of IT on productivity and profitability differed depending on the size and scale of banks' operations. The 8,315 retail banks[20] in the US may be broadly segmented into three groups – large, mid-size and regional, and small – based on the size of their assets (usually correlated with size of their customer base).

MGI's analysis focused primarily on the large and the mid-sized regional segments. Large banks had asset sizes ranging from $90 billion to $900 billion in 2000. In the same year, the top ten bank holding companies accounted for 49 percent of commercial and savings banks' assets. These included Citigroup, JPMorgan Chase, Bank of America, Wells Fargo, Bank One, First Union/Wachovia, Washington Mutual, FleetBoston Financial, SunTrust, and National City. Beyond the top 10 bank holding companies, there are approximately 40 to 50 mid-size, regional banks with asset sizes between $10 billion and $90 billion. These include banks like Fifth Third Bank, PNC Bank, Huntington Bancshares, Union Bank of California, Sovereign Bank, ABN AMRO North America. Their assets represent an estimated 25 percent of total commercial and savings banks' assets. Small banks have an average asset size of approximately $250 million.

The differences in impact of IT between the large and mid-sized regional banks were related primarily to the scale and complexity of operations (Exhibit 23). Three IT investments showed difference in impact for the two segments:

¶ **VRUs and call center technology.** The impact of VRUs and call center technology was lower for the mid-sized regional segment because call center operations were not of sufficient scale to enable large efficiencies. Further, many of their customers still preferred branch-based interactions versus remote services.

¶ **Lending systems.** Lending systems had less impact in the mid-sized regional segment compared with the large banks, chiefly because their consumer lending operations were not such a significant part of their overall workforce. In addition, many of them offered third-party consumer lending products from monolines such as MBNA to their customers and did not incur significant IT expenses for lending systems.

¶ **Core banking software.** Large banks have seen less impact from improvements in core banking systems, driven in part by the need to

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[20] Based on FDIC data for 2000.

Exhibit 23

IMPACT OF IT DIFFERS DEPENDING ON SIZE OF RETAIL BANKS

▨ IT investments with difference in impact
○ Low
◑ Medium
● High

Key investments*	Large banks (>$90 billion in assets) Impact on productivity	Large banks (>$90 billion in assets) Rationale	Mid-size regional banks ($10 billion-90 billion in assets) Impact on productivity	Mid-size regional banks ($10 billion-90 billion in assets) Rationale
▨ **VRU/call center technology****	●	• Reduced labor costs with improved functionality replacing branch employees, customer service reps • Unmeasured consumer benefits • Increased number of transactions	◑	• Reduced labor costs somewhat, but many call center operations not at scale • Many customers still prefer branch-based interaction
▨ **Lending systems**	●	• Automation of selected credit processes reduced labor costs • Increased number and quality of loans processed	◑	• Automation of selected credit processes reduced labor costs • Lending operations not significant part of overall bank workforce
CRM	○	• Limited revenue increase due to low usage • Existing organizational skills not adequate to exploit CRM, e.g., cross-selling, improved asset management • High consulting/integration costs	○	• Limited revenue increase due to low usage • Existing organizational skills not adequate to exploit CRM, e.g., cross-selling, improved asset management • High consulting/integration costs
Check imaging	◑	• Reduced storage and labor costs in archiving and retrieval • Limited usage at point-of-deposit limits savings • Improved customer service	◑	• Reduced storage and labor costs in archiving and retrieval • Limited usage at point-of-deposit limits savings • Improved customer service
On-line banking	○	• Limited adoption by customers • Overall transaction costs have increased due to channel proliferation	○	• Limited adoption by customers • Overall transaction costs have increased due to channel proliferation
▨ **Core banking software**	◑	• Reduced labor and IT costs from back-office automation and outsourcing • Large banks continue to have multiple core banking platforms, with high maintenance costs	●	• Reduced software development and maintenance costs through standardization • Some banks have outsourced selected back-end systems to IT vendors
Branch automation	○	• Banks have over-invested in PCs and software functionality in branches, with limited impact on revenue increase	○	• Banks have-over invested in PCs and software functionality in branches with limited impact on revenue increase

* ATMs not included because majority of investments in ATM networks occurred before 1990
** Includes CTI, auto-dialer, and other call center technologies

Source: Interviews with McKinsey experts; MGI analysis support multiple platforms and the diseconomies of scale in large, complex IT environments. Standardization of core banking software and outsourcing of certain back-end systems have had greater impact in mid-sized regional and small banks in terms of reducing maintenance and development expenses.

IT's role in merger activity

Retail banking saw a wave of merger activity in the 1990s arising from product deregulation and changes in interstate banking laws (Exhibit 24). IT did play a role in capturing benefits from merger activity, but overall impact on profitability was limited by costs from increased IT complexity and a lack of significant additional scale benefits in some core operations such as check processing. Some productivity gains were realized through synergies and scale benefits as consolidation of IT and non-IT operations led to workforce reductions. Overall employment in the sector dropped by 5 percent during 1993-2000, with increased workforce reduction in 1997-2000 reflecting the impact of merger activity (Exhibit 25). Typical IT-related savings from a merger of two banks of equal size are 10-20 percent of total initial IT cost structure, which includes that portion of the overall costs that are IT-related. Overall cost savings amount to 15 to 25 percent of combined expense base of both banks (Exhibit 26 and 27).

However, synergies were limited by poor execution, IT complexity, and limited operational scale benefits. Implementation difficulties meant that many IT merger projects were left incomplete, limiting synergies from consolidation of IT systems and operations. For example, Bank One acquired several retail banks and their assets in the 1990s but did not immediately consolidate many of the acquired systems. The resulting inefficiencies from not integrating the various inherited technology platforms cost Bank One an estimated $300,000 to $500,000 per day to maintain and support the many legacy systems.[21] In some cases, organizational problems and lack of leadership may have played a role in the poor execution of the IT merger project.

Furthermore, large, complex IT environments often presented diseconomies of scale in IT operations due to the additional complexity in product, channel, and geographic mix as well as the diseconomies associated with managing large IT operations, particularly in postmerger situations. In these environments, architectural complexity tended to rise significantly with the multiplication of systems interfaces. Also, lack of transparency in IT projects and the challenge of

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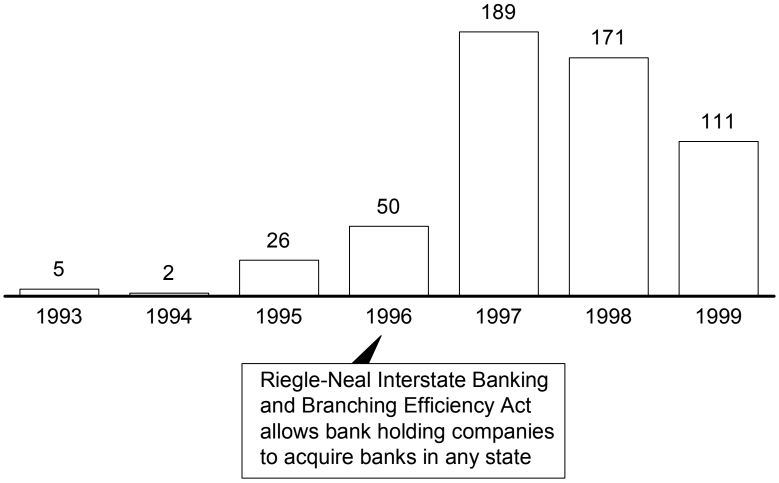
[21] As reported in *American Banker;* Bank One is currently in the process of converting its multiple platforms into a single one, and projects an estimated savings of $200 million in 2003.

Exhibit 24

MERGER AND CONSOLIDATION ACTIVITY IN THE 1990s SET THE STAGE FOR REALIZING SCALE BENEFITS

Number of interstate bank mergers
1993-99



Riegle-Neal Interstate Banking and Branching Efficiency Act allows bank holding companies to acquire banks in any state

Source: FDIC

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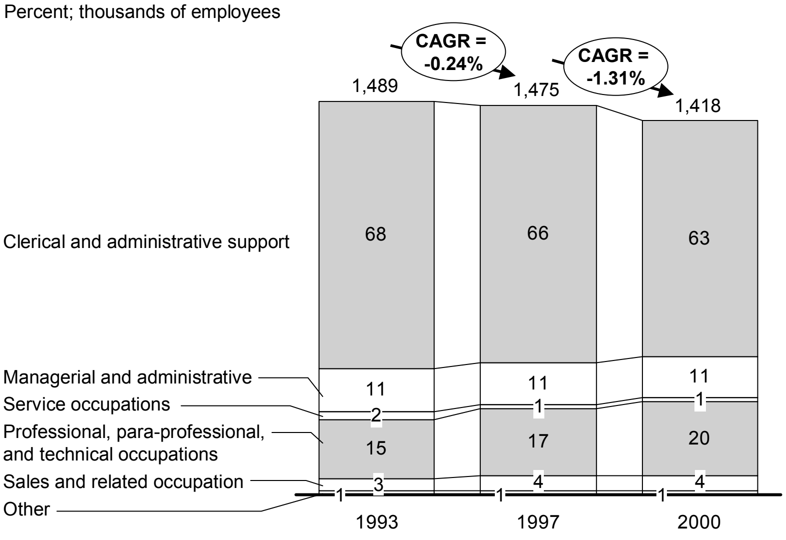
Exhibit 25

MERGERS ENABLED OVERALL WORKFORCE REDUCTIONS, WITH SHIFTS IN LABOR POOLS

Occupational categories in commercial banking, 1993-2000*
Percent; thousands of employees

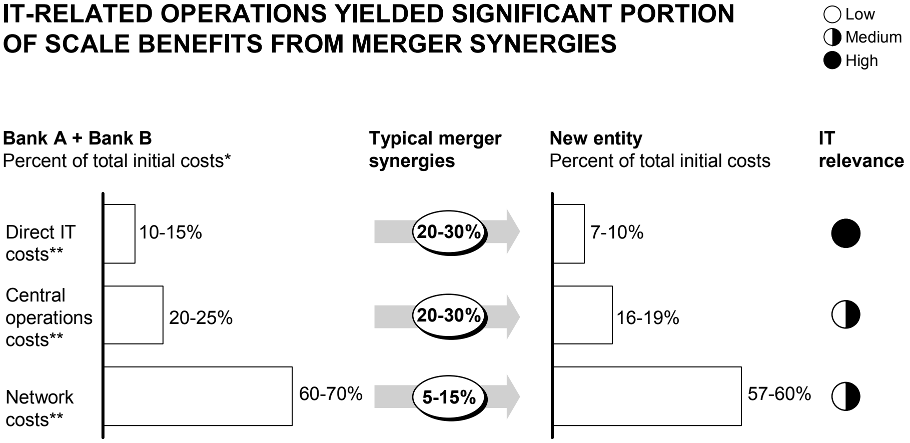


* Includes occupations classified under SIC 602 by BLS for commercial banks

Source: BLS; MGI analysis

Exhibit 26

IT-RELATED OPERATIONS YIELDED SIGNIFICANT PORTION OF SCALE BENEFITS FROM MERGER SYNERGIES



* Assumes that Bank A and B are of equal size; total initial costs include portion of overall costs that are IT-related; overall costs savings are typically 15-20% of combined expense base

** Direct IT costs are those related to IT consolidation (servers, data, IT personnel), central operations costs include back office and shared services, and network costs include ATM costs, branch connectivity, etc.; synergies are very dependent on initial relative efficiency and do not include branch network restructuring

Source: McKinsey Post-Merger Management (PMM) Practice

Exhibit 27

IT COST-REDUCTION OPPORTUNITIES EXIST IN MERGER SITUATIONS

Areas of spend in IT operations	**Typical share of IT spending**	**Typical savings from merger***	**Typical sources of savings**
Application development and support	20-60%	0-40%	• Fewer development/support people • Lower license fees
Data centers and distributed servers	15-35%	10-20%	• Fewer support and operations people • Closure of physical facilities • Greater vendor leverage • More efficient capacity management • Fewer users
Networks	15-25%	10-20%	• Fewer technical support people • Greater vendor leverage • More efficient capacity management • Fewer users
Desktop infrastructure and support	10-20%	10-20%	• Fewer help desk and technical support people • Greater vendor leverage • Fewer users

* Assumes a merger between banks of equal size

Source: McKinsey Post-Merger Management (PMM) Practice coordinating larger, cross-functional projects meant redundant work in various product silos.

Finally, incremental scale benefits were limited. In mergers between large banks, many of the existing facilities were already at minimum efficient scale, so operations such as check processing and call centers did not always see significant scale benefits.

IT architecture in retail banks

Banks' ability to derive value from their IT investments depends in large part on the capability and flexibility of the underlying IT architecture. IT architecture in retail banking is still in the process of evolving from being accounting and product-centric to being channel-centric, and even further, to being customer-centric (Exhibit 28).

A customer-centric IT architecture provides an integrated view of the customer across all channels. It also allows easier access to, and availability of, accurate customer information along with flexibility in product development with faster time to market. In contrast, accounting-centric and product-centric IT architectures typically have relatively limited channel support, poor connectivity across different product modules, inflexible product support, and fragmented customer data.

While the target, customer-centric IT architecture[22] may be well understood, banks have had limited ability to adapt to the new requirements of performance, scalability, and flexibility using existing legacy IT systems. Most retail banks in the US find themselves at various stages of the evolution. For example, banks with a product-oriented IT architecture are in the process of changing their IT systems to provide an integrated channel view. Other banks are building a robust, customer-centric system that allows their branches, call centers, and other channels to obtain an integrated view of the customer.

Merger activity further complicated the transition process with the need to integrate across different core banking platforms, customer and product data sets, channels, and front-end systems. As a result, few banks have achieved best practice in terms of customer-centric IT architecture.

During the 1990s, this shift from a focus on accounting and products to channels and customers led many banks to build capabilities in ways that did not maximize

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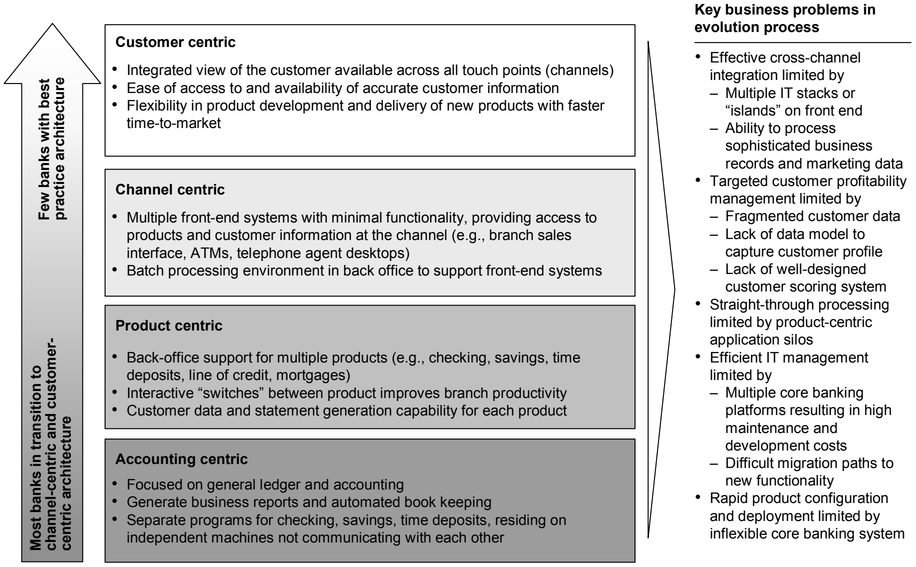
[22] Target IT architecture changed from a traditional mainframe-based system to a three-tier system (e.g., channels, front-end, and back-end), and now to a flexible, multi-tiered system with appropriate middleware. Components of best-practice target IT architecture include channel systems, customer information system, middleware, front-end systems, back-end systems, and external-facing systems.

Exhibit 28

IT ARCHITECTURE IN RETAIL BANKS IS EVOLVING TOWARDS BEING CUSTOMER-CENTRIC



Customer centric

- Integrated view of the customer available across all touch points (channels)
- Ease of access to and availability of accurate customer information
- Flexibility in product development and delivery of new products with faster time-to-market

Channel centric

- Multiple front-end systems with minimal functionality, providing access to products and customer information at the channel (e.g., branch sales interface, ATMs, telephone agent desktops)
- Batch processing environment in back office to support front-end systems

Product centric

- Back-office support for multiple products (e.g., checking, savings, time deposits, line of credit, mortgages)
- Interactive “switches” between product improves branch productivity
- Customer data and statement generation capability for each product

Accounting centric

- Focused on general ledger and accounting
- Generate business reports and automated book keeping
- Separate programs for checking, savings, time deposits, residing on independent machines not communicating with each other

Key business problems in evolution process

- Effective cross-channel integration limited by
  - Multiple IT stacks or “islands” on front end
  - Ability to process sophisticated business records and marketing data
- Targeted customer profitability management limited by
  - Fragmented customer data
  - Lack of data model to capture customer profile
  - Lack of well-designed customer scoring system
- Straight-through processing limited by product-centric application silos
- Efficient IT management limited by
  - Multiple core banking platforms resulting in high maintenance and development costs
  - Difficult migration paths to new functionality
- Rapid product configuration and deployment limited by inflexible core banking system

Source: Interviews; MGI analysis

the productivity of their IT investments. Many banks did not implement best practices in migrating to a customer-centric architecture. Thus, key components of their IT architecture have not aligned with their business needs:

- ¶ Effective cross-channel integration was limited by multiple IT stacks or "islands" on the front-end and a lack of ability to process sophisticated business records and marketing data.
- ¶ Targeted customer profitability management was limited by fragmented customer data, the lack of proper data models to capture customer profile, and the lack of a well-designed customer scoring system for managing customer interactions.
- ¶ Straight-through processing was limited by product-centric application "silos."
- ¶ Efficient IT management was limited by multiple core banking platforms that result in high maintenance and development costs, and difficult migration paths to new functionality arising from new standards and applications.
- ¶ Rapid product configuration and deployment were limited by inflexible core banking systems that are unable to adequately support faster time-to-market needs.

Sector averages vs. best practice IT architecture

Our research found gaps between elements of the sector's IT architecture and what we identify as best practices for retail banking. These gaps were especially prevalent in banks' customer information, channel integration, and back-end systems.

Customer information systems (CIS)

An integrated, accurate, near-real-time, and enterprise-wide view of customer information is considered a key component of best-practice IT architecture today. This gives banks the capability to offer improved quality of service and manage customer profitability effectively. Banks with good CIS systems saw benefits in the 1990s from subsequent IT investments that leveraged these CIS capabilities.

However, many banks (including the average bank and IT laggards) did not have a centralized CIS layer, resulting in slower data access times, customer data inaccuracies, and reduced service quality. Furthermore, redundant customer and product data existed across channels, front-end systems, and multiple core banking platforms, increasing overall complexity. Investments in front-end systems (e.g., CRM) in such cases were likely to have lower impact due to poor data quality and inefficient linkages between channels and product and/or customer data.

Channels

Best practice IT systems also offer an integrated view of the customer across all channels along with accurate and consistent product and transaction data. In addition, best practice banks use a well-designed scoring system based on the customer's lifetime value. This system is fundamental to retaining customers and effective cross-selling.

Channel-related IT systems at the average retail bank generated disparate customer views across various channels. The call centers, Web site, ATMs, and the branches existed as "islands" and often did not communicate with each other. Overall, this reduced productivity of customer service professionals in the channels and lowered quality of service to the customer. Furthermore, banks with problematic IT situations had disparate customer databases and unreliable product information, resulting in higher transaction costs along with poor service quality.

Back-end systems

Best practice IT architecture calls for a single platform for core banking systems, with various products interfacing through common messaging middleware. This allows the banks to lower costs in maintenance and custom application development and enables the product factory to develop new, innovative products with faster time-to-market.

In contrast, some retail banks in the 1990s (especially those with problem IT situations) had multiple legacy core banking platforms with limited product development functionality. In addition, products existed in "silos," which results in uncoordinated product support across channels and less flexibility in developing and launching new products quickly. Mergers further reduced efficiencies if they were not managed well, requiring the banks to maintain multiple platforms and redundant data systems.

IT as a source of competitive advantage

Retail banks have found it difficult to derive sustainable competitive advantage solely from their IT investments. Most IT-enabled innovations tend to diffuse rapidly across the sector. As a result, IT applications that are considered "differentiating" rapidly transition to becoming core. For example, on-line banking and CRM investments in the 1990s were fueled in part by an "arms race" mentality among banks, fed by the fear of losing customers and/or revenues if they did not provide the latest functionality.

This rapid diffusion of IT applications had several causes. First, the regulatory environment mandated numerous common reporting and compliance guidelines, pushing banks toward standardization. Also, the industry saw a high degree of collaboration, particularly in core businesses such as checking and savings products where historically banks have not experienced high levels of competitive intensity. Industry forums such as the Banking Administration Institute and the American Bankers Association offered banks an opportunity to share learnings and collaborate on projects of common interest. Third, IT vendors developed and sold new IT solutions to a wide range of banks, limiting the ability of any one bank to keep an innovation to itself for a significant length of time. Finally, we found a high level of interconnectedness within the sector in terms of payment settlement, shared ATM networks, and check clearing. This is further formalized by the existence of several shared industry utilities such as ATM networks, bank card networks, and check clearing houses, which allowed many banks to leverage scale benefits from IT across the banking system (Exhibit 29).

As these IT capabilities spread rapidly across the sector, they cease to be differentiating; individual banks have rarely obtained competitive advantage or improved overall profitability simply by deploying these applications. When IT investments have created competitive advantage for individual firms, it was usually in the context of developing and expanding scale-based and cost-based advantages. For example, JPMorgan Chase strengthened its scale and cost advantages in the auto financing market by deploying DealerTrack, a software program used by auto dealers that processes auto loans for several banks. The bank deployed an automated, end-to-end solution that was paperless and gained significant cost advantages in the process, further strengthening its presence in the auto loan market (Exhibit 30).

Citibank's credit card unit achieved significant cost benefits from streamlining the credit card application process using IT. Citibank used its imaging and scanning platform to store key data elements in its customer information system and to compress the process of screening credit card applications. Citibank then deployed the credit screening process with the imaging platform in its other consumer loan businesses and achieved economies in scale and scope in the process (Exhibit 31).

Fifth-Third Bank attributes its low efficiency ratios (45 percent vs. industry average of 62 percent in 2000) to its efficient operating platform. This has helped Fifth-Third achieve greater synergies from merger integration as it began acquiring several regional banks to build scale, and this ability is now considered a core competency at Fifth Third Bank (Exhibit 32).

Some IT investments such as fraud detection and reporting and security-related applications are not designed to obtain competitive advantage. Investments in transaction-based credit card fraud and check fraud detection, for instance, were designed to be leveraged by all banks since these detection systems address a threat to the profitability of the industry as a whole.

Exhibit 29

BANKS HAVE LEVERAGED SHARED UTILITIES TO CREATE VALUE

Definition: Shared utilities are bank-owned and bank-operated organizations providing core processing services and end point connectivity to corporate banks
Examples: Bank card associations (Visa, MasterCard), EFT/ATM networks, ACH associations (NACHA), wholesale payment networks (CHIPS, Fedwire, DTC), and check processing clearing houses*

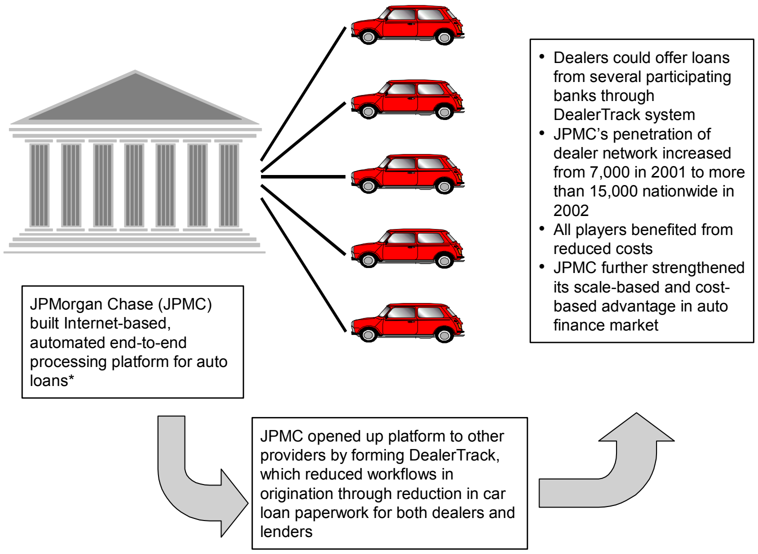
Benefits of shared utilities	**Examples**
Force convergence around common standard	• NACHA has led over 56% of private sector and 95% of public sector to use direct deposit • Check standards underpin over $70 billion in bank revenue
Grow overall market for bank products and services	• Visa had less than 60 million cardholders in 1980; today it has 240 million • Bank cards generate over $75 billion in revenue
Reduce risk	• New York Clearing House (NYCH) has never failed to settle in its 145-year history • ATM networks and card associations have significantly reduced fraud risks
Reduce cost/investment	• ACH reduces bank costs by $3 billion per year • CHIPS saves banks $33 million per year; fees 50% lower than Fedwire
Create barrier to entry by nonbanks	• CHIPS limits membership to banks regulated by NY banking authority and establishes credit and financial stability standards

* NACHA: National Automated Clearing House Association; EFT: Electronic Funds Transfer; ATM: Automated Teller Machine; CHIPS: Clearing House Interbank Payment System; DTC: Depository Trust Company

Source: NACHA; DTC; CHIPS; FDIC; Card Industry Directory; MGI analysis

Exhibit 30

JPMORGAN CHASE DEVELOPED COMPETITIVE ADVANTAGE THROUGH USE OF IT IN AUTO FINANCE MARKET



JPMorgan Chase (JPMC) built Internet-based, automated end-to-end processing platform for auto loans*

JPMC opened up platform to other providers by forming DealerTrack, which reduced workflows in origination through reduction in car loan paperwork for both dealers and lenders

- Dealers could offer loans from several participating banks through DealerTrack system
- JPMC's penetration of dealer network increased from 7,000 in 2001 to more than 15,000 nationwide in 2002
- All players benefited from reduced costs
- JPMC further strengthened its scale-based and cost-based advantage in auto finance market

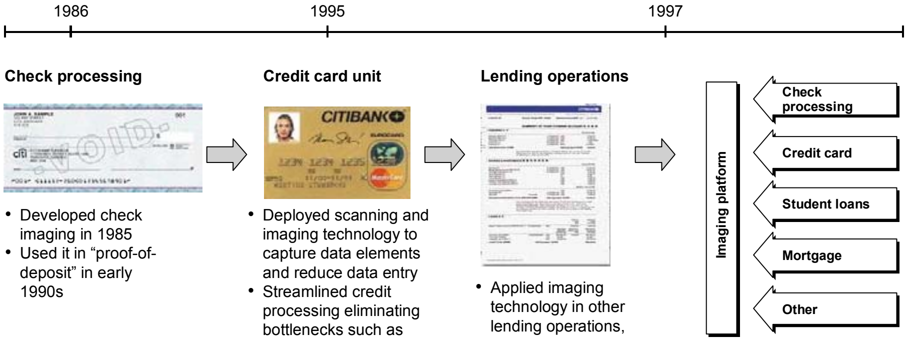
* System developed by LabMorgan, a JPMorgan Chase subsidiary

Source: DealerTrack Web site; JPMorgan Chase Web site

Exhibit 31

CITIBANK INNOVATED IN HIGHLY COMPETITIVE CREDIT CARD BUSINESS AND APPLIED INNOVATION IN OTHER BUSINESS UNITS TO GAIN COST ADVANTAGE

Citibank applies imaging technology innovation to multiple business processes



Check processing

- Developed check imaging in 1985
- Used it in “proof-of-deposit” in early 1990s

Credit card unit

- Deployed scanning and imaging technology to capture data elements and reduce data entry
- Streamlined credit processing eliminating bottlenecks such as credit bureau
- Used imaging in query and remittance processing

Lending operations

- Applied imaging technology in other lending operations, e.g., student loans, mortgages, retail installment loans

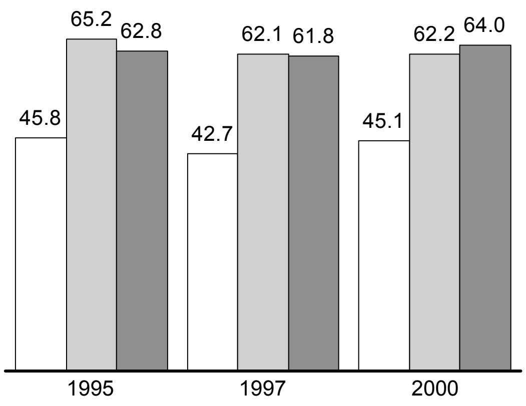
- Integration of imaging platforms allowed Citibank to further lower unit costs and increase productivity through better asset utilization

Source: Interviews

Exhibit 32

IT PLATFORM EFFICIENCIES HELPED FIFTH THIRD BANK ACHIEVE LOW EFFICIENCY RATIO

Efficiency ratio*
Percent, 1995-2000



> "By installing its highly efficient operating platform, Fifth Third significantly reduces overhead expenses at the companies it acquires."
>
> – BAI interview with George Schaefer, CEO of Fifth Third Bank, June 1998

* Defined as total noninterest expense/(net interest income + total noninterest income)

Source: BAI (Bank Administration Institute); BHC, Bankscope; BAI interview

SUMMARY OF RELATIONSHIP BETWEEN KEY IT INVESTMENTS AND PERFORMANCE

To summarize our analysis of where IT investments have or have not had impact on retail bank performance, we can point to three key characteristics of IT investments from which banks have derived value:

1. They were tailored to specific business processes and linked to key performance levers. These applications streamlined a given process and improved its performance by addressing critical bottlenecks or enhancing the quality of decision making at customer touch points. For example, lending systems such as credit scoring software enabled handling of high application volume, lowered costs in processing, and enabled fast, consistent decision making. VRU and IVR systems were configured specifically for customer service needs in retail banking, and resulted in shorter wait times and more calls handled per employee.

2. They were part of a disciplined approach to ensuring that key IT capabilities were in place prior to new IT investments. Having access to accurate customer data and ensuring that the information linkages to the CSR/loan agent desktop enabled investments in lending systems, as well as call center technology to have impact. As we have mentioned, the lack of consistent, accurate, and reliable customer data across different channels (e.g., via a central CIS) has been a key reason for the low impact of CRM investments thus far.

3. They co-evolved with business process changes and managerial/technical innovation. When IT investments were made in conjunction with changes in the business process, organization structure, incentive structure, and workflow, they tended to have greater impact. For example, innovative use of customer behavior information along with deployment of fraud detection software in credit card operations was instrumental in reducing transaction fraud losses.

Investments made in CRM, check imaging, and on-line banking without aligned and adequate business processes did not yield high impact. In particular, IT investments targeted at increasing revenues (e.g., CRM) that cut across various business units were not made in concert with changes in the banks' organizational and incentive structures.

OUTLOOK

Notwithstanding the current economic downturn, retail banking could be on the verge of another strong phase of productivity growth, driven by pressures for cost reduction, improvements in multichannel management, and increased use of electronic forms of payment. Efforts in customer data integration and merger integration have been significant and have yet to yield large benefits, but they do position banks to capture value from initiatives such as multichannel distribution and other IT-related cost reduction efforts. Banks can achieve these gains from focused, incremental investments and changes in business processes.

As banks seek to reduce costs in the current economic environment, they will look for greater efficiencies from their existing IT investments. In the near term, the focus will be on smaller, incremental investments that enable banks to capture value from existing IT investments. Banks are less likely to make big bets around IT, except in exceptional cases. While banks have captured some of the first-order merger-related benefits from IT, the more difficult (and potentially more valuable) IT-related efficiencies from these mergers have yet to be realized. These additional IT-related synergies from merged operations (e.g., cost savings from lower maintenance and development expenses by converting multiple core banking systems into a single platform) will continue to drive productivity enhancements. Trends in business process outsourcing (BPO), offshoring, and standardization of IT applications may further drive productivity improvements through cost reduction. In particular, BPO may have a significant impact on profitability, as banks outsource some of their IT-related back-office processing, maintenance, and other noncritical functions.

Banks are investing in multichannel management capabilities designed to provide more accurate and comprehensive views of the customer across various channels. The underlying IT systems integrate customer and product information, thereby allowing for better profitability management. While the impact on overall productivity may be moderate, the impact on profitability will likely be significant for firms that deploy multi-channel management effectively (Exhibit 33).

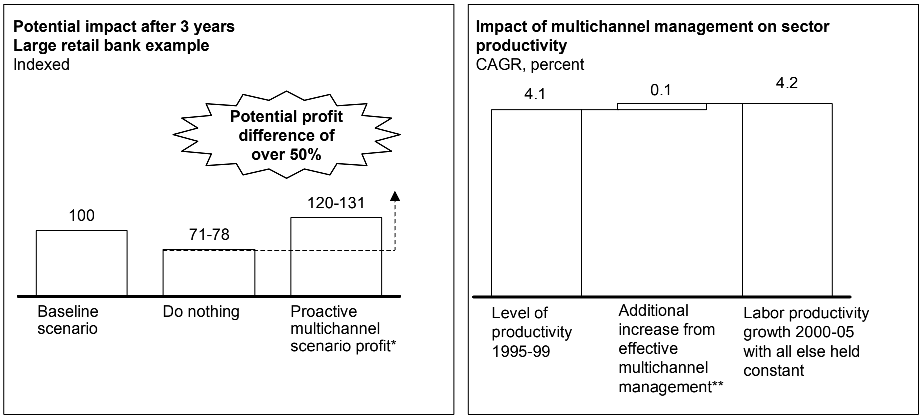
Finally, decreased use of paper-based checks and an increase in electronic forms of payments offer banks the opportunity to see productivity gains from lower costs in check processing. Despite the loss of fees and float from the current check-processing activities, the additional workforce reductions are likely to reduce costs and increase labor effectiveness (Exhibit 34). In fact, the decrease in check volume in the late 1990s suggests that banks should not make large IT investments in check processing going forward.

OPPORTUNITIES AND CHALLENGES FOR RETAIL BANKS, SHARED UTILITIES, AND THEIR IT VENDORS

Retail banks, shared utilities, and IT vendors face significant opportunities and challenges in deriving greater value from their IT investments. Banks need to examine the key productivity levers that can be exploited through IT, and can take steps to ensure that they capture the associated profitability gains as well. In addition, MGI identified trends with significant implications for shared industry

Exhibit 33

MULTICHANNEL DISTRIBUTION MAY HAVE MODERATE PRODUCTIVITY IMPACT AND HIGH IMPACT ON INDIVIDUAL BANK PROFITABILITY



Profit potential from executing well on multichannel distribution can be significant . . .

. . . with some productivity gains at the sector level, primarily from reduced labor costs

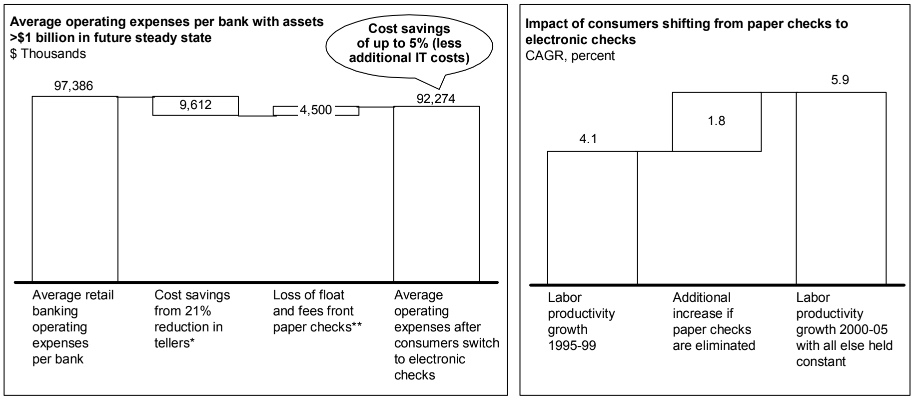
* Key improvements include 10% reduction in branches, improvement in customer retention from 80% to 84%, and improved wallet share from 35% to 37%; do nothing scenario is based on 76% customer retention rate, and 33% wallet share

** Estimate based on 10% reduction in branches and branch personnel (tellers) through effective multichannel distribution; assumes relatively small increase in personnel at call center and on-line banking support. Does not include potential sector-wide increases in sales of new products and services resulting from improved multichannel capabilities

Source: McKinsey Retail Banking and Consumer Credit practice; Functional Cost Analysis (Federal Reserve); MGI analysis

Exhibit 34

TRANSITION FROM PAPER-BASED PROCESS TO ELECTRONIC PAYMENTS MAY HAVE STRONG IMPACT ON PRODUCTIVITY AND PROFITABILITY



Banks can reduce their operating expenses if consumers originate all their checks electronically . . .

. . . and elimination of paper checks will lead to increased productivity in the sector

* Based on assumption that 21% of tellers are currently dedicated to receiving check deposits, and can be eliminated

** Based on average volume of 50 million checks processed annually, with an average face value of $360 and 3% interest, held for 3 days, and assuming that other fees and prices remain constant

Source: ABA; FDIC; Functional Cost Analysis; MGI analysis utilities. Finally, banks' focus on deriving more value from IT investments implies that IT vendors face greater challenges in ensuring that their products and services are used more effectively going forward.

Implications for retail banks

Banks will likely be operating with more constrained IT resources than in the recent past. The current economic environment will pressure banks to reduce their IT costs. Furthermore, increased IT spending on security-related projects in the post-September 11 era implies that banks' IT budgets for maintenance, development, and new investments will probably continue to shrink.

Banks have an opportunity to get greater value from IT by improving their performance along key productivity levers, effectively migrating toward a customer-centric IT architecture, implementing key characteristics of high-impact IT investments, and exploring innovative ways to build competitive advantage through the use of IT. Doing so will not be easy. In particular, retail banks will need to make difficult decisions as their IT systems evolve toward a customer-centric IT architecture. The need to migrate from multiple, complex IT platforms resulting from mergers toward single, flexible, multitier platforms will be challenging and critical to operational efficiency.

Nonetheless, retail banking could be on the verge of another strong phase of productivity growth, driven by pressures for cost reduction, improvements in multichannel management, and increased use of electronic forms of payment. IT can play a significant enabling role in this growth; however, banks need to make new IT investments with caution, for two reasons. First, banks have spent heavily on IT in the recent past. Their near-term efforts, therefore, can benefit from a focus on incremental investments that leverage existing IT investments. Second, consumers are fundamentally changing the way they initiate and accept payments. Banks should consider the impact of key transaction trends in productivity measures (such as check volume and electronic payments) when making any new IT investments.

In light of this outlook, we will discuss three implications for retail banks:

¶ IT strategy as a core component of business strategy.

¶ Deriving greater value from IT through operational improvements and strategic choices.

¶ Making IT investments with a near-term and a longer-term perspective.

IT strategy as a core component of business strategy

Banks that can effectively combine IT with disciplined business strategy and operations to extract value will emerge as leaders in the sector. In addition, a clear understanding of business priorities is essential for making effective IT decisions. CIOs need to be actively involved in the strategy planning process to ensure that they are optimizing IT efforts, and providing the expertise necessary to facilitate the co-evolution of business and technology innovation.

Deriving greater value from IT through operational improvements and strategic choices

Banks can capture more value from IT if they look to best practices to close performance gaps, align business processes and IT capabilities toward higher impact, and continue to innovate to maintain competitive advantage.

First, banks can close performance gaps in productivity by improving along several key levers:

¶ **Substitute capital for labor**. Ensure that opportunities to automate key business processes have been explored (e.g., best practice use of VRU/ IVR systems for customer service in call centers, improved utilization of imaging platform, and use of credit-scoring software for lending decisions where applicable).

¶ **Deploy labor more effectively.** Explore opportunities to centralize branch-based functions (e.g., branch-based vs. centralized credit review process), redeploy IT personnel into more value-added roles than routine maintenance (e.g., by using standardized core banking systems that reduce maintenance-related workload/costs). In addition, migrating customers effectively from high-cost to low-cost channels will result in reduced labor costs through improved labor deployment.

¶ **Increase labor efficiency.** Improve cross-sell ratios through better use of CRM tools in outbound call center operations and branch-based sales efforts.

¶ **Increase asset utilization.** Increase utilization of imaging platform (e.g., across all items and applications processed) and optimize VRU usage rates[23] (e.g., best-practice diversion rates of incoming calls to VRU).

¶ **Sell new value-added services.** Improve cross-sell ratios by originating more products through low-cost channels (such as Internet and call centers) and develop relevant products (e.g., by adding new features) with faster time-to-market. The key challenge is to prevent product proliferation, which will result in increased overall costs to support the new products, and thus limit the productivity benefit.

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[23] Optimal diversion to VRUs implies a balance between routing information inquiries to the automated voice response system and agent interception of phone calls based on customer priority or cross-sell potential.

¶ **Shift to higher-value goods in current portfolio.** Improve profitability of product mix through better customer profitability management (e.g., via a well-designed customer scoring system) and effective migration of customers from high-cost channels to low-cost channels for selected transactions (e.g., migrate routine balance inquiries and credit applications from branch-based service to on-line or call center service).

¶ **Realize more value from goods in current portfolio.** Explore opportunities to increase prices on selected products (e.g., increase fees for on-line banking services). This can be particularly challenging given the tendency toward banks seeing limited impact on profitability from certain IT investments due to consumers capturing the surplus through increased convenience.

Second, they can close the performance gaps in IT architecture. This begins with an examination of how the bank compares with best practice in terms of the ability of their IT architecture to adequately meet business requirements. Banks that focus on building customer-centric IT capabilities (e.g., the ability to provide cross-channel access to accurate data on customers, products, and profitability) are likely to leverage their existing IT investments more effectively. In doing so, the key challenge faced by banks is implementing best practices in migration to a customer-centric IT architecture.

Third, banks will benefit from aligning their business processes and IT capabilities to achieve greater impact. IT applications must co-evolve with business process changes, including organizational changes, changes to incentive structures, and changes toward customer-centric IT architectures. Furthermore, banks need a disciplined approach to ensure that key prerequisite IT capabilities are in place prior to new IT investments. This means, for example, enterprise-wide access and availability of accurate customer data through a robust customer information system, prior to making large investments in CRM software.

Finally, despite the tendency for IT innovations to diffuse rapidly across the sector, banks should not stop trying to build and sustain competitive advantages. Potentially sustainable moves include enhancing scale-based advantages through use of IT, enabling faster time-to-market with new and innovative products, or innovation around processes to reduce costs.

Making IT investments with a near-term and longer-term perspective

In making IT decisions going forward, banks will benefit from explicit consideration of both near- and longer-term investment trends. In the near term, the focus will be on key incremental investments. Banks will look to smaller, incremental investments that enable them to capture value from existing IT investments. Banks are less likely to make "big bets" around IT except in extreme cases.

Furthermore, key transaction trends, including checks versus electronic forms of payment, the use of alternate channels, and increases in information transactions, have implications for banks' IT investments. For example, the decreasing volume of checks processed is likely to impact banks' investments in check imaging systems and their utilization. Banks will likely need to explore innovative ways to increase utilization of existing imaging platforms, or develop alternate, low-cost solutions (e.g., outsourcing, deploying low-cost branch-based image POD technology).

As the number of electronic transactions (debit card, credit card, and ACH transfers) increases, banks will likely need to invest in IT solutions to improve scalability, reliability, fraud detection/prevention, and speed of response for authorization/ settlement. Also, increasing use of alternate channels such as on-line banking and call centers implies that banks need to make IT investments to improve the quality of service in such channels and maximize customer profitability (e.g., effective multichannel management, improved VRU/IVR systems). Finally, as information transactions continue to increase rapidly, banks need to consider implementing reliable and secure IT solutions to cost-effectively serve the information needs of their customers (e.g., use of lower-cost servers, innovative self-service products, outsourcing).

Implications for shared utilities in retail banking

Shared industry utilities such as bank card networks, ATM networks, and check clearing houses are an integral part of the banking landscape in the US. Most of these utilities, which were formed in the pre-consolidation era, have seen dramatic changes in recent years. These changes are driven primarily by bank consolidation, changing customer needs, technological change, and a decline in the privileged position of utilities. While banks have seen several strategic benefits to having shared utilities, these changes have resulted in some utilities not being well aligned with customer needs. Transaction trends, shifting IT spend patterns by banks, and changing industry dynamics have several implications for shared utilities as well as retail banks.

¶ As electronic payment transactions such as debit card transactions and ACH transfers continue to grow, banks and utilities involved in the settlement process need to ensure that their IT systems are able to handle and process the increased volumes of such transactions. Many systems are not currently capable of supporting these volumes and banks as well as utilities need to address this issue before it negatively impacts the customer experience.

¶ The potential overcapacity in the check clearing utilities arising from reduction in check volumes has three key implications. First, there may be fundamental changes to the structure of these utilities so as to reduce operational costs, such as consolidation, forming of new utilities, and outsourcing. Second, banks and utilities will look to new sources of revenue, such as debit cards and other electronic payments, to replace the falling income from check processing. These alternate sources, however, will contribute lower revenue than the checks they replace, resulting in the need for a “single voice” across the different business units in banks in their interactions with the different utilities. Third, the Federal Reserve, which operates 46 check processing centers across the country, will need to explore ways to better utilize its huge fixed-cost infrastructure in check processing.

Implications for IT vendors in retail banking

The pressure to reduce IT-related costs and an increased focus by banks on deriving value from existing IT investments has several implications for IT vendors:

¶ In the short term, revenues are likely to remain depressed as banks cut back on spending for big bets and large IT projects. Banks have already begun to reduce the spending on such projects, e.g., additional CRM modules.

¶ The banks that continue to spend on such large projects are likely to be the ones that did not do so during the 1995-2000 period and are in the investing phase of their budget cycles. In such cases, both banks and IT vendors have an opportunity to maximize the value capture potential by preventing typical implementation mistakes.

¶ For other customers, vendors must focus on incremental IT investments that will enable banks to better leverage their existing IT stock. Banks have made substantial investments in data warehouses, CRM, and customer data integration, and are looking for means of capturing more value without incurring significant additional expenses. Vendors have an opportunity to develop long-term relationships with banks by developing solutions to address this need, for example by helping banks understand and implement best-practice use of existing on-line banking or CRM tools.

¶ Vendors will need to develop innovative solutions for cost reduction in concert with banks, such as outsourcing or offshoring programs. Banks are increasingly looking to reduce their maintenance and development costs, especially given the need to reallocate IT budgets to account for the increased spend on security concerns. IT vendors can help banks understand the various options available and develop solutions tailored to the bank’s size, scope, and complexity of operations.

Glossary of terms used in retail banking sector case

Term	**Definition**
ACD	Automatic call dialer.
ACH	Automated clearing house.
ATM	Automated teller machines.
BEA	Bureau of Economic Analysis, US Department of Commerce.
BLS	Bureau of Labor Statistics, US Department of Labor.
BPO	Business process outsourcing.
Channels	Branches, call centers, Internet, ATMs, and other touch points through which customers interact with banks.
CIS	Customer information system.
Core banking systems	Retail banks' basic IT platform that provides central accounting, transaction processing, and customer information management functions.
CRM	Customer relationship management; refers to tools and software for automating and improving effectiveness of sales, marketing and customer service functions.
CSR	Customer service representative.
CTI	Computer telephony integration.
DDA	Demand deposit application.
Efficiency ratio	Measure of banks' cost effectiveness in acquiring revenue, defined as (total noninterest expense)/(net interest income + total noninterest income).
EFTPOS	Electronic funds transfer at point-of-sale.

Term	**Definition**
FDIC	Federal Deposit Insurance Corporation, created to insure deposits and promote safe and sound banking practices.
Front-end systems	Systems and software used by banks at customer touch points to facilitate customer interaction.
FTE	Full-time equivalent employees.
HR	Human resources.
IVR	Integrated voice response system.
LOB	Line of business.
Middleware	Software that helps disparate systems communicate and work with each other.
MIS	Management information systems.
NACHA	National Automated Clearing House Association, a shared industry utility that settles payments.
Payment transactions	Transactions involving checks, credit cards, debit cards, ATMs, and ACH transfers.
POD	Proof of deposit.
POS	Point-of-sale debit card transactions.
ROA	Return on assets.
SIC	Standard Industrial Classification, a system used by the US Bureau of the Census to categorize firms by business type.
VRU	Voice response unit, used in call centers to automate the handling of telephone inquiries.
Y2K	Software changes and IT system modifications to prevent disasters arising from "Year 2000" date change.

IT and productivity growth in the semiconductor sector

SUMMARY

The semiconductor industry experienced one of the highest labor productivity growth rates in the 1990s, averaging more than 35 times the average annual US productivity growth rate of 2 percent from 1993-2000. This sector also experienced an increase in IT intensity[1] in 1995-2000 relative to 1987-1995. During the 1990s, the increase in labor productivity in semiconductors was predominantly driven by changes in output quality as measured by the output deflator. A combination of factors, including high absolute demand (in part from increased penetration of computers) and demand specifically for high-performing chips (in part due to rapid PC upgrade cycles) shifted the output mix toward the cutting-edge, higher-quality products.

Of the various semiconductor subsectors, microcomponents and memory experienced the highest change in output quality[2] and demand. In microcomponents and memory, microprocessors (MPUs) and dynamic random access memory (DRAM) were significant (approximately 50 percent) contributors to the sector revenues. In MPUs and DRAMs, IT played a critical enabling role in driving line width reduction that led to improved functionality and integration – quality changes that were the main drivers of productivity improvements in these subsectors in the 1990s.

The impact and role of key IT systems on the productivity and profitability levers in the sector depended on the subsector characteristics and requirements. All the semiconductor companies (or their partners[3]) in microcomponents and memory invested in the key IT systems, but the level of impact varied based on the institutional knowledge and the effectiveness of companies in leveraging these investments. In spite of these complexities, key IT applications that improved productivity in the sector shared three common characteristics. First, key productivity-enhancing applications in the semiconductor sector – electronic

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[1] IT refers to software (prepackaged, own account, and custom software), hardware (PC, mainframes, servers), peripherals (storage devices, printers), and communication equipment; refer to the main section for more details. “IT intensity” refers to real IT capital stock per people employed in production.

[2] Microprocessors is a significant part of microcomponents revenues; therefore, it is assumed that the subsector output deflator is equal to that of the MPU output deflator.

[3] “Partners” refers to IP houses for core design blocks, ASIC houses for back-end design and wafer fabrication, and foundries for wafer fabrication.

design automation (EDA) tools, manufacturing automation systems, process control systems, and process diagnostic tools – were vertical applications with a focus on key business processes. Second, they helped build business process and technological capabilities in parallel. Third, they were deployed in concert with business process changes and technical innovations.

Horizontal IT applications, on the other hand, have had minimal impact to date on the sector's performance. For example, due to noncustomized products and long implementation schedules, enterprise resource planning (ERP) failed to deliver sector-wide impact, although individual companies have deployed and seen benefits from some components of ERP systems.

Across microcomponents and memory segments, IT investments can be grouped into a four-tier "value stack." The first and second tiers consist of IT investments that help to design complex chips with greater functionality and integration and to manufacture them with reduced throughput times and faster ramp-up rates, thus accelerating the introduction of newer and higher quality products. All semiconductor companies (or their partners) have invested in first-tier systems and have seen benefits from these investments. Investments in the second tier were made by the majority of larger semiconductor companies in their newer design and production facilities. Due to rapid growth in external demand and large across-the-board productivity improvements in the 1990s, semiconductor companies did not need to rely upon IT to differentiate themselves, and hence made few third and fourth tier investments. As a result, these categories represent forward-looking investments that may in the future yield competitive advantages for some firms, while pushing the sector's performance frontier.

Moving forward, with slower demand growth, semiconductor companies should seek to generate further productivity gains by evaluating their performance along the productivity levers, both against the levers already generally employed across the sector, and along those that still remain to be used. In doing so, companies can likely benefit by considering IT investments to increase their "stack height," that is, to differentiate themselves in the subsegment, where valuable.

IT vendors interested in participating in this space can help in two ways: by collaborating with customers to develop IT systems that impact underutilized productivity levers, and by developing applications for the third tier of the value stack to help customers gain a competitive advantage. In doing so they should ensure that IT improvements continue to co-evolve with advances in material science and business innovation.

INTRODUCTION

The electronic machinery sector (of which the semiconductor sector is a part[4]) experienced strong labor productivity and IT intensity growth in the 1990s. The semiconductor sector was the largest contributor to labor productivity growth in the 1990s and experienced more than 35 times the average annual labor productivity growth rate of the US economy. Labor productivity in semiconductors grew at a 72 percent CAGR from 1993-2000 compared to 2 percent for the overall US economy (Exhibit 1).

This sector is one of a few that both consume and create IT, and its products serve as inputs to several industries including computer manufacturing, telecom, and consumer goods. Productivity improvements in semiconductors have a spillover effect throughout the economy as increased output quality of semiconductor chips flows through other sectors. In this case, the McKinsey Global Institute (MGI) found:

¶ The semiconductor sector contributed significantly to economy-wide productivity growth and acceleration.

¶ Productivity improvements in DRAMs and MPUs were driven by increased customer demand and reduced line widths.

¶ IT as an input played an enabling role in the sector; its role was significant but complex.

¶ Key IT applications that impacted performance in the semiconductor sector shared three general characteristics.

¶ Significant opportunities and challenges exist for semiconductor companies and for IT vendors wanting to participate in this space.

Focus of current project

The semiconductor sector experienced labor productivity growth of 71.6 percent per year from 1993-2000. Change in output quality as measured by the output deflator, and hence change in real value added, drove this labor productivity growth (Exhibit 2).[5] The output deflator in semiconductors can be impacted by a

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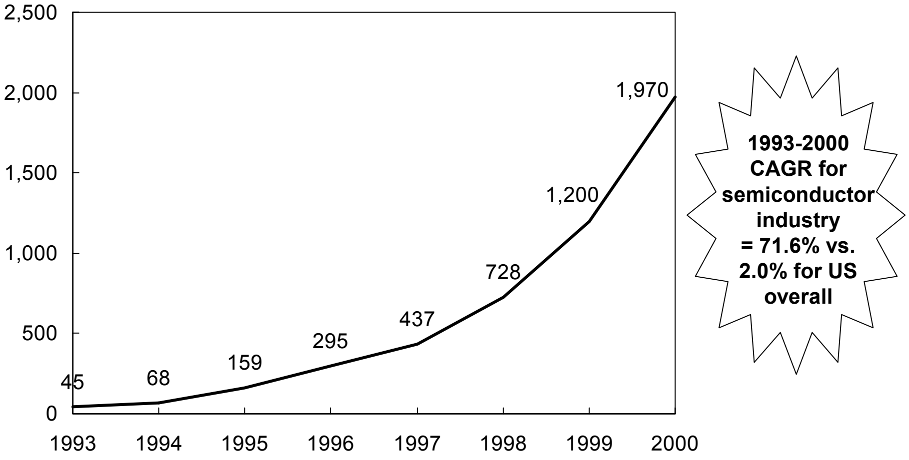
[4] MGI's US Productivity Growth report identified semiconductors as a predominant component of electronic machinery. Hence, we interchangeably use electronic machinery and semiconductors, and the current project focuses only on semiconductors. Data for semiconductor productivity was obtained from the National Bureau of Economic Research (NBER) and the US Census; see appendix for further details.

[5] It is MGI's estimate that outsourcing/offshoring has had minimal impact on the productivity growth. If it is assumed that all the employees in TSMC, UMC, and Chartered were located in US from 1993-2000, productivity growth would have decreased by only 1.3 percent to 70.3 percent (assuming no change in value added).

Exhibit 1

SEMICONDUCTOR SECTOR EXPERIENCED EXPONENTIAL LABOR PRODUCTIVITY GROWTH IN 1990s

Thousands of chained (1996) dollars per PEP



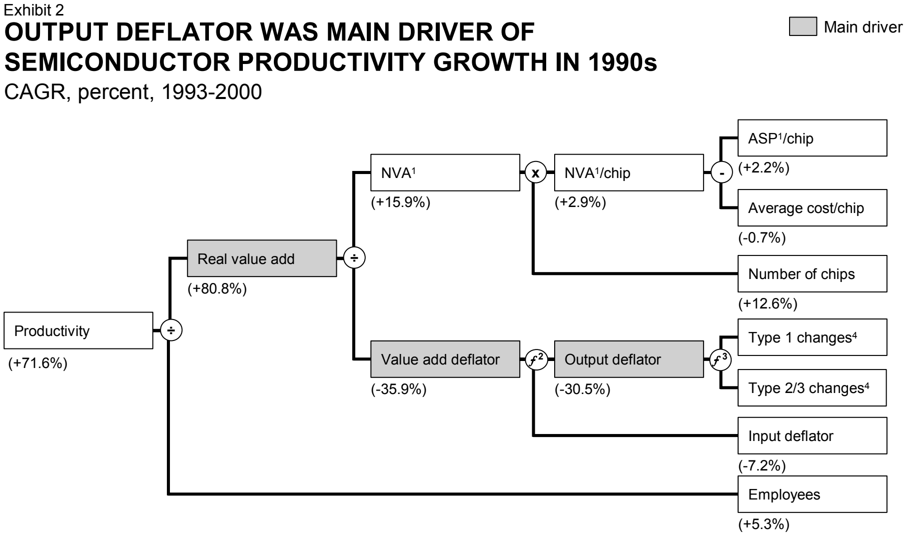
1993-2000 CAGR for semiconductor industry = 71.6% vs. 2.0% for US overall

Source: National Bureau of Economic Research; Bureau of Labor Statistics; Census of Manufacturers

Exhibit 2

OUTPUT DEFLATOR WAS MAIN DRIVER OF SEMICONDUCTOR PRODUCTIVITY GROWTH IN 1990s

CAGR, percent, 1993-2000



[1] ASP = average selling price; NVA = nominal value add
[2] Product calculated using Fisher formula (geometric average)
[3] Output deflator is function of type 1 and type 2/type 3 changes
[4] Type 1, type 2, and type 3 refers to type of quality changes and are semiconductor specific; type 1 changes involve underlying process technology changes, type 2 and 3 changes involve design changes (functional/architectural)

Source: National Bureau of Economic Research; Census of Manufacturing; Bureau of Labor Statistics; IC Insights change in process technology (defined as Type 1 change) and by changes in functionality and architecture (defined as Type 2 and Type 3 changes) in the chip.[6]

Of the various subsectors, microcomponents (of which MPUs are a significant part) and memory (of which DRAMs are a significant part) experienced the highest change in output deflator and demand (Exhibit 3). These two subsectors also accounted for more than half of worldwide semiconductor sales in 2000 (Exhibit 4). Thus, MGI focused on studying MPUs and DRAMs to understand the role of IT in the productivity growth of the semiconductor sector in the 1990s.

Definition and scope of IT for current project

Semiconductors occupy a unique position in the economy. The semiconductor sector (along with computer manufacturing, telecom, and IT services as part of business services) both consumes and produces IT. As an IT producing sector, semiconductors drove, through rapid improvements in product quality, productivity gains in multiple sectors that include them as an intermediate input (e.g., computer manufacturing, telecom, consumer goods, and manufacturing). In other words, increases in the quality of semiconductors affected the quality of the output in other sectors and thus flowed through the various output deflators in the economy.

In addition, IT also played an important role as an input to the semiconductor industry in enhancing labor productivity during the 1990s. This study focuses primarily on the role of IT as an input (e.g., we looked at the extent to which IT as an input helped to drive quality increases in the output).

This study focused on two types of IT inputs – direct and indirect – since both types of IT played a critical enabling role in improving labor productivity (Exhibit 5). “Direct” IT includes hardware (mainframe computers, PCs, storage devices, and peripherals), software (prepackaged, custom, and own-account software), and communication equipment. The study also considered “indirect” IT investments, which include software and hardware that are embedded or bundled as a part of the system (e.g., process control hardware and software in etch equipment in foundries, and inspection hardware and software in AOI). Typically these investments are captured in the BEA instruments category.

SECTOR PRODUCTIVITY

The semiconductor sector was a significant contributor to the US economy’s labor

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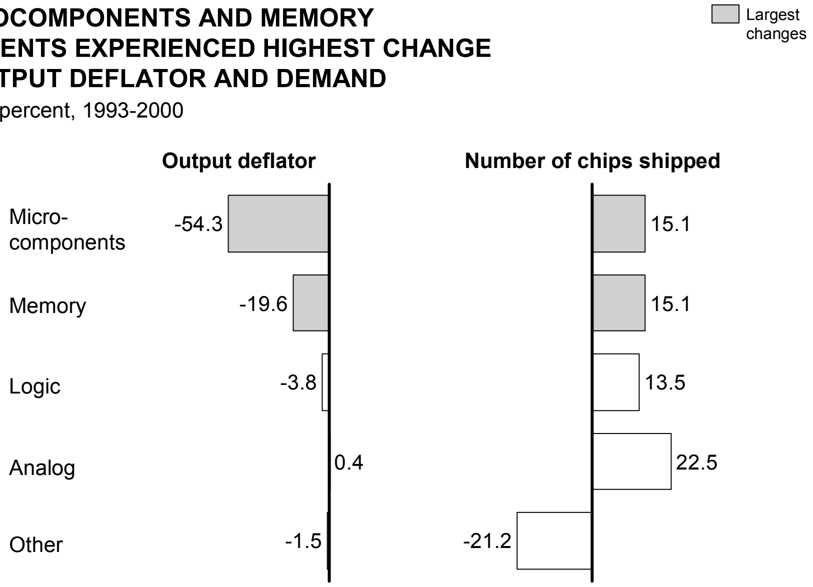
[6] Refer to next section for more details.

Exhibit 3

MICROCOMPONENTS AND MEMORY SEGMENTS EXPERIENCED HIGHEST CHANGE IN OUTPUT DEFLATOR AND DEMAND

CAGR, percent, 1993-2000

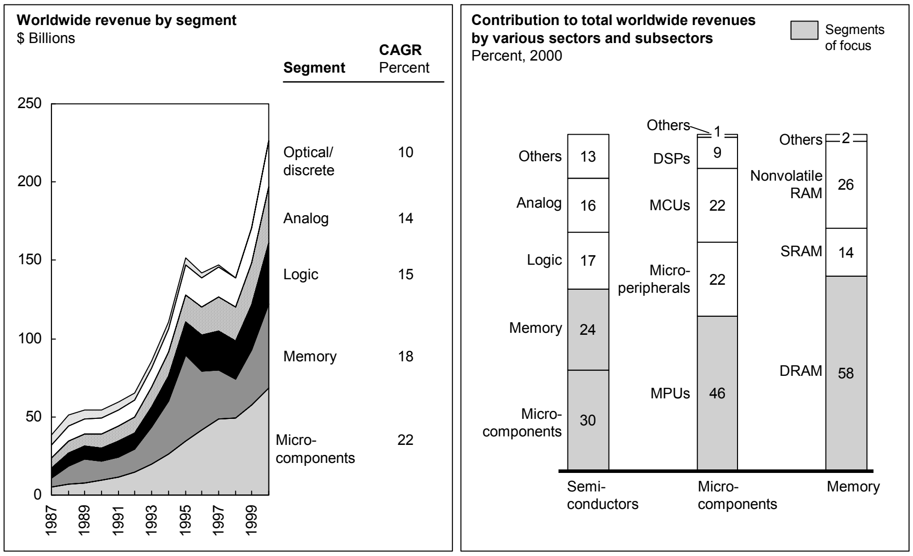


Note: Microprocessor, memory devices, transistors, diodes and rectifiers, and other, deflators from BLS were mapped to the micro-component, memory, logic, analog, and other segments as defined by IC Insights

Source: IC Insights; Bureau of Labor Statistics; MGI analysis

Exhibit 4

MICROCOMPONENTS AND MEMORY SEGMENTS ARE MAJOR CONTRIBUTORS TO SECTOR REVENUES



Worldwide revenue by segment
$ Billions

Contribution to total worldwide revenues by various sectors and subsectors
Percent, 2000

Source: Bureau of Labor Statistics; Dataquest

Exhibit 5

CURRENT PROJECT CONSIDERED “DIRECT” AND “INDIRECT” IT INVESTMENTS

Focus of study

	“Direct”	**“Indirect”**
Description	• Computation hardware and related peripherals, software, and data/voice communication spend made as “main focus”/nonbundled, nonembedded investments	• Computation hardware and related peripherals, software, and data/voice communication spend bundled/ embedded in other types of capital spend
Examples	• Personal computers • Mainframe computers • Direct access storage devices • Computer printers • Computer terminals • Computer tape drives • Computer storage devices • Integrated systems • Prepackaged software • Custom software • Own-account software • Communication equipment	• Embedded process control software/hardware in manufacturing equipment • Embedded software, hardware and related peripherals in metrology equipment
Rationale for focus	• Conventional definition of IT	• Embedded software and hardware help leverage improvements in other types of technology, i.e., material science and process technology

Source: MGI analysis

productivity growth and productivity jump[7] in the 1990s. Semiconductors along with wholesale, securities, retail, computer manufacturing, and telecom contributed to more than 75 percent of net US productivity growth and to more than 80 percent of the net jump in the 1990s.

Sector contribution to economy-wide productivity growth in the 1990s

The semiconductor sector, which represented only 0.18 percent of private employment and contributed to 0.48 percent of nominal GDP in 1993, was the biggest contributor to labor productivity growth over the 1990s, accounting for 20[8] percent of the growth (Exhibit 6).

Sector contribution to economy-wide productivity growth acceleration in the late 1990s

In MGI's US Productivity Growth report,[9] semiconductors was one of the six sectors that contributed to 99 percent of the net, economy-wide productivity jump. Productivity acceleration in semiconductors was predominantly driven by output quality as measured by the output deflator. The primary causes of the productivity acceleration in the microprocessors subsegment were twofold: heightened competitive intensity attributable to the "race" between AMD and Intel to have the fastest chip on the market, and technological innovation in process technology, which reduced throughput time for new chips and facilitated the firms' decision to shorten product life cycles (or to release new products more frequently).

The previous report's findings remained unchanged when updated with now-available 2000 data.[10] Electronic machinery continued to be a major contributor to the economy-wide acceleration in productivity growth. While contributing only 3 percent of US nominal GDP in 1995, electronic machinery contributed a full 11 percent of the acceleration in productivity growth in 1995-2000 (Exhibits 7a and 7b). Productivity acceleration in semiconductors also continued to be driven by changes in the value-added deflator. Interestingly, with the release of new economic data, the change in the value-added deflator (and hence real value

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[7] "Jump" is defined as the difference between the productivity growth in two time periods.

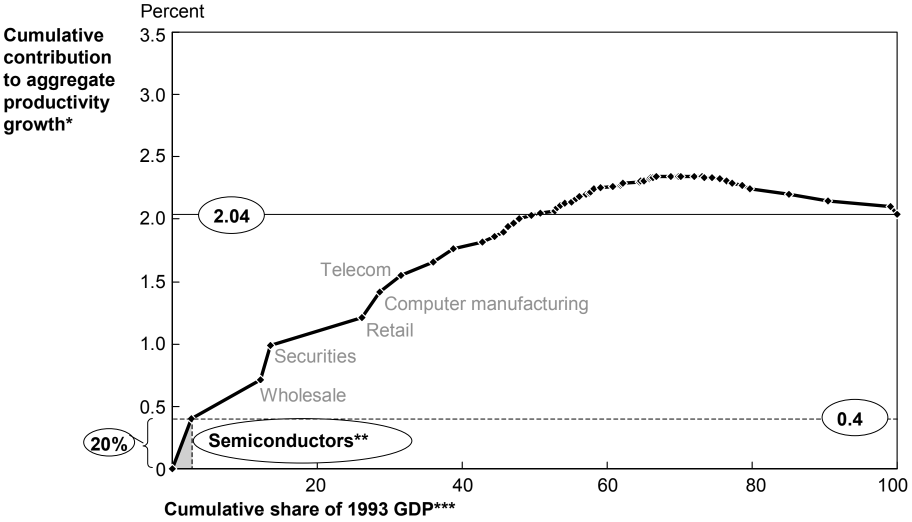
[8] Contribution of the electronic machinery sector overall, not semiconductor subsegment alone

[9] MGI "US Productivity Growth 1995-2000, Understanding the Contribution of Information Technology Relative to Other Factors," released October 2001.

[10] See appendix to this report for details.

Exhibit 6

SEMICONDUCTORS WAS THE BIGGEST CONTRIBUTOR TO US LABOR PRODUCTIVITY GROWTH IN THE 1990s



* CAGR from 1993-2000; does not include farm and government sectors; real estate and holdings contribution evenly divided among sectors excluding top 6

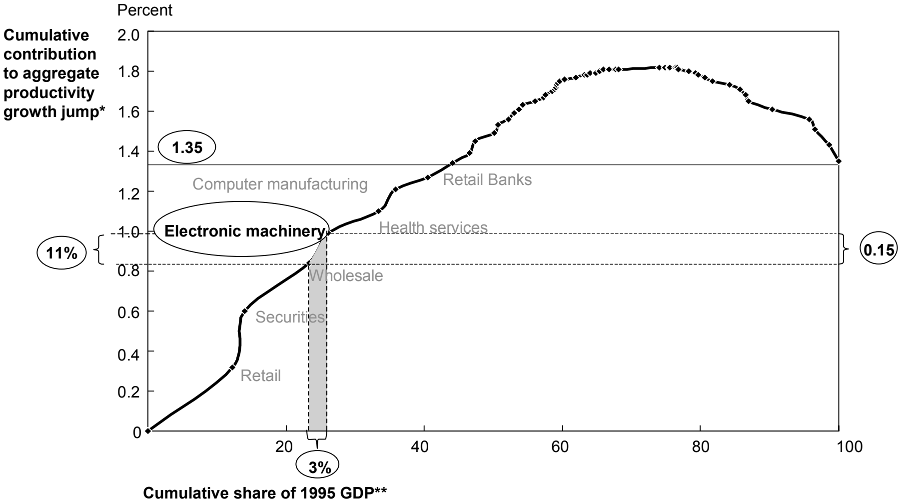
** MGI's US Productivity Growth report identified semiconductors and computer manufacturing as the predominant (by contribution to growth) subsectors of electronic machinery and industrial machinery; thus the sector and the corresponding subsector are used interchangeably in this chart

*** Does not include farm, government, holdings, and real estate sectors

Source: Bureau of Economic Analysis; MGI analysis

Exhibit 7a

ELECTRONIC MACHINERY MADE A DISPROPORTIONATE CONTRIBUTION TO JUMP IN 1995-2000



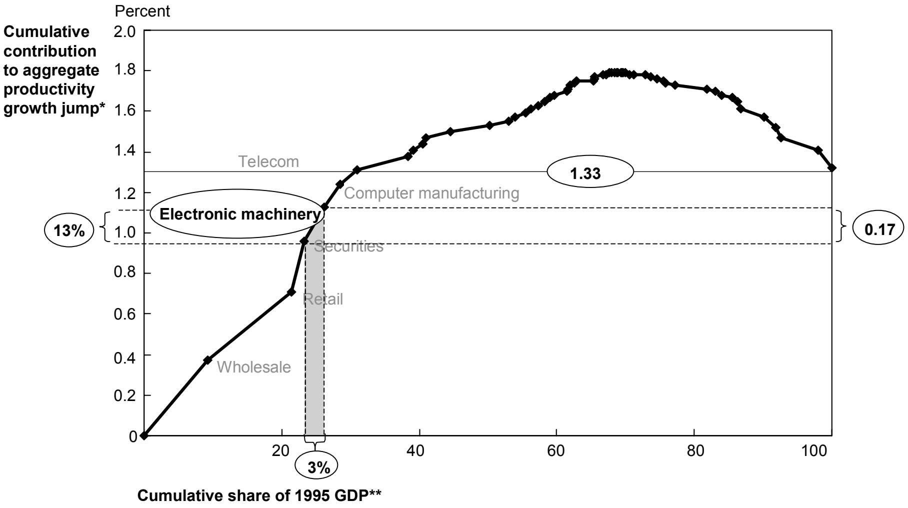
* Jump is defined as difference between 1995-2000 CAGR and 1987-95 CAGR; does not include farm and government sectors; real estate and holdings contribution evenly divided among sectors excluding the top 6

** Does not include farm, government, real estate, and holdings sectors

Source: Bureau of Economic Analysis; MGI analysis

Exhibit 7b

2001 MGI REPORT ALSO SHOWED ELECTRONIC MACHINERY'S DISPROPORTIONATE CONTRIBUTION TO JUMP IN 1995-99



* Jump is defined as difference between 1995-99 CAGR and 1987-95 CAGR; does not include farm and government sectors; real estate and holdings contribution evenly divided among sectors excluding the top 6

** Does not include farm, government, real estate, and holdings sectors

Source: Bureau of Economic Analysis; MGI analysis

added) is even more significant than it was in the original report[11] (Exhibits 8a and 8b). The productivity jump in microprocessors can still be attributed to high absolute levels of demand, technological innovations in reducing line widths, and increased competitive intensity between AMD and Intel (Exhibit 9).

PRODUCTIVITY IMPROVEMENTS IN MPUs AND DRAMs

A reinforcing cycle drove productivity improvements in MPUs and DRAMs in the 1990s. This continuous cycle involved external demand for higher-quality chips from the PC market, increased capability to manufacture chips at reduced line widths (leading to better quality), and increased capability to design chips at lower line widths (leading to better functionality and integration) (Exhibit 10). However, it is not possible to name any one of these factors as the initiator of the productivity growth.

¶ **External demand.** Increased demand for PCs, and especially for PCs priced under $1,000 per unit, played a critical role in increasing demand for higher-quality, low-cost chips. In the US, PC penetration per individual increased from about 20 percent in 1990 to approximately 60 percent in 2000, while sub-$1,000 PC penetration went from 0 percent to 20 percent from 1997 to 2001 (Exhibit 11).

¶ **Capability to manufacture at lower line widths**. Advances in material science and process technologies offered manufacturers the capability to produce higher-quality chips at lower unit cost (Moore's law[12]), while cost advantages of lower line widths[13] and competitive dynamics made capital upgrades to lower line widths very compelling. For example, investment in foundries that could manufacture to lower line widths was driven by Intel's desire to have the fastest chip on the market at any given time, and adoption in the DRAM subsector was driven by the desire of DRAM players to become the lowest cost producers and to gain market share in a commodity market.

¶ **Capability to design at lower line widths.** Advances in design tools allowed firms to take advantage of the ability to manufacture at lower

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[11] The other significant change is the jump in the growth rate of employees; initial indications are that the industry accelerated its hiring significantly in 2000, just at the end of the boom, a common pitfall in cyclical industries. See appendix for details.

[12] Moore's law predicts that the number of transistors per unit area will double approximately every 18 months.

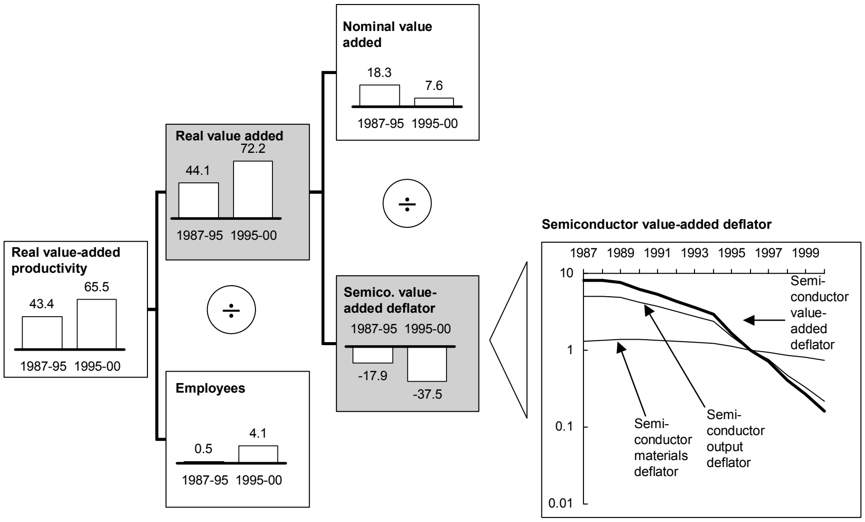
[13] Manufacturing chips at lower line widths yields more chips for the same wafer size, thus reducing cost per chip.

Exhibit 8a

VALUE-ADDED DEFLATOR WAS MAIN DRIVER OF SEMICONDUCTOR PRODUCTIVITY JUMP IN 1995-2000

▨ Primary driver

CAGR, percent



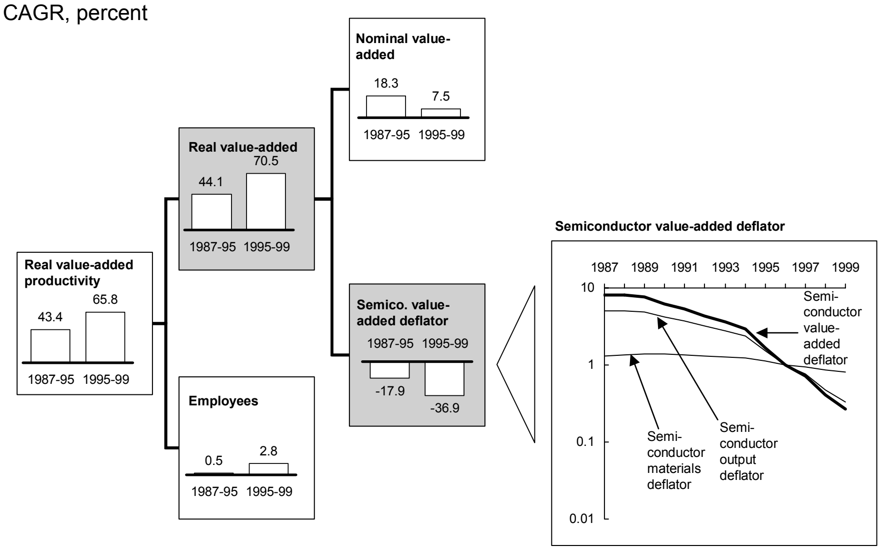
Source: Bureaus of Labor Statistics; Census of Manufacturing; National Bureau of Economic Research; McKinsey analysis

Exhibit 8b

2001 MGI REPORT ALSO SHOWED VALUE-ADDED DEFLATOR WAS MAIN DRIVER OF SEMICONDUCTOR PRODUCTIVITY JUMP IN 1995-99

▨ Primary driver

CAGR, percent

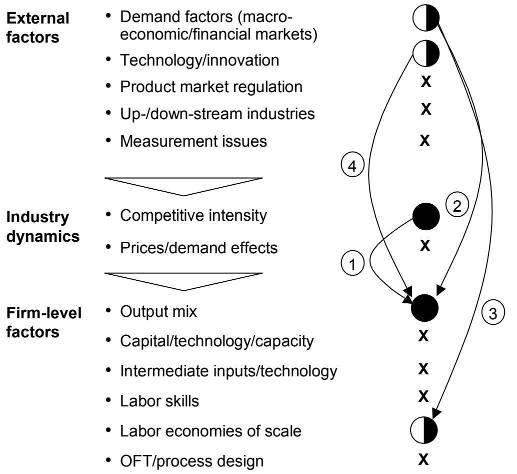


Source: Bureau of Labor Statistics; Census of Manufacturing; National Bureau Economic Research; McKinsey analysis

Exhibit 9

COMPETITIVE INTENSITY AND DEMAND WERE CAUSAL FACTORS FOR SEMICONDUCTOR INDUSTRY PRODUCTIVITY JUMP

● Important (>50% of acceleration)
◑ Somewhat important (10-50% of acceleration)
○ Not important (<10% of acceleration: asterisk to right indicates significant negative)

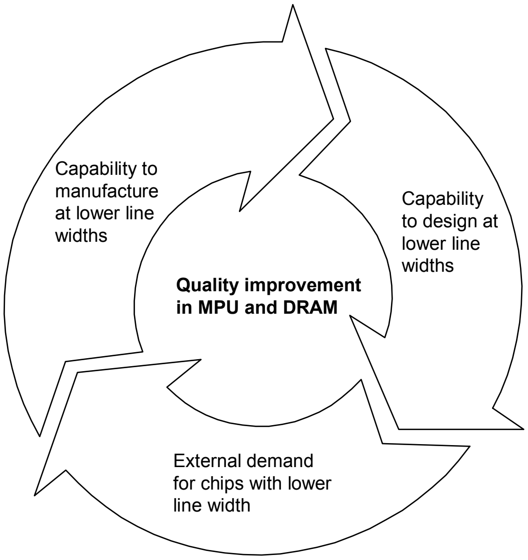


1. A surge in competitive intensity from AMD pushed Intel to more frequently release new chips such that, at any given time, Intel had the highest-performing chip on the market
2. High absolute levels of demand (in part from increased penetration) as well as demand specifically for high-performing chips (in part from upgrading behavior) shifted the output mix toward the "cutting edge"
3. High demand allowed microprocessor manufacturers to amortize R&D and other fixed labor costs more quickly
4. Technological improvements in both the semiconductor manufacturing equipment and in the wafer inspection/yield management industries shortened the time to profitable production yields and facilitated firms' decisions to shorten the product life cycle (or to release new products more frequently)

Source: MGI "US Productivity Growth 1995-2000" report, released October 2001

Exhibit 10

SELF-REINFORCING CYCLE DROVE PRODUCTIVITY IMPROVEMENTS IN DRAMs AND MPUs

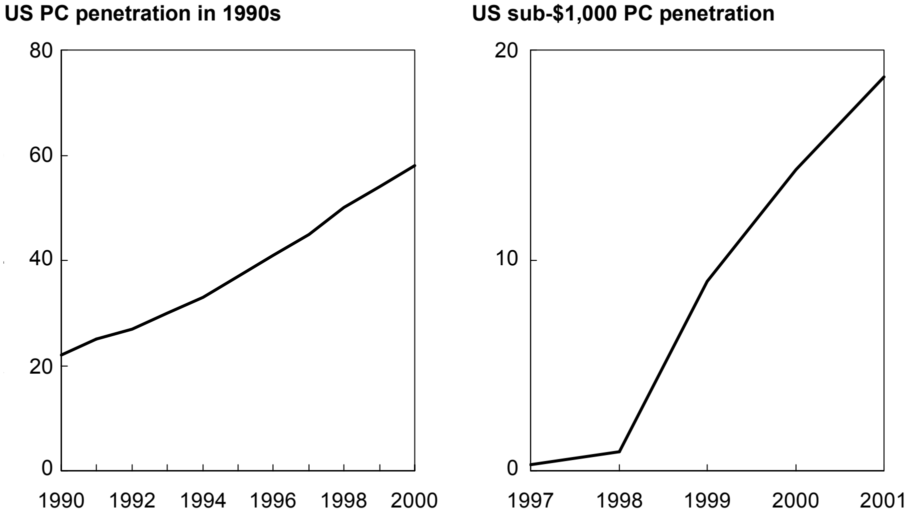


Source: MGI analysis

Exhibit 11

US PC PENETRATION, ESPECIALLY SUB-$1,000 PC PENETRATION, INCREASED SIGNIFICANTLY

Percent



Source: Computer Almanac; IDC; MGI analysis line widths and enabled design of higher-quality chips due to higher availability of gates per unit area.[14]

Drivers of output quality in MPUs and DRAMs

Improvements in output quality can be decomposed into three types of quality changes.[15] The first type, primarily, drove output quality during the 1990s.

¶ **Type 1 changes.** Type 1 changes are attributable to underlying process technology and not a change in architecture or functionality. This typically results in both lower unit cost and better quality (e.g., better functionality). Line width reduction is a major driver of Type 1 changes.

¶ **Type 2 changes.** Type 2 changes come from new functionality, not including core logic redesign. For example, the change from Intel Pentium® to the Intel Pentium® MMX would be a Type 2 change. This change typically results in better quality but has only a marginal impact on unit cost.

¶ **Type 3 changes.** These changes come from a fundamental shift in product architecture or core logic of the chip, typically resulting in better quality but at a higher unit cost relative to the previous generation. For example, the change from the 486 chip to Intel Pentium® would be a Type 3 change. Type 3 changes usually result in a discontinuous advance such as a new platform architecture.The change in the output deflator cannot be systematically and numerically allocated to Type 1, Type 2, and Type 3 changes because in a concentrated market such as MPUs, nominal prices can drop significantly with no change in quality for competitive and mass market adoption reasons. The lower price would affect the output deflator. This is also true for the DRAM market, which is a commodity market where nominal prices can drop when new capacity comes on-line. However, interviews with industry experts indicated that quality improvements (which were driven by reduction in line widths) were the predominant drivers of the output deflator in the 1990s. Analysis of line width reductions in MPUs and DRAMs indicates that both these subsectors experienced very strong Type 1 change (Exhibit 12). This further supports the conclusion that line width reduction was the major driver of the output deflator in the past decade.

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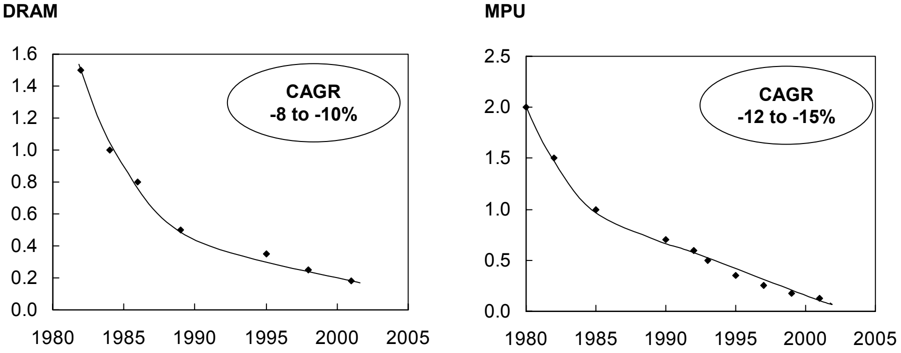
[14] But these advances did not keep pace with process technology advances, causing the “design gap”; see Exhibit 17 in this section for more details.

[15] For more details, see “An alternative methodology: valuing quality change for microprocessors in the PPI,” by Mike Holdway of Bureau of Labor Statistics.

Exhibit 12

MPUs AND DRAMs EXPERIENCED EXPONENTIAL REDUCTION IN LINE WIDTHS

Reduction in line width over time
Microns



Source: Merrill Lynch report – Nov 1999; ITRS 1998; IC Insights; MGI analysis

ENABLING ROLE OF IT

The semiconductor sector is one of several sectors (including healthcare, telecom, and aerospace) that experienced constant technological innovation, resulting in improved quality of product offerings in the past decade. Across sectors, IT played a critical enabling role in leveraging and commercializing these technological innovations. For firms, the level of impact from the various IT investments depended on a firm's strategy, its execution, its business processes, and the institutional knowledge within the company required to take advantage of the investments. IT alone did not offer a competitive advantage but, when complemented with good business decisions, IT enabled firms to significantly improve their performance. For example at Intel, IT investments in design and manufacturing complemented their strategy (e.g., the decision to exit the DRAM business to focus on MPUs), execution (excellent marketing has made the Intel® brand the world's fourth most powerful brand[16]), and institutional knowledge to make Intel the world's largest semiconductor company and the world leader in MPUs.

Overview of business processes and key IT components

Critical IT applications enabling reductions in line widths, improvements in functionality and integration, and increases in labor productivity in MPUs and DRAMs were sector-specific and impacted key business processes.

A typical semiconductor company (and its partners) has three business processes (Exhibit 13a):

¶ **Design.** The design process includes all aspects of the chip design such as front-end design (i.e., design specification, logic simulation, and synthesis) and back-end design (place and route, formal verification, and final synthesis).

¶ **Manufacturing.** Manufacturing entails front-end planning (e.g., raw materials procurement and production scheduling), front-end wafer fabrication (e.g., wafer processing,[17] inspection), and back-end wafer fabrication (e.g., dicing, bonding, encapsulation, and testing).

¶ **Central functions.** This includes all functions to ensure continuous, smooth operations of a semiconductor company.

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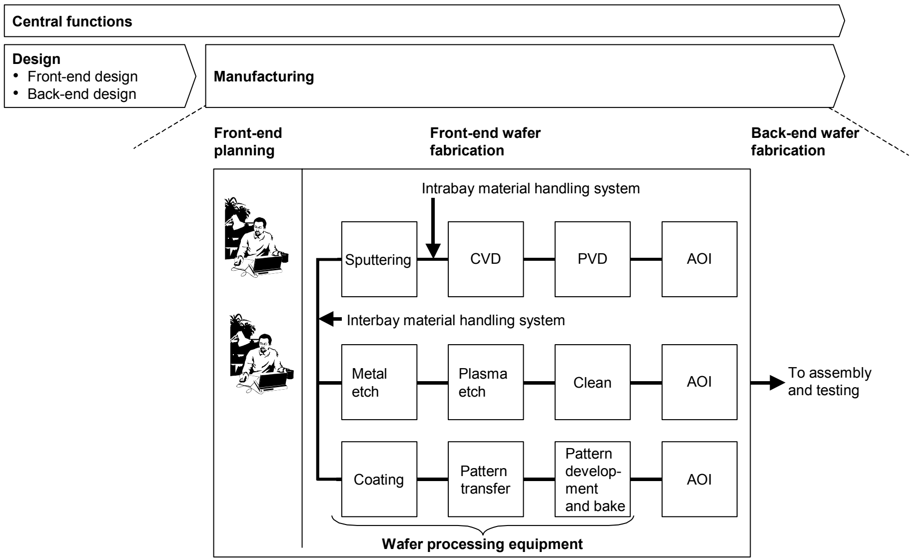
[16] Interbrand 2000 ranking.

[17] Wafer processing involves several steps such as epitaxial layer formation, chemical-mechanical planarization (CMP), oxidation, chemical vapor deposition (CVD), plasma vapor deposition (PVD), lithography (coating, pattern transfer, pattern development, and bake), etch, and ion implantation.

Exhibit 13a

BUSINESS PROCESSES IN SEMICONDUCTOR SECTOR

ILLUSTRATIVE



Source: MGI analysis

Mapping potential IT investments across these business processes, IT investments can be grouped into five bundles (Exhibit 13b):

1. **Design tools** are software and associated hardware that automate design processes and provide the ability to design complex chips (better functionality and integration) relatively faster.
2. **Manufacturing automation systems** are automated wafer handling systems and flow management software to reduce human handling and to increase operational efficiency in the fab; these systems include both manufacturing execution systems (MES) and manufacturing control systems (MCS)/automatic material handling systems (AMHS).
3. **Process control systems** are software and hardware to control process steps within the wafer processing equipment.
4. **Process diagnostic tools** are test equipment and software to track and respond to defects and problems in the wafer manufacturing production line.
5. **Support IT systems** include central and corporate IT systems to support various activities in the enterprise; they include infrastructure systems (e.g., network management, storage systems, security) and various horizontal applications.

Impact of key IT systems on performance levers

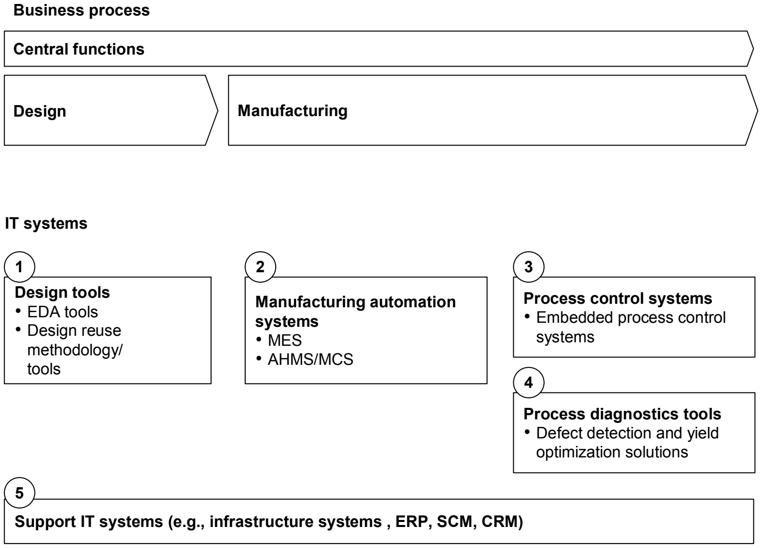
Across both the MPU and DRAM subsectors IT investments helped increase sector asset utilization and sector labor efficiency (Exhibit 14). For example, across subsectors, process control systems played a critical role in realizing improvements in material science and process technology, and MES streamlined material and paper flow within a fab. In MPUs, EDA tools and process diagnostics tools played a key role in reducing the design and production throughput times for new, higher-quality products thus reducing their time to market. Reducing time to market consequently increased the value of the existing portfolio by increasing the fraction of new value-added products.

However, key IT systems impacted different productivity and profitability levers within the subsectors due to the variation in subsector characteristics and requirements. For example in MPUs, where it is important to have the fastest chip in the market and customers are willing to pay a higher price for the “hottest” product, IT helped develop new products to enhance revenue, and they helped reduce time to profitable yield, increasing asset utilization. On the other hand in

Exhibit 13b

IT SYSTEMS IN THESE BUSINESS PROCESSES CAN BE GROUPED INTO 5 BUNDLES

ILLUSTRATIVE



Business process

Central functions

Design

Manufacturing

IT systems

① **Design tools**
- EDA tools
- Design reuse methodology/ tools

② **Manufacturing automation systems**
- MES
- AHMS/MCS

③ **Process control systems**
- Embedded process control systems

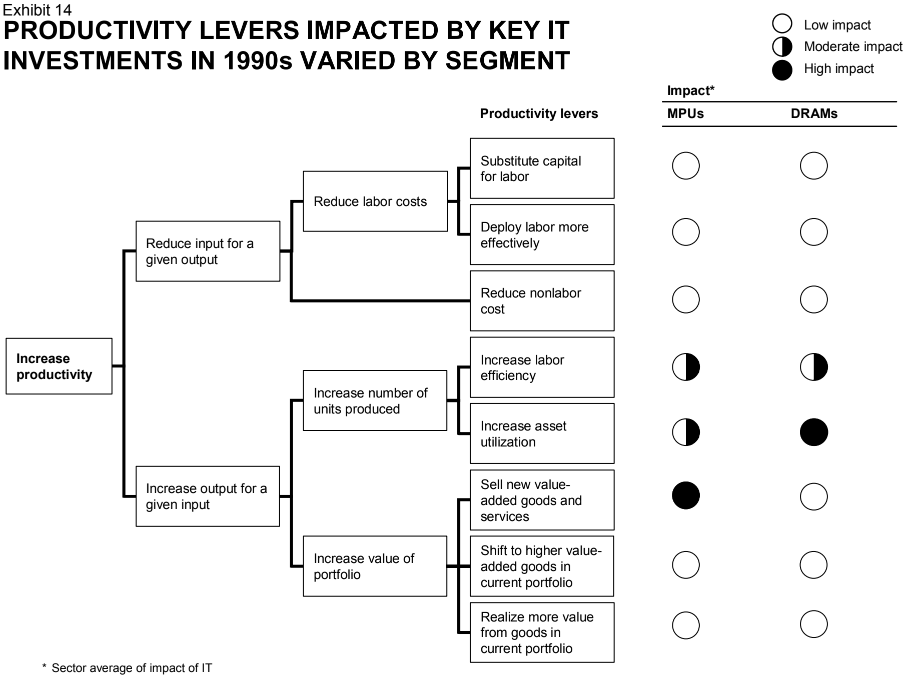
④ **Process diagnostics tools**
- Defect detection and yield optimization solutions

⑤ **Support IT systems (e.g., infrastructure systems , ERP, SCM, CRM)**

Source: MGI analysis

Exhibit 14

PRODUCTIVITY LEVERS IMPACTED BY KEY IT INVESTMENTS IN 1990s VARIED BY SEGMENT



○ Low impact
◐ Moderate impact
● High impact

				Impact*	
			Productivity levers	**MPUs**	**DRAMs**
Increase productivity	Reduce input for a given output	Reduce labor costs	Substitute capital for labor	○	○
			Deploy labor more effectively	○	○
			Reduce nonlabor cost	○	○
	Increase output for a given input	Increase number of units produced	Increase labor efficiency	◐	◐
			Increase asset utilization	◐	●
		Increase value of portfolio	Sell new value-added goods and services	●	○
			Shift to higher value-added goods in current portfolio	○	○
			Realize more value from goods in current portfolio	○	○

* Sector average of impact of IT

Source: Interviews; MGI analysis

the cost-conscious DRAM subsector, IT helped increase asset utilization and labor efficiency and thus helped reduce unitized fixed costs.

For the most part, there was a direct relationship between improvements in productivity and profitability. For instance, a decrease in unit fixed costs (creating a decrease in the ratio of manufacturing costs to revenues), was affected to a great extent by better fab utilization in MPUs and DRAMs. Similarly, increasing the value of the existing portfolio in MPUs increased revenues and ratio of revenues to PP&E (plant, property, and equipment) in this subsector (Exhibit 15).

Relationship between critical IT investments and subsector characteristics

The critical business processes vary by subsegment and thus the relative importance and role of each IT "bundle" depends on the subsector requirements and characteristics (Exhibit 16).

- ¶ The DRAM subsegment is largely a commoditized market, and firms in this space have huge fixed costs and are price takers. Hence this segment is primarily focused on increasing throughput and on reducing unit costs. Operational effectiveness (and thus process capabilities) is critical in reducing unit fixed costs and maintaining a low cost structure, elements essential to surviving and competing in this market. Consequently, the critical IT investments that drove productivity in this subsector are process control systems, process diagnostics tools, and manufacturing automation solutions.
- ¶ The MPU subsegment has differentiated products as well as customers who are willing to pay a premium for new, higher-quality products. Hence this segment is more focused on revenue maximization. In this market, design superiority and enhanced manufacturing capabilities are critical to gaining a first mover's advantage and thus a competitive advantage. The key IT investments are EDA tools, process control systems, process diagnostics tools, and manufacturing automation solutions

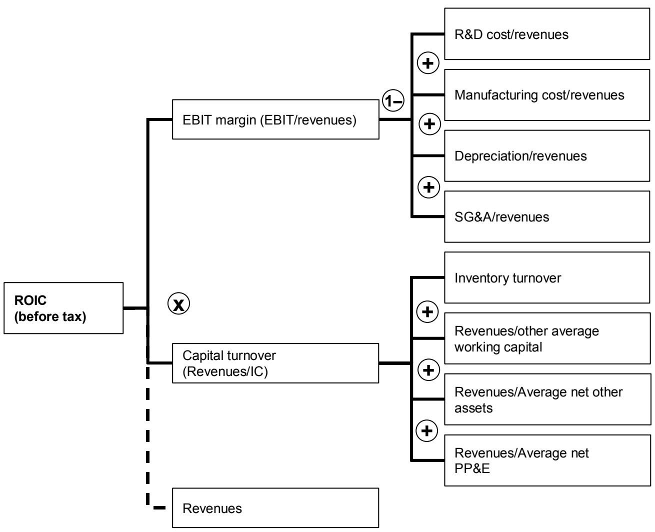
IT architecture in semiconductor sector

Semiconductor companies have deployed IT across their value chain. At a sector level, vertical IT investments have played a critical enabling role in design and wafer processing, but horizontal applications have had limited impact to date.

Exhibit 15

IT IMPACTED DIFFERENT PROFITABILITY LEVERS ACROSS SUBSEGMENTS IN THE 1990s

++ High impact
+ Medium impact
0 No impact



	Impact*	
Levers	MPUs	DRAMs
R&D cost/revenues	+	0
Manufacturing cost/revenues	++	++
Depreciation/revenues	0	0
SG&A/revenues	0	0
Inventory turnover	+	+
Revenues/other average working capital	0	0
Revenues/Average net other assets	0	0
Revenues/Average net PP&E	++	+
Revenues	++	+

* Sector average of impact of IT
Source: Interviews; MGI analysis

Exhibit 16

SUBSECTOR CHARACTERISTICS AND REQUIREMENTS DETERMINE CRITICAL IT INVESTMENTS

	DRAMs	MPUs
Sector characteristics	• Commodity market with no product differentiation • Firms are price takers, and prices drop as more production capacity comes on-line • Competitive advantage gained from improved process capabilities	• Market with perceived differentiated products with accelerated new products introduction • Customers willing to pay for higher quality products and market rewards reduced throughput time for new chips • Competitive advantage gained from improved design capabilities
Sector requirements	• Sector requires low cost structure and operational effectiveness to compete effectively • Sector dynamics demand reducing unitized fixed costs and labor costs by better asset utilization and improved labor efficiency	• Sector values reduced time to market for new products and hence requires faster ramp-up rates • Sector requires exponential quality increase in products
Key IT investments	• Process control systems • Process diagnostic tools • Manufacturing automation systems	• Design reuse methodology/tools • Process control systems • Process diagnostic tools

Source: Interviews; MGI analysis

Role of IT in design

In the past 10 years, process innovations sharply increased the available gate per unit area due to reductions in line widths. This allowed higher quality chips with more functionality and integration (and thus increased performance) to be designed at a constant or lower price. EDA tools have helped increase the number of gates that can be designed per unit area. They have, however, been unable to match improvements in process technology, and thus have not been able to fully utilize the total gates available for design, resulting in a "design gap" (Exhibit 17). Companies such as Cadence, Synopsys/Avant!, and Mentor Graphics offer EDA tools. In spite of this limitation, the design gap would have been much wider if EDA tools had not continued to improve.

In particular, EDA tools helped in three areas. First, they helped in designing semiconductors at an increasing level of abstraction (Exhibit 18).[18] In the early 1990s, semiconductors were designed at the gate level; however, by 1993, register transfer level (RTL) design had become mainstream; now, behavioral design has become mainstream. This higher level of abstraction has improved design productivity by 200 to 750 percent (Exhibit 19). In turn, the increasing level of abstraction played a key role in reducing "real" design time – chip design time adjusted for increasing complexity. "Nominal" time, the actual time it takes to design a chip, has increased due to the increased complexity of chip design, but at a much lower rate than warranted. In a sample ASIC design (Exhibit 20), EDA tools helped to reduce design time by more than 90 percent in design specification, synthesis, and formal verification, and to reduce design time for logic simulation by 69 percent and for place and route by 23 percent. Impact of the EDA tools on the various design steps is uneven because the computing effort for simulation and place and route increases exponentially with gate design, but does so linearly for other steps.

Second, improved accuracy in the design tools reduced the number of prototypes, which reduced overall development costs and time to market for a new design.

Third, EDA tools helped leverage improvements in process innovations that reduced the line widths. The tools were needed for updating libraries and for generating new masks when chips designed for the older line widths needed to be produced in a newer foundry running the new lower line widths.

Role of IT in wafer processing

Improvements in process technology have been a key driver of the exponential reduction in line widths in semiconductors (for example, line widths in DRAMs

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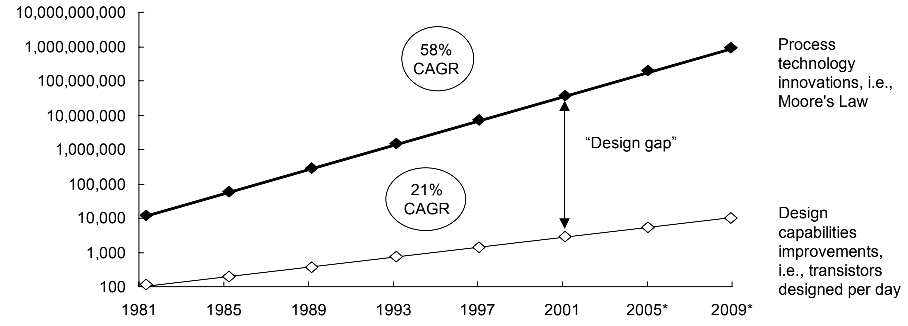
[18] Designing at a higher level of abstraction refers to the ability to design more at a conceptual level.

Exhibit 17

IMPROVEMENTS IN DESIGN CAPABILITIES HAVE NOT KEPT PACE WITH PROCESS TECHNOLOGY INNOVATIONS

ASIC EXAMPLE

ASIC design productivity shortfall
Logic transistors



Estimated time taken for design team to complete a design version** Years	0.06	0.16	0.5	1.4	4.0	12.0	34.0	98.0

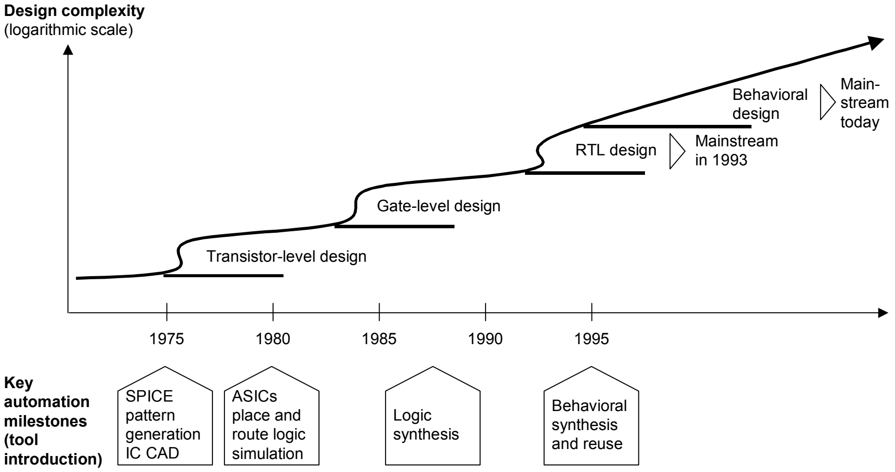
* Forecast

** Assuming a 6-person design team

Source: Sematech; McClean Report, 2002; MGI analysis

Exhibit 18

EDA ENABLED DESIGN AT AN INCREASING LEVEL OF ABSTRACTION



Source: MGI analysis

Exhibit 19

NEW EDA METHODS IMPROVED DESIGN PRODUCTIVITY BY 200-750%

EXAMPLE

Productivity comparison
Working days

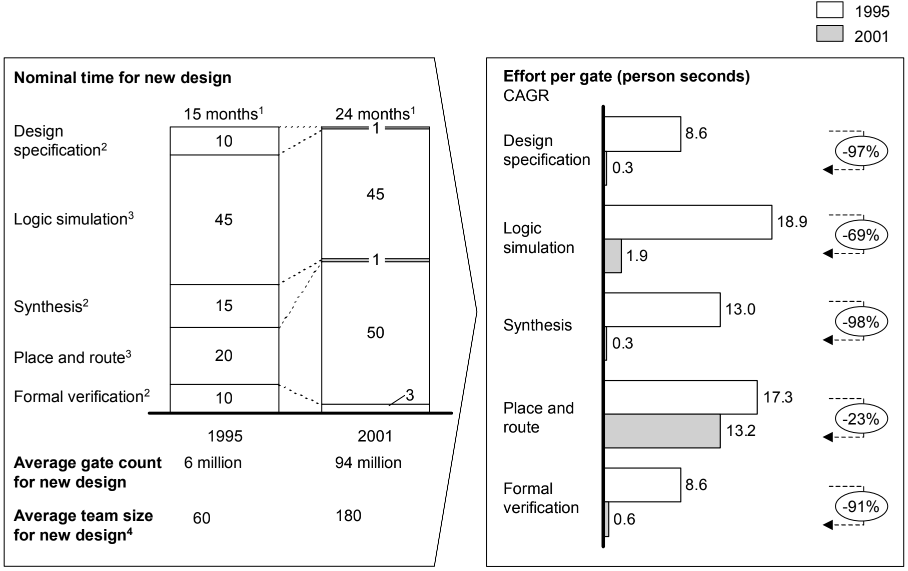
	Design methodology		
Application	**RTL synthesis**	**Behavioral synthesis**	**Productivity improvements** Percent
• ATM cell scheduler	30	10	300
• Graphics processor	60	15	400
• Satellite DSP	400	180	220
• MPEG 2-color converter	60	10	600
• Disk drive controller	15	2	750

Source: Synopsys; MGI analysis

Exhibit 20

EDA TOOLS HELPED REDUCE “REAL” DESIGN TIME

ASIC EXAMPLE



1 Average time for new design based on prevalent process technology (250 nm in 1995, 130 nm in 2001)
2 Computing effort (e.g., computer time spent to calculate power consumption) scales roughly linearly with gate count
3 Computing effort (e.g., computer time spent in checking for timing violations) scales nonlinearly with gate count
4 Design team sizes have tripled in the past 10 years

Source: MGI interviews; McClean Report

reduced by a factor of eight from 1.5 microns in 1982 to 0.18 microns in 2001), and hence of increased productivity in semiconductors. IT has played an important role in enabling and leveraging these improvements. The critical IT systems in manufacturing are manufacturing automation systems, process control systems, and process diagnostic tools.

Manufacturing automation systems. These systems include manufacturing execution systems (MES) and material control systems/automatic material handling systems (MCS/AHMS). Offerings such as PROMIS and FACTORYworks from Brooks-PRI and WorkStream from Applied Materials are examples of MES available in the market today. Companies such as Brooks-PRI and Asyst offer MCS. In the 1990s, MES played a key role in streamlining material and paper flow and in reducing human handling within a fab. These developments reduced human errors, and equipment and labor idle time, thus increasing the operational efficiency of a fab. MCS, which automated movement of wafers between various processing equipment, provided some incremental benefits in performance, but its effect on sector productivity was moderate. The reasons for the moderate impact are: MCS had not reached 100 percent penetration in the industry; incremental benefits, in addition to MES, were marginal; and wafer processing and variability in the process, not the actual movement of wafers between equipment, were the critical bottlenecks for improved performance.

Going forward, AMHS is expected to be more widely deployed as 300 mm wafers become mainstream. AMHS will be needed given the bigger size of 300 mm wafers; a typical 300 mm wafer carrier can weigh 10 kilograms/22 pounds, and for health and safety reasons cannot be handled manually. In the future, AHMS can be expected to impact performance by increasing foundry utilization and by enhancing labor efficiency in the fabs.

Process control systems. Process control systems include embedded software and hardware in the various wafer-processing equipment (embedded hardware and software in etch equipment from Applied Materials, Lam Research, Tokyo Electron, etc., are examples of process control systems). Indirect IT systems in this equipment were critical to realizing improvements in process technologies by helping maintain tighter process specifications through closed-loop, real-time process control.

Process diagnostics tools. Process diagnostic tools include automatic optical inspection (AOI) equipment for mask, reticle, and wafer inspection, and yield optimization software. Automatic test equipment (ATE) is not considered part of process diagnostics since they test the finished product and are considered necessary investments for quality control in end products.

In the 1990s, indirect IT systems played a critical role in increasing the detection sensitivity of the inspection equipment, while direct IT systems such as improved computation software and faster computers have helped convert inspection data into intelligent and enhanced decision support information. This advancement is of particular importance when newer technologies are introduced. Manufacturing to reduced line widths results in new kinds of defects – imperfections that do not affect the quality of the finished product at a greater line width could become material at reduced line widths, and this requires more sensitive and sophisticated testing and analysis. Also, as process technology continues to mature, these advancements are still critical for maintaining and improving yields. In the 1990s they helped improve time to profitable yield, thereby reducing throughput times. For example, the time for 5,000 wafer starts per week reduced from 36 months for 0.80 microns to less than 12 months for 0.13 microns (Exhibit 21).

Role of horizontal applications

Enterprise resource planning (ERP), supply chain management (SCM), and customer relationship management (CRM) are the three main horizontal applications that were widely deployed in the semiconductor sector in the 1990s. To date, these applications have had relatively little impact on the productivity of the sector as a whole. However, as the sector faces more challenging external demand conditions, and as leading firms continue experimenting with these applications, they may grow in importance and impact.

ERP software that allows enterprises to automate or outsource support and administrative functions has had minimal impact on productivity to date. The sector has not experienced significant reductions in the labor pool of support and administrative staff (Exhibit 22), and semiconductor companies have not reported great improvements[19] in their back-end operations. The lack of impact can be attributed to three causes: lack of customization around basic business processes, late adoption in the sector, and long implementation schedules. Going forward, as the industry faces an economic downturn, ERP could play a role in improving operational effectiveness and in reducing costs by automating support functions and reducing the number of employees.

SCM applications that manage the flow of materials and information between fabs, suppliers, and planners have had minimal impact to date for two reasons. First, semiconductors have a relatively simple supply chain (silicon and a limited number of chemicals for raw materials), and a small number of SKUs, so supply chain management software is not critical. Second, there is little interoperability and collaboration between suppliers and semiconductor companies. Going forward, SCM could play a role in improving productivity due to features such as availability to promise and capacity to promise (ATP/CTP), which can reduce

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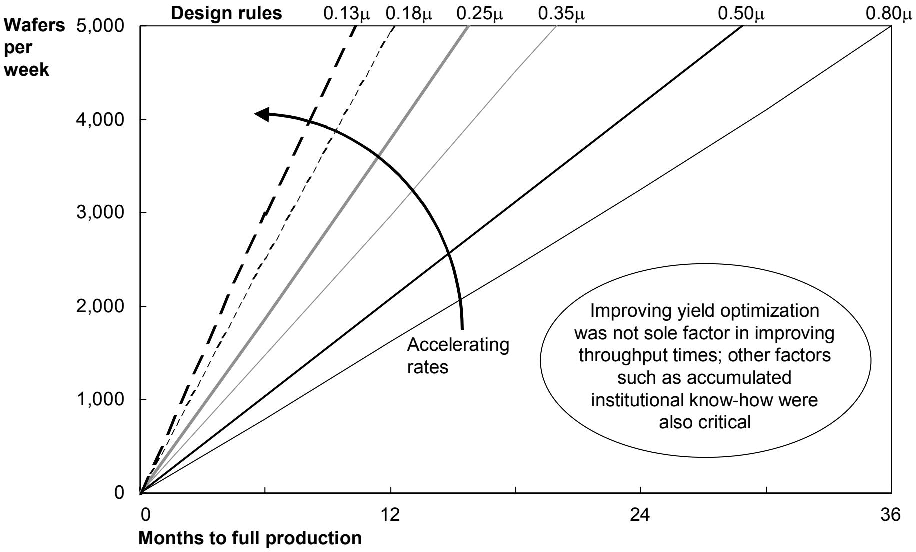
[19] Customer interviews.

Exhibit 21

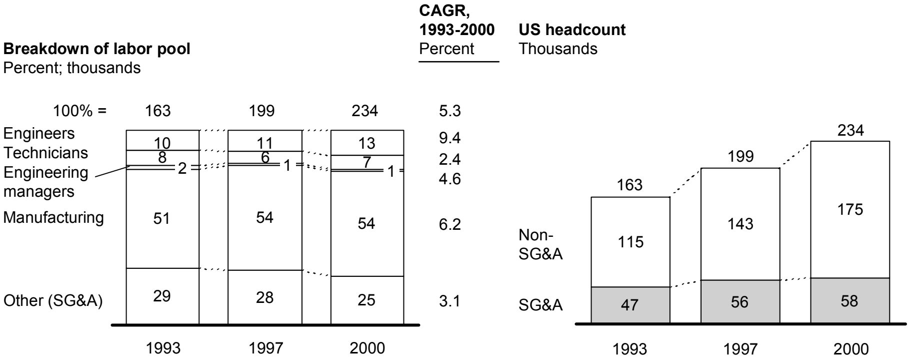
YIELD OPTIMIZATION TOOLS PLAYED CRITICAL ROLE IN ACCELERATING FAB RAMP-UP RATES IN 1990s



Source: Rose Associates; IC insights

Exhibit 22

SEMICONDUCTOR SECTOR DID NOT EXPERIENCE SIGNIFICANT REDUCTION IN SUPPORT LABOR POOL IN THE 1990s



Note: Split in technical labor pool is assumed to have the same profile as in SIC 367 (electronics); SG&A numbers determined by subtracting manufacturing and technical employees from the total labor pool

Source: Bureau of Labor Statistics; National Bureau of Economic Research; Census; SIA; MGI analysis inventory, optimize capacity utilization, and increase revenue per wafer for the foundries.

CRM software that automates account and channel management information has had minimal impact in the sector to date because, historically, semiconductor companies have not needed to focus on specific vertical market solutions, and thus have not required better customer management. Furthermore, semiconductor firms can have varied and atypical relationships with their major customers, ranging anywhere from an "arm's length" commodity relationship to an extensive product design and codevelopment relationship with major customers. Neither of these relationship types is likely to benefit from a standard "off-the-shelf" CRM application (Exhibit 23). Going forward, CRM could play a role in sector performance with changes in industry structure, increased focus on specific customers and vertical market solutions, and increased customer management requirements.

Currently, at a firm level, some companies are reported to have leveraged these horizontal applications to gain some productivity and profitability impact (Exhibit 24a and 24b). The effectiveness of these efforts and the speed with which they diffuse across the industry will determine their sector impact.

IT as a source of competitive advantage

Semiconductor companies (or their partners) in the microcomponents and memory subsectors have invested in most of the IT bundles listed in the previous sections. Therefore, no semiconductor company to date has leveraged its IT investments beyond its competitors to such an extent that it has gained competitive advantage from the IT systems alone.

Across these subsectors, components of the five IT bundles can be segmented into four tiers (Exhibit 25). The first two tiers represent current IT investments in the sector, while the latter two refer to potential investments.

- **Basic cost of doing business.** All semiconductor companies in the subsectors studied have invested in these systems and have reached a minimum acceptable threshold of performance. Leading semiconductor companies have seen improved performance not only because they have made these investments but also because they have developed the tacit in-house knowledge to complement and leverage these investments disproportionately. Examples of basic cost-of-doing-business investments include EDA tools, wafer processing equipment, MES, AOI equipment, and yield optimization solutions.
- **Extended cost of doing business.** These investments do not have 100 percent penetration in semiconductor companies and are typically seen in

Exhibit 23

SEMICONDUCTOR COMPANIES HAVE VARIED RELATIONSHIPS WITH THEIR MAJOR CUSTOMERS

Low **Level of cooperation with customers** **High**

"Take or pay" contracts

- Common in standardized, commodity products (e.g., DRAMs, flash memory)
- Typically multiple suppliers exist for same product line
- "Arm's-length" relationship exists between semiconductor company and customers
- Medium-term contracts are common (2-3 years)
  - – Lock-in capacity and assured sales volume
  - – Facilitate risk-sharing between semiconductor and next level manufacturers
- Examples
  - – AMD's contract with Alcatel to supply flash memory products
  - – Nokia's contract to buy DRAMs from Samsung
  - – Intel's contract to sell flash memory products to Cisco

"Design win" contracts

- Prevalent in specialized components and subsystems
- Semiconductor supplier works closely with next level customers to develop the needed IP
- After successful design, semiconductor manufacturer is exclusive supplier
- Examples
  - – Dialog will supply mixed signal ASIC for Ericsson 3G systems
  - – TI supplies DSP to Nokia
  - – Celeritek will supply handset GaA semiconductor components and subsystems to a US company

Source: Industry press; MGI analysis

Exhibit 24a

INDIVIDUAL COMPANIES ARE REPORTED TO HAVE LEVERAGED CERTAIN HORIZONTAL APPLICATIONS

Intel

- In 1998, started SCM initiative to have access to vendors' MRP systems to synchronize output with OEM demand; this investment helped reduce costs
- In 1998, took half of its orders on-line at a rate of $1 billion per month, reducing order handling costs
- By end of 1998, 100% of Taiwanese customers were doing business on-line; more than 90% were very satisfied with experience, and 15% of worldwide orders were placed after regular business hours, instead of waiting for next business day
- E-commerce initiative helped SME customers who did not have EDI; orders which initially were handled through faxes and telephones were handled through extranet, reducing order handling costs
- Extranet provided information on Intel products and offered on-line support to reduce expensive and traditional method of supporting customers
- Order tracking service allowed customers to check order status on-line and eliminated need to call customer service representatives
- Extranet eliminated 45,000 faxes per month from Taiwanese customers in 1998
- By May 2000, 100% of customers ordered product on-line

Source: Literature search

Exhibit 24b

INDIVIDUAL COMPANIES ARE REPORTED TO HAVE LEVERAGED CERTAIN HORIZONTAL APPLICATIONS (CONTINUED)

AMD

- In 1999, e-MRO solution was expected to generate annual savings of $15 million-37 million
- In May 2000, announced plans to join B2B exchange for SCM. Initiative was expected to help increase supply chain efficiency and improve delivery of products and services, thus increasing customer satisfaction
- In February 2001, company started implementing ERP to increase customers' real-time visibility into AMD's production and supply chain; this was expected to help AMD deal with component shortages that plagued high-tech manufacturers and help it enter the business PC market
- In 2001, expected Web-based procurement applications to reduce procurement and related costs by 30-40%
- Currently expecting ERP to help the goal of closing books at end of every business day

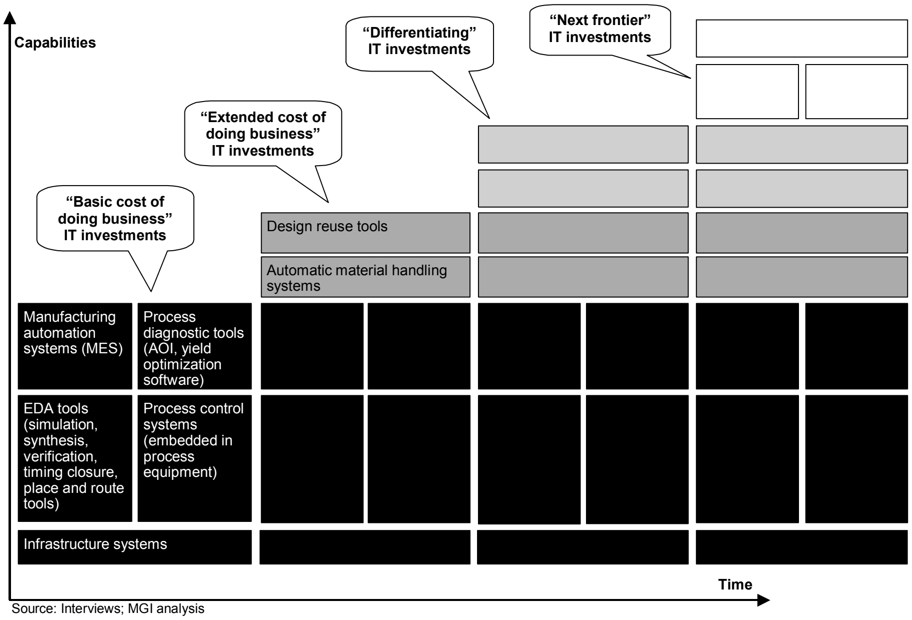
Micron

- Embraced RosettaNet aggressively to increase communication among engineers, buyers, and sellers to achieve time and costs savings in conducting business transactions

Source: Literature search

Exhibit 25

IT INVESTMENTS CAN BE SEGMENTED INTO 4 TIERS



Source: Interviews; MGI analysis

newer foundries and for newer products. Examples include MCS/AMHS in foundries, and design reuse in engineering.

¶ **Differentiating.** This segment, along with the next tier of investment, represents a set of forward-looking investments. Currently no player has leveraged IT alone to significantly differentiate itself. As mentioned above, some companies are beginning to employ horizontal applications that may provide incremental economic benefits to those firms, but are unlikely to yield distinctive competitive advantage. Going forward, with demand less buoyant, players may deepen and tailor their investments in this tier in hopes of differentiating themselves. The likely differentiating IT investments will include design tools for simultaneous hardware/software co-verification, enhanced timing closure engines, and cost and throughput time-reducing process control and enhanced process diagnostics systems for 300 mm wafers and copper interconnects.

¶ **Next frontier.** These are the investments that will push the performance frontiers of the leading semiconductor companies and of the overall semiconductor sector. These might include new lithography options as a replacement for photolithography.[20]

These four categories of investment together form the value stack. Currently, all semiconductor companies in the microcomponents and memory segments have two components of the value stack and are at similar levels. The leading players in the sector have the institutional knowledge to better leverage existing IT investments, and may capture more value in the future as they increase their stack height, that is, as they invest in differentiating and next frontier investments to jump ahead of the competition.

Parallel capability building in semiconductors

IT and business capabilities in the semiconductor sector were built by firms with a focus on their specific position in the value chain, such that the sector as a whole was building its IT and business capabilities through the parallel efforts of multiple firms. This trend co-evolved and was reinforced as firms focused on specific parts of the value chain (resulting in the atomization of the industry) and on rapidly building process and technological capabilities to complement their choice and to compete successfully.

Initially, companies adopted an integrated device manufacturer (IDM) model, where the front- and back-end design, wafer fabrication, and assembly and testing were done internally (Intel and Micron Semiconductors are IDMs). In the 1980s,

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[20] As line width reduces significantly below the wavelength of light, visible light cannot be used for transferring patterns from mask to the die and options such as X-rays are currently being considered as a replacement.

the market transitioned to a customer-owns-tools (COT) and ASIC business model, where the semiconductor company did the front-end design and outsourced the back-end design, wafer fabrication, and assembly and testing to an ASIC house. For example, for AMCC products, AMCC did the front-end chip design, and IBM did the back-end design and fabrication of the chip. In the early 1990s, the market transitioned to a fabless or fab-light COT and foundry model – the semiconductor companies performed the front-end and back-end design and predominantly outsourced wafer fabrication and assembly and testing to a foundry (TSMC, UMC, and Chartered dominate the foundry space). To illustrate, Broadcom does the chip design (both front-end and back-end) and outsources the chip manufacturing to TSMC. Currently, companies are buying certain design modules from IP houses (e.g., ARM, MIPS) (Exhibit 26).

The transition from an IDM to a COT/ASIC to a fabless COT/IP and foundry business model has helped companies focus on a single part of the value chain, and has played a part in enabling firms to build capabilities in parallel. Atomization of the value chain and the build-up of specialized technological capabilities in parallel reinforced each other to continue the trend. In some cases these capabilities have created an effective barrier to entry in certain parts of the value chain. For example, tacit knowledge creates an effective barrier to entry in wafer fabrication; a new company must make huge capital investments and recruit multiple key experienced individuals to start a foundry. In other cases, atomization has reduced barriers to entry. In design, companies with innovative design/IP can focus on design and outsource all other aspects of production or sell design elements to other players.

SUMMARY OF RELATIONSHIP BETWEEN KEY IT APPLICATIONS AND PERFORMANCE

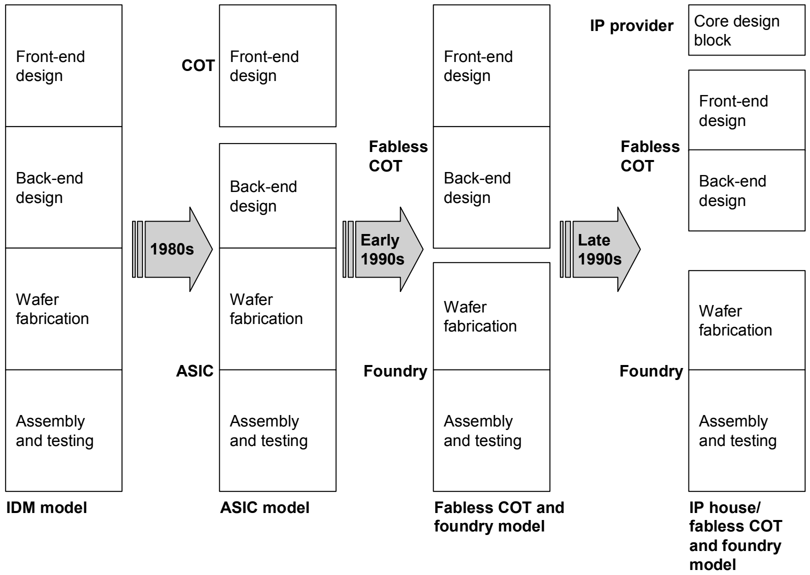
As discussed in the previous section, much of the richness in trying to understand the role of IT in enabling productivity gains in the semiconductor sector lies in understanding the business processes, performance levers, and the IT architecture specific not only to the sector as a whole but also to the different subsectors. In summary, we found that key productivity-enhancing applications in this sector shared three general characteristics:

1. They were vertical applications with a focus on key business processes, and they impacted critical performance levers.

Across the microcomponents and memory segments, vertical IT investments targeting important business processes delivered the highest impact. For example,

Exhibit 26

INDUSTRY VALUE CHAIN ATOMIZED OVER TIME



Source: Interviews, MGI analysis

as line widths reduced from 0.80 microns in the late 1980s to 0.18 microns today, the photolithography[21] process experienced significant technological improvements[22] to etch narrower line widths. Embedded hardware and software in the steppers (i.e., photolithography equipment) played a critical role in leveraging these process improvements by enabling a real-time feedback loop and by maintaining tight process control.

Key technology investments played an enabling role in positively impacting the subsector-specific performance (productivity and profitability) levers. For example at Intel, third-party and in-house developed EDA tools as well as process control systems in manufacturing helped to accelerate the introduction of new products to maximize revenues. Similarly, in the DRAM subsector, process control systems and process diagnostic tools played a core role in reducing throughput times (thus increasing fab utilization) and thereby reducing unitized fixed costs.

2. Key IT investments helped build capabilities in parallel

The semiconductor sector has been characterized by a growing atomization of the value chain from an IDM to a COT/ASIC to a COT/foundry model. Firms in the sector used IT to build technological/process capabilities with a focus on their specific position in their value chain, such that the sector as a whole was building its IT and business capabilities through the parallel efforts of multiple firms. This trend co-evolved and was reinforced as the industry atomized, with firms rapidly building a narrow set of technology and IT capabilities in parallel to achieve excellence in their part of the value chain.

3. They were deployed in concert with business process changes and technological innovations

Across the sector, significant technology investments codeveloped with changes in the business processes. For example, as line widths reduced, the number of gates per unit area available for design increased, and the need for more stringent process control and process diagnostics became critical. This led to investments in EDA tools that could enable design at a higher level of abstraction and in more sophisticated wafer process equipment and process diagnostics tools to take advantage of these technological innovations.

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[21] Process of transferring the patterns from the mask to the wafer.

[22] The wavelength of light used for transferring patterns from mask to die transitioned from 436 nm (G-Line) in 1986 to 365 nm (I-line) to 248 nm (DUV) in 2001.

FUTURE OUTLOOK FOR IT INVESTMENTS

The semiconductor sector has seen productivity benefits from existing vertical IT investments. However, horizontal applications have not significantly impacted the sector's performance to date. As this sector struggles to emerge from a trough of weak demand, companies may benefit from leveraging their existing horizontal IT investments to improve their operational effectiveness and to reduce their cost structure. In particular, some firms may achieve gains by making incremental IT investments to better tailor existing investments in various horizontal IT applications, including SCM, ERP, and CRM, to business process requirements and link them to performance metrics.

Going forward, as the sector makes the transition to 300 mm wafers and copper interconnects, the sector will most likely see additional IT investments in manufacturing (e.g., investments in automated material handling systems and in inspection and test equipment) due to the added complexity of bigger wafer size and new interconnect material. These investments will be on top of the regular capital investments made by the sector to keep up with Moore's law. Intel, for instance, plans to spend $12.5 billion over the next two years on new manufacturing technology[23].

OPPORTUNITIES AND CHALLENGES FOR USERS AND VENDORS

MGI's findings have implications for both semiconductor companies and IT vendors interested in participating in this space. As the economy slows down and as the sector struggles to cope with reduced demand, individual semiconductor companies need to identify and evaluate options to maximize impact from all performance levers. They can use IT along with other investments to differentiate and gain competitive advantage. IT vendors can help by developing solutions to leverage underutilized performance levers through work with companies to increase their "stack height," and by providing technology solutions to maintain strong productivity growth.

Implications for semiconductor companies

In the 1990s, increased customer demand, the upbeat US economy, and the continued effects of Moore's law helped semiconductor companies maintain strong performance growth. IT vendors also benefited from the boom as companies invested not only in IT to design faster chips and build new fabs, but also in applications designed to improve other types of operations, such as

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[23] Wall Street Journal, August 13, 2002

customer order management, procurement, and ERP. However, during the current downturn, the strategic focus of semiconductor companies is shifting from ramping up to meet demand to optimizing operations to maximize productivity. In this environment, MGI's findings have three significant implications for semiconductor companies:

1. Employ additional productivity levers. The semiconductor sector saw an exponential productivity improvement in the 1990s, but the increase was primarily driven by only three of the eight productivity levers in MPUs and by only two of the eight productivity levers in DRAMs. Going forward, as the economy slows and the sector struggles to find additional sources of productivity besides growth, individual companies need to evaluate options to employ the remaining levers.

- In MPUs and DRAMs, companies can increase the emphasis on the "substitute capital for labor" lever by fine tuning their business processes, training their personnel, and making incremental IT investments to fully take advantage of their existing ERP investments and automating their back-end operations.
- In the commodity DRAM market, individual companies could consider investing in additional EDA tools to increase functionality and integration in memory chips and employ the "offer new value-added goods and services" lever.

The nature of the sector prevents certain levers from having significant impact on productivity, and companies should consider employing these levers only after they have utilized the higher-priority levers. For example, in both MPUs and DRAMs, labor efficiency is not a critical lever since labor is a small portion of the cost structure; thus, companies should not initially focus their efforts on pulling the "employ labor more efficiently" lever. Similarly, individual companies in DRAMs are price takers and should not initially target the "realize more value from goods in current portfolio" lever.

2. Identify differentiating IT investments. To date, semiconductor companies have had limited success in using IT to differentiate themselves from one another. This is somewhat ironic for an IT-producing sector, and points to a future agenda for firms. Going forward, individual semiconductor companies in both the MPU and DRAM subsectors may benefit, as firms in other sectors have, from identifying differentiating IT investments, aligning their business processes and organizational structure behind these IT investments, and leveraging the investments to move up the value stack. For example, design complexity, atomization of the industry structure, and cost considerations have driven design teams to be dispersed across national and company boundaries, a trend that will continue to accelerate in the future. Consequently, one of the differentiating investments in the future could be IT systems that provide the ability to successfully perform collaborative design and thus reduce the time to market for new design and increase the functionality and integration per chip.

3. Maximize impact from current investments. As the semiconductor sector is a relatively high spender on direct and indirect IT, individual companies need to consider options to maximize impact from their existing IT investments. One such option would be for individual companies to form a shared utility group with other companies for IT investments in business processes that do not offer a competitive advantage. For example, a DRAM company could form a shared utility with other semiconductor companies for their order receiving and order processing operations, instead of each company investing in back-office automation. Similarly as line widths shrink every 18 months and semiconductor companies invest in new capital equipment for the next generation wafer processing, companies could use their existing capital equipment to act as a contract manufacturer and/or outsourcee for market segments that need products two to three generations behind.

Implications for IT vendors

The findings also have two implications for IT vendors wanting to participate in this space:

1. Help customers pull levers. As the semiconductor industry struggles to recover from the trough, its IT vendors can "ease the pain" for their semiconductor customers by helping them achieve high impact from appropriate productivity and profitability levers. For example, design tool vendors need to evaluate options to close the design gap. In particular, EDA vendors have opportunities to improve in the logic simulation and place and route portion of the design. Improvements in these areas have lagged those seen in other design areas such as design specification, synthesis, and formal verification. These efforts could enable DRAM companies to employ the "sell new value-added goods and services" lever and help MPU companies to continue to pull this lever effectively.

2. Build collaborative customer relationships. Independent software vendors (ISVs) can collaborate with individual semiconductor companies to develop customized offerings based on their strategy and business processes to help the semiconductor company achieve its IT-enabled differentiation. For example, an ISV developing a collaborative product design suite can work with a semiconductor company that has multiple design teams at various geographic locations to help it design chips in parallel in the various locations, in a relatively shorter period of time, with more functionality and integration. This would enable the semiconductor company to use IT as a differentiator.

Glossary of terms used in semiconductor sector case

Term	**Definition**
AMHS	Automatic material handling system; includes interbay and intrabay wafer handling system in foundries.
CAGR	Cumulative annual growth rate.
Chip	Autonym for semiconductors.
COT	Customer owns tools; refers to companies doing back-end and/or front-end chip design in-house.
CRM	Customer relationship management; refers to tools and software for automating and improving effectiveness of sales, marketing and customer service functions.
Deflator	A price index; used to convert nominal numbers to quality-adjusted output measures.
DRAM	Dynamic random access memory; stores data which are needed for application processing.
Design gap	Difference between gates designed and gates available for design per unit area.
Design specification	Step in chip design.
Die	Autonym for semiconductors.
Direct IT	Includes hardware (mainframe computers, PCs, storage devices, and peripherals), software (prepackaged, custom, and own account software), and communication equipment.
EDA	Electronic design automation; tools for chip design.
ERP	Enterprise resource planning; applications to automate back-end office processes.
Fabs	Refer to foundry.
Final synthesis	Process in chip design.

Term	**Definition**
Foundry	Manufacturing facility for semiconductors, also known as fabs.
Formal verification	Process in chip design.
IDM	Integrated device manufacturer; refers to chip companies performing all the required processes from chip design to chip manufacturing in-house.
Indirect IT	Includes software and hardware that are embedded or bundled as a part of the system (e.g., process control hardware and software in etch equipment in foundries and inspection hardware and software in AOI). Typically these investments are captured in the BEA instruments category.
IT intensity	Real IT capital stock per person engaged in production.
Line width	Distance between the source and the drain in a transistor; determines the number of transistors that can be placed per unit area.
Logic simulation	Process in chip design.
MCS	Material control system; also known as AMHS.
MES	Manufacturing execution system; application to automate several processes in the foundry.
Microns	Unit of measurement; 10^{-6} meters.
Moore’s law	Predicts that the number of transistors per unit area will double approximately every 18 months.
MPUs	Microprocessors.
Photolithography	Manufacturing process in wafer fabrication.
Place and route	Process in chip design.
SCM	Supply chain management; applications to manage flow of data and material among fabs, suppliers, and planners/customer service providers.
Synthesis	Process in chip design.
Wafer	Unit of production in front-end manufacturing; one wafer yields several chips.

Appendix A
2000 labor productivity updates to MGI's US Productivity Growth report

This appendix updates the findings from the McKinsey Global Institute's (MGI's) US Productivity Growth report of last year.[1] It applies the most recently available data to our productivity analysis for six sectors: computer manufacturing, retail banking, retail trade and subsectors, semiconductors, telecommunications services (mobile access subsector), and wholesale trade. We summarize below for each of these sectors our methodology for calculating labor productivity and our updated productivity findings.

COMPUTER MANUFACTURING

The original MGI report looked at productivity growth rates between 1987-1995 and 1995-1998 for the computer manufacturing industry and noted acceleration in the labor productivity growth rates between the two periods. When updated with recently available 2000 data, the findings still hold true: productivity growth accelerated between the periods 1987-1995 and 1995-2000, and the majority of the jump was driven by an increase in real value added per employee. The output deflator, which measures the quality of the finished product, continued to be the main driver of the jump in real value added per employee.

Methodology for calculating labor productivity

MGI used data from the National Bureau of Economic Research (NBER), the US Census Bureau, and the Bureau of Labor Statistics (BLS) to measure productivity growth and jump in computer manufacturing. The real value of shipments and the real cost of materials were determined from the nominal value of shipments and nominal cost of materials and the input and output deflator. The real value added (the difference between the real value of shipments and the real value of inputs) and total number of employees were used to determine productivity, productivity growth, and productivity jump in the sector.

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[1] MGI "US Productivity Growth 1995-2000, Understanding the Contribution of Information Technology Relative to Other Factors," released October 2001.

2000 update of productivity measures

In this sector, acceleration in productivity growth and capital spending, and trends in computer production and sector employment looked similar to the results in the US Productivity Growth report, when updated with 2000 numbers.

Acceleration in productivity growth and capital spending

The 1995-2000 productivity acceleration picture in computer manufacturing looks similar to the 1995-1998 acceleration picture. The majority of the jump (approximately 75 percent) is driven by an increase in real value added per employee and only a small portion driven by increase in number of units per employee. Change in the output deflator is a significant driver of change in real value added per employee. Other factors such as growth in number of units and employees, change in the input deflator, and changes in nominal input and output per employee played only a modest role in the jump (Exhibits 1a and 1b). Also, MGI's analysis based on value added productivity measures is consistent with the BLS real gross output productivity results (Exhibit 2).

The sector's decrease in employment was significantly more pronounced for 1995-2000 than for 1995-1998. This difference can be attributed to the increasing importance of contract manufacturing in this sector (Exhibit 3).

Industrial machinery (of which computer manufacturing is a subsegment) continued to have a strong increase in IT intensity, but it experienced only a modest increase in total capital intensity in 1995-2000 when compared to 1987-1995 (Exhibit 4).

Trends in units of computers produced, 1993-2000

Physical units of computers produced in the US increased at an approximately 20 percent CAGR in 1993-2000, similar to the growth rate calculated for the 1993-1999 time period (Exhibit 5). There was no significant change in revenue split among servers, desktops, and laptops in the late 1990s (Exhibit 6).

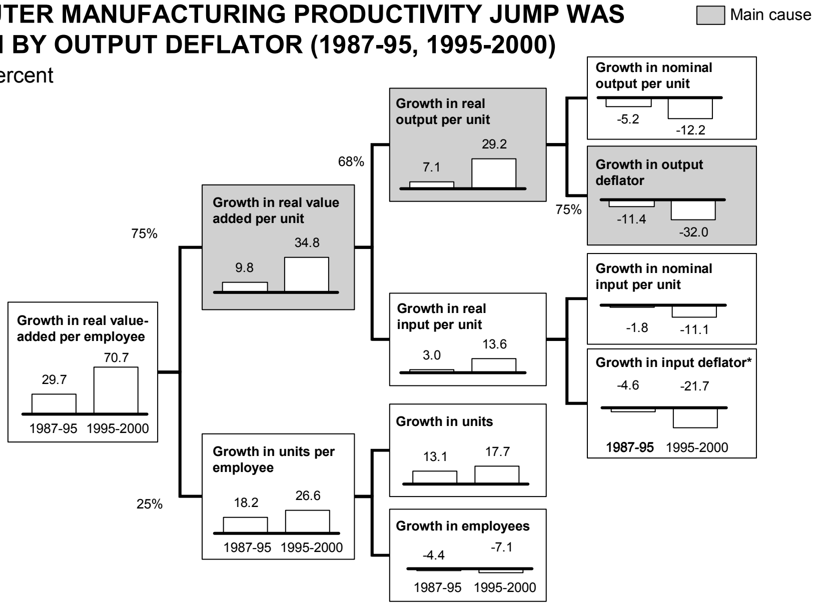
Also, as indicated in our previous report, production and nonproduction employment in the computer industry continues to shrink because of outsourcing (Exhibit 7). Architectural simplification and outsourcing to contract manufacturers were the primary drivers of unit-based productivity growth in this sector (Exhibit 8).

While there was a pattern of steady growth in the number of units and a parallel reduction in the number of US employees due to outsourcing, the main driver of acceleration (as opposed to growth) in labor productivity was the real value added per unit.

Exhibit 1a

COMPUTER MANUFACTURING PRODUCTIVITY JUMP WAS DRIVEN BY OUTPUT DEFLATOR (1987-95, 1995-2000)

CAGR, percent



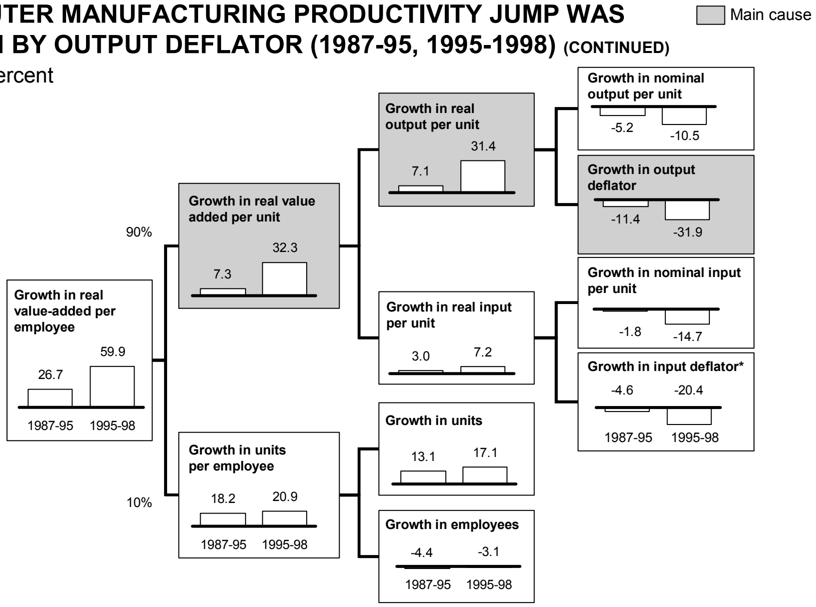
* No input deflator available for 1997-2000. Input price deflator decreased by 13.3% in 1996. We assume price of inputs decreases at 23.7% CAGR for 1997-2000 to take into account the faster decline in microprocessors due to higher levels of competition in 1997 (see semiconductor case for details)

Source: NBER; US Census Bureau; Dataquest; BLS; MGI analysis

Exhibit 1b

COMPUTER MANUFACTURING PRODUCTIVITY JUMP WAS DRIVEN BY OUTPUT DEFLATOR (1987-95, 1995-1998) (CONTINUED)

CAGR, percent



* No input deflator available for 1997 and 1998. Input price deflator decreased by 13.3% in 1996. We assume price of inputs decreases at 23.7% CAGR for 1997 and 1998 to take into account the faster decline in microprocessors due to higher levels of competition in 1997 (see semiconductor case for details)

Source: NBER; US Census Bureau; Dataquest; BLS; MGI analysis

Exhibit 2

COMPARISON OF MGI AND BLS PRODUCTIVITY GROWTH RATES

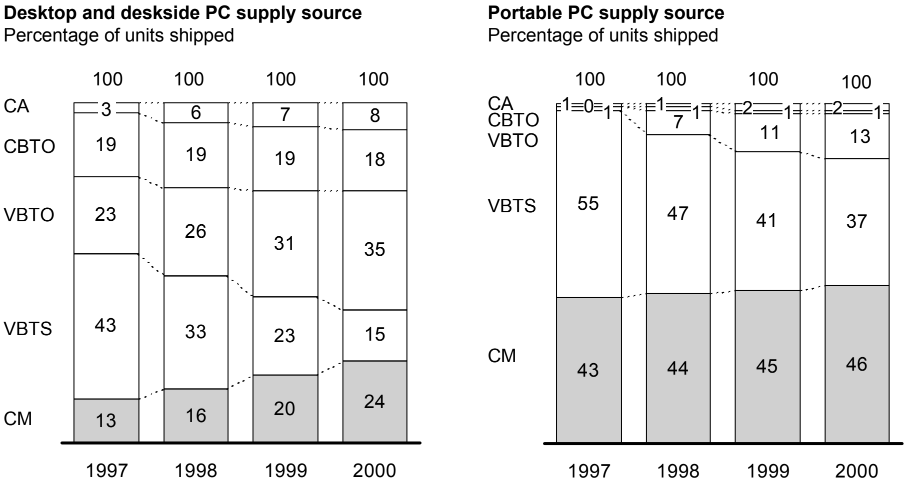

MGI real value added per employee
CAGR, percent

BLS real gross output per employee
CAGR, percent

Source: BLS; MGI analysis

Exhibit 3

CONTRACT MANUFACTURING IS BECOMING MORE IMPORTANT IN COMPUTER MANUFACTURING SECTOR


Desktop and deskside PC supply source
Percentage of units shipped

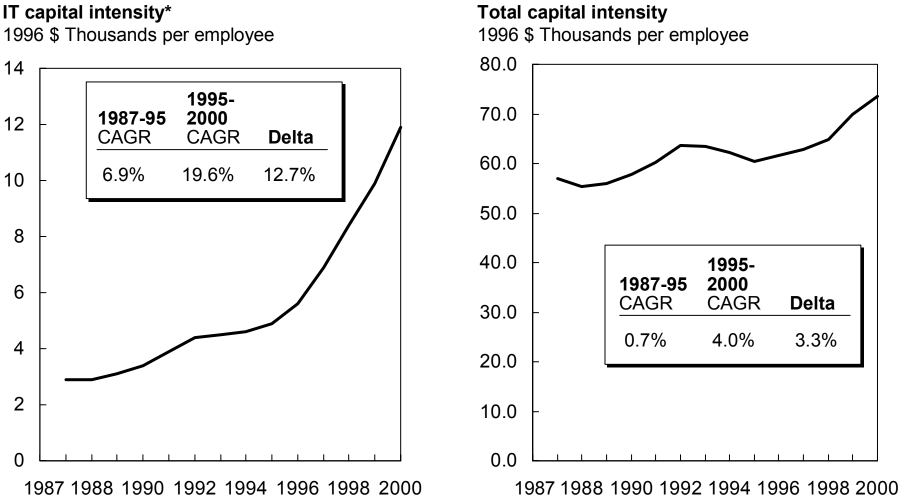
Portable PC supply source
Percentage of units shipped

Note: VBTO – Vendor Build to Order; CBTO – Channel Build to Order; CA – Channel Assembly;
CM – Contract manufactured; VBTS – Vendor Build to Stock

Source: Dataquest; MGI analysis

Exhibit 4

IT AND TOTAL CAPITAL INTENSITY GROWTH FOR INDUSTRIAL MACHINERY AND EQUIPMENT SECTOR ACCELERATED



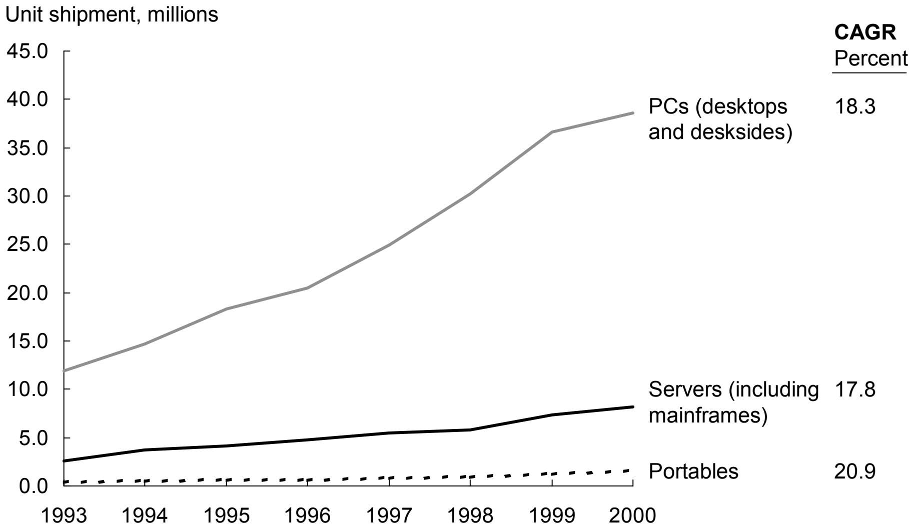
* Real IT stock per PEP (persons engaged in production)

Note: MGI's US Productivity Growth report identified computer manufacturing as the predominant (by contribution to growth and jump) subsegment of industrial machinery and equipment sector

Source: BEA; MGI analysis

Exhibit 5

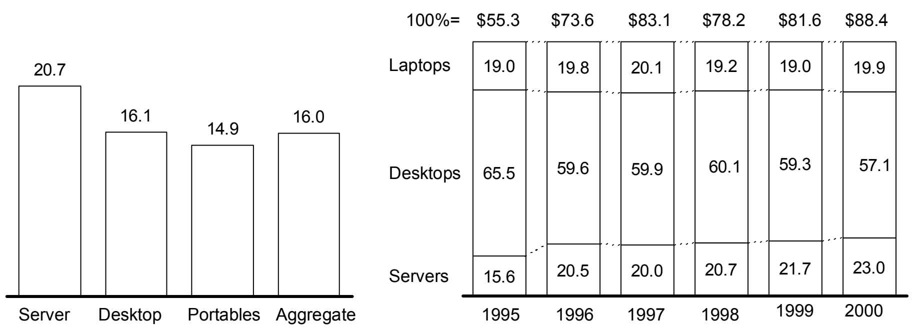
PHYSICAL UNITS OF COMPUTERS PRODUCED IN THE US HAVE BEEN INCREASING AT ALMOST 20% SINCE 1993



Source: Dataquest (Server Computing and Personal Computers Report); MGI analysis

Exhibit 6

COMPUTER MANUFACTURING BY PLATFORM: 1995-2000



Growth in units by platform
CAGR, percent, 1995-2000

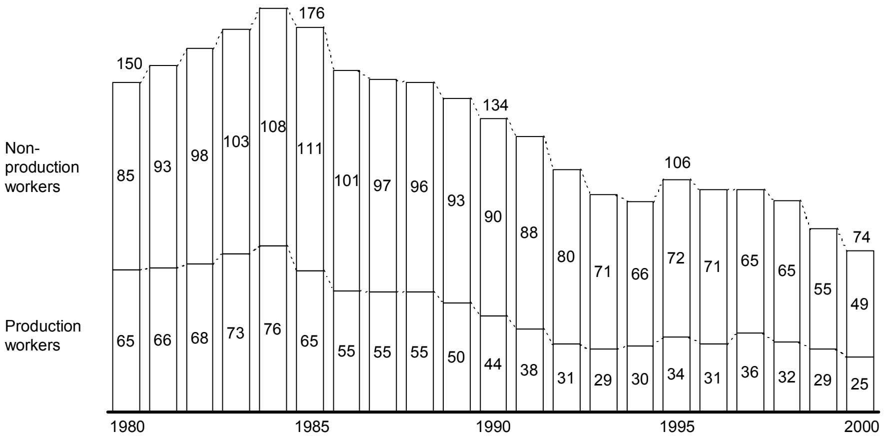
Revenue share by platform
Percent, $ Billions

Source: Dataquest; MGI analysis

Exhibit 7

EMPLOYMENT IN THE COMPUTER INDUSTRY HAS BEEN SHRINKING

Thousands of US workers



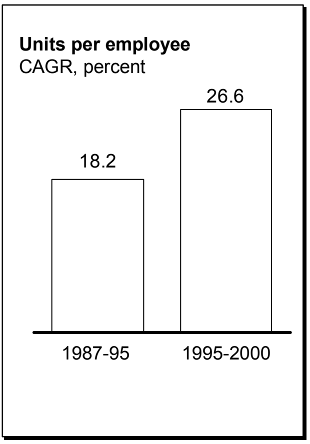
Source: NBER; US Census Bureau ASM; MGI analysis

Exhibit 8

DRIVERS OF UNIT-BASED PRODUCTIVITY GROWTH IN COMPUTER MANUFACTURING

● >50%
◕ ~25-50%
◑ ~10-25%
◔ <10%

	1987-95	1995-2000
• Architectural simplification – Hardware integration – Fewer components/standardization	●	●
• Outsourcing to contract manufacturers	◔	◕
• Economy of scale	◑	◔
• Changes in the manufacturing process – Automation – Reorganization of the work force (cells)	◔	◔
• IT enabled drivers – Supply chain management and automation – Customer interface automation – Built-to-order automation	◔	◔



Source: Interviews; MGI analysis

RETAIL BANKING

The US Productivity Growth report showed that retail banking experienced a slowdown in productivity growth during 1995-1999 while IT intensity in the sector accelerated, suggesting that retail banking was a "paradox" sector. New data for the year 2000 indicates that this story remains unchanged for the period 1995-2000.

On the output side, during the 1990s, checks represented the largest single contributor to output measures, although electronic payments and information transactions grew at a significantly faster rate than check and other payment transactions. Real estate loans grew at 4.8 percent, while growth in other loans as well as savings accounts remained flat or slow during the 1990s.

On the input side, labor hours dropped by 2 percent during this period, largely due to automation and consolidation. Productivity did grow from 1999 to 2000, driven by a reduction in labor hours as continued consolidation in the sector resulted in additional workforce reductions. However, the sector overall continued to experience declining productivity growth during the period 1995-2000 when compared with 1982-1987 and 1987-1995.

Methodology for calculating labor productivity

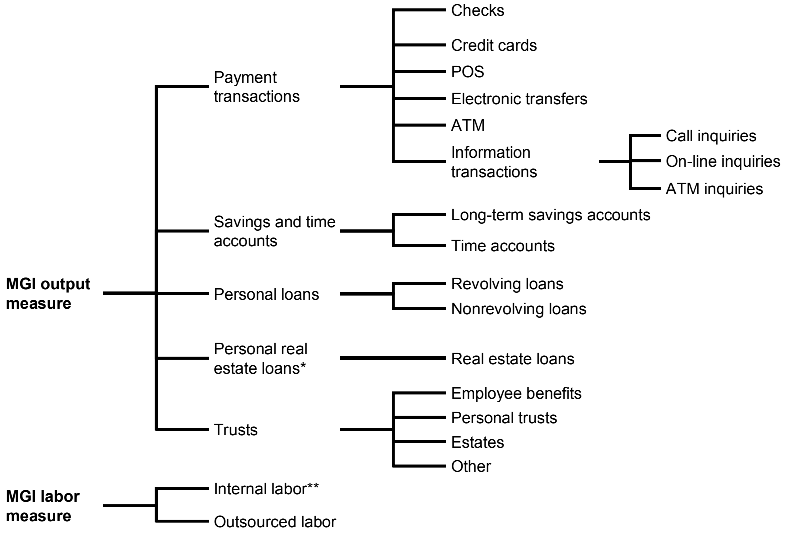
Labor productivity was calculated using data on physical output and input measures such as payment transactions, savings and time accounts, personal loans, personal real estate loans, trusts, and internal and outsourced labor (Exhibit 9). The retail banking definition for the purposes of MGI's productivity calculation included commercial banks and savings institutions, and did not include credit unions and foreign banks or branches of foreign banks.

MGI's output measure is a Fisher quantity index of the number of payment and information transactions, savings and time accounts, personal loans, personal real estate loans, and trust accounts. Aggregation of each of the five output categories was done using revenue share. MGI used the "user opportunity cost" approach to estimate revenue share. Transactions' share of total banking revenue is 61 percent, while savings and time accounts' share is 8 percent. The revenue share from personal loans is 12 percent, while that from real estate loans is 7 percent. Finally, banks' revenue share from trusts is 12 percent.

Total labor was measured by the number of full-time equivalent employees (FTEs) employed in commercial banks and savings institutions, plus outsourced FTEs, less the number of workers that performed nonretail activities.

Exhibit 9

PHYSICAL OUTPUT MEASURES WERE USED TO CALCULATE LABOR PRODUCTIVITY IN RETAIL BANKING



* Does not include commercial loans

** Does not include workers in nonretail activities (e.g., commercial real estate loans and commercial loans)

Source: MGI's "US Productivity Growth 1995-2000" report, October 2001

2000 update of labor productivity measures for retail banking

Productivity calculations using 2000 data showed that productivity grew at a rate of 7.4 percent during 1999 to 2000, but overall productivity growth during 1995-2000 remained lower than growth during 1982-1987 and 1987-1995 (Exhibits 10 and 11).

- ¶ **Payment transactions.** Payment transactions grew at 4.7 percent during 1999-2000. Although growth in check volume declined by 0.6 percent (compared to an increase of 1.9 percent CAGR during 1995-1999), other payment transactions such as credit card transactions and ACH transfers continued to increase. Growth in debit card transactions slowed down to 22 percent during 1999-2000, compared with 48 percent CAGR for the period 1995-1999. Credit card transaction growth declined to 4 percent from 12 percent during this period. ATM transactions increased at a rate of 21 percent during 1999-2000, compared with 3 percent CAGR for 1995-1999.
- ¶ **Information transactions.** Information transactions grew 25 percent in 2000 compared with 10 percent CAGR during 1995-1999, driven by increases, in large part, in on-line and ATM inquiries.
- ¶ **Loans, savings accounts, and trusts.** Savings and time accounts, credit card loans, and institutional loans grew in 2000, reversing a declining trend during 1995-1999. Personal real estate loans grew at 4.6 percent, higher than the 3.2 percent CAGR during 1995-1999. Growth in trusts, however, declined -3.4 percent versus 1.2 percent CAGR for the 1995-1999 period.
- ¶ **Labor hours.** Total labor hours declined at a rate of 2.8 percent in 2000, compared with a rate of decline of 0.9 percent for the 1995-1999 period. In particular, outsourcing hours declined by 25 percent, reversing a 9 percent CAGR during 1995-1999.

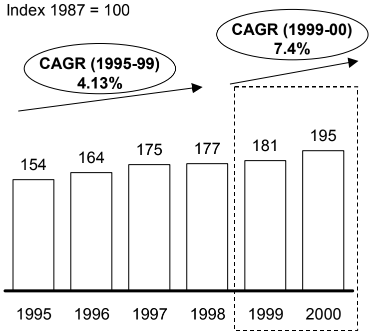
Trends in productivity measures, 1990-2000

During the 1990s, payment transactions, information inquiries, credit card loans, and personal real estate loans grew, while time and savings accounts, trusts, and institutional loans declined.

Exhibit 10

RETAIL BANKING EXPERIENCED SIGNIFICANT PRODUCTIVITY GROWTH FROM 1999 TO 2000

Labor productivity
Index 1987 = 100



Growth in productivity measures
CAGR, percent

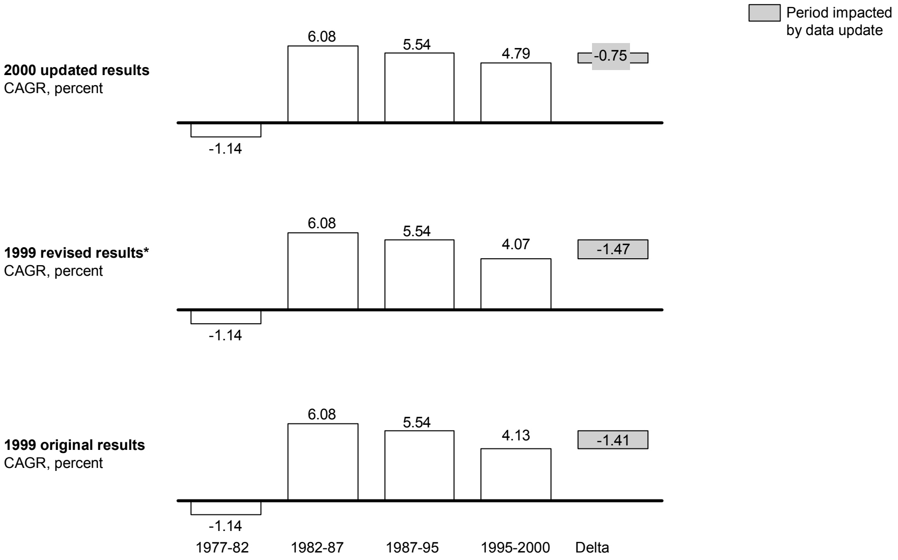
	1995-99	1999-2000
• Payment transactions		
– Checks	1.9	-0.6
– Credit cards	11.9	4.2
– POS	17.2	21.8
– Electronic transfers	48.3	14.1
– ATM	3.0	21.2
– Information transactions		
• Call inquiries	19	11.3
• On-line inquiries	1,037	95
• ATM inquiries	3.0	21.2
• Personal loans	-4.5	6.8
• Real estate loans	3.2	4.6
• Trusts	1.4	-3.4
• Savings and time accounts	-3.0	5.3
• Labor hours	-0.9	-2.8

Key changes impacting 2000 productivity include
- Reduction in check volume
- Increase in information transactions, particularly on-line and ATM inquiries
- Increase in electronic forms of payment (credit cards, POS, electronic transfers)
- Increase in ATM transactions
- Decrease in labor hours

Source: MGI's "US Productivity Growth 1995-2000" report, October 2001; Bank of International Settlements (checks processed); *Card Industry Directory/EFT Databook* (ATM transactions, credit cards, EFTPOS), NACHA (ACH transfers); American Bankers Association (call inquiries); On-line Banking Report (on-line inquiries); MGI analysis

Exhibit 11

MGI METHODOLOGY USING 2000 DATA SHOWS RETAIL BANKING SAW DECLINING PRODUCTIVITY GROWTH 1982-2000



* Based on revised data on productivity measures for 1999

Source: MGI's "US Productivity Growth 1995-2000" report, October 2001; BEA; BLS; *Card Industry Directory*; Bank of International Settlements; MGI analysis

¶ **Payment transactions.** Total payment transactions grew at 4.6 percent CAGR (Exhibit 12). The number of checks processed as a fraction of total payment transactions decreased from 82 percent in 1990 to 63 percent in 2000. Furthermore, growth in checks slowed from 2.2 percent CAGR during 1990-1995 to 1.4 percent CAGR during 1995-2000. Growth in debit card usage (39 percent CAGR during 1990-2000) may have substituted for growth in more traditional forms of payment, such as ATM transactions, credit cards, and checks.

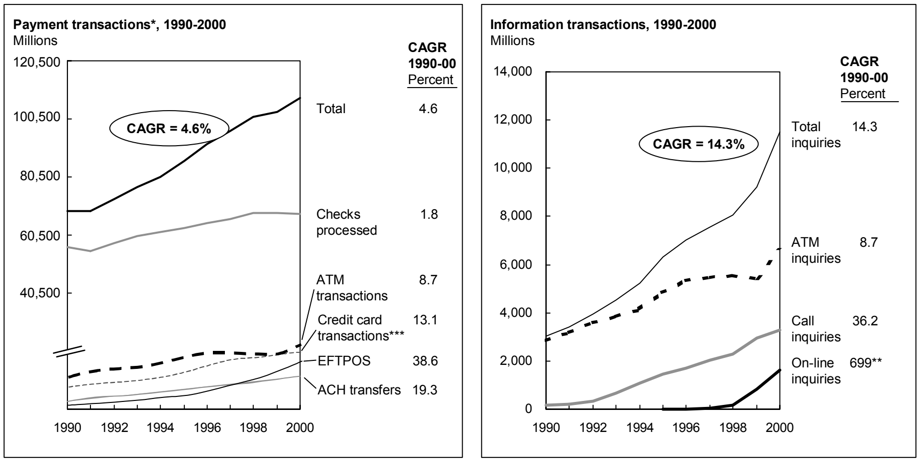
¶ **Information transactions.** Information transactions grew at 14.3 percent CAGR (Exhibit 12). On-line inquiries are the fastest growing category of information transactions, with an estimated 1.6 billion inquiries in 2000. Telephone inquiries grew at 36.2 percent CAGR during 1990-2000.

¶ **Loans and savings accounts.** Personal real estate loans grew at 4.8 percent, while growth in savings accounts and other loans was flat or lower (Exhibit 13). The decrease in time and savings accounts after 1996 was the result of a shift from savings accounts to equities and other products offered during the stock market boom by institutions that were not retail banks. An increase in the number of real estate loans was due in part to strong US macroeconomic growth and a decrease in mortgage rates from 10.13 percent to 8.06 percent between 1990 and 2000.

¶ **Labor hours.** Labor hours declined at 1.9 percent CAGR (Exhibit 14). Labor hours decreased during 1990-1997, reflecting a reduction in workforce in the sector, driven in part by large mergers. They increased in 1998 and 1999, due in part to increased hiring of IT and sales/marketing professionals for Y2K and direct marketing/CRM efforts. 2000 saw a drop in labor hours due to continued workforce reductions from consolidations such as the Bank of America/NationsBank and First Union/Wachovia mergers.

Exhibit 12

ELECTRONIC FORMS OF PAYMENT AND INFORMATION TRANSACTIONS GREW SIGNIFICANTLY FASTER THAN CHECKS IN THE 1990s



* Does not include information inquiries; credit cards do not include Amex and Discover cards

** On-line banking CAGR is for 1995-2000

*** Growth in credit card transactions dropped 4.2% during 1999-2000 per *Card Industry Directory* vs. an 8% drop per Nilson (credit card transactions) reports

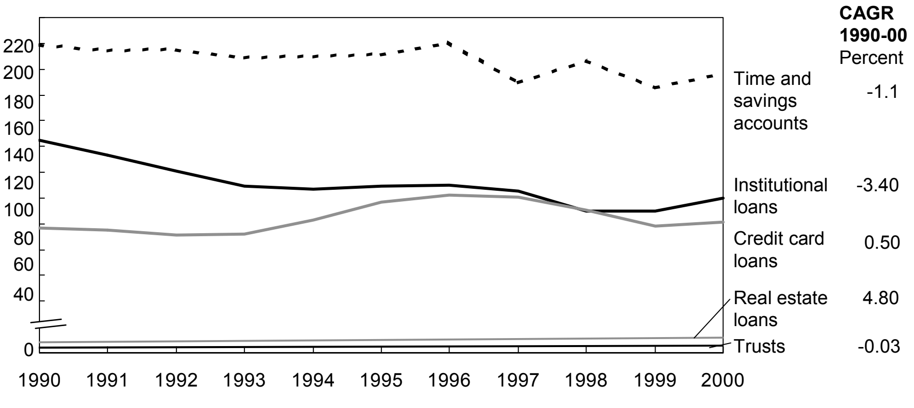
Note: Recent data released by Federal Reserve revised estimates of volume of checks written annually to 42.5 billion for 2000

Source: Bank of International Settlements (checks processed); *Card Industry Directory/EFT Databook* (ATM transactions, credit cards, EFTPOS), NACHA (ACH transfers); American Bankers Association (call inquiries); On-line Banking Report (on-line inquiries); MGI analysis

Exhibit 13

REAL ESTATE LOANS GREW AT 5%, WHILE GROWTH IN SAVINGS ACCOUNTS AND OTHER LOANS WAS FLAT OR SLOWER IN THE 1990s

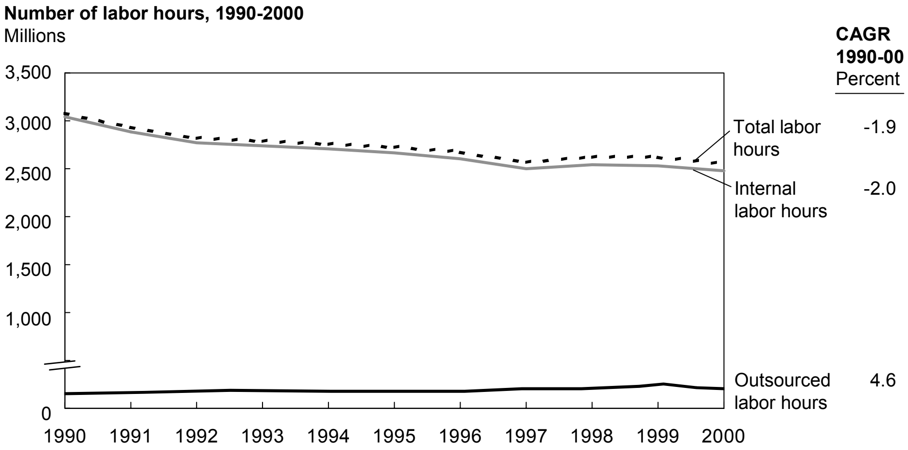
Number of loans, trusts, time and savings accounts, 1990-2000
Millions



Source: FDIC (institutional and credit card loans); BLS (real estate loans, trusts)

Exhibit 14

LABOR HOURS REDUCED BY 2% 1990-2000



Source: BLS; MGI analysis

RETAIL TRADE AND SUBSECTORS

MGI's US Productivity Growth report looked at productivity growth rates between 1987-1995 and 1995-1999 for the retail trade and subsectors within retail. In particular, the report focused on the general merchandise (GMS) subsector. During the course of the current study, the productivity metrics were updated using revised 1999 data and to include newly available data for the year 2000. The productivity story in the retail sector does not change as a result of the update and the observations made in the original report continue to hold true.

Retail trade saw acceleration in value-added productivity growth from a growth rate of 2.0 percent between 1987-1995 to 6.5 percent between 1995-2000. In GMS, labor productivity grew at 5.3 percent per year from 1987-1995, increasing to an average of 8.3 percent per year for the period from 1995-2000. The apparel, home improvement, and electronics/furniture subsectors also experienced acceleration in productivity in the mid- to late-1990s, but were not examined in as much detail.

Methodology for calculating labor productivity

MGI created estimates of value-added productivity for retail and its subsectors by using Bureau of Economic Analysis (BEA), US Census Bureau, and BLS data. Gross margin is available annually at the subsector level from the BEA, and this data was used as a starting point. Nominal value added was calculated by subtracting an estimate of purchased services per subsector from the subsector gross margin. The US Census Bureau provides subsector purchased services every five years in Census years. Thus, nominal value added is available every five years. Value added for inter-Census years was calculated by linear interpolation between the Census years and linear extrapolation using 1997 Census figures to arrive at an estimate for the year 2000. In addition, the interpolation/extrapolation was normalized using the annual BEA purchased services total to provide additional confidence in the estimates. MGI constructed a value-added deflator at the subsector level by constructing a Fisher index for each subsector (following the BEA methodology). Finally, our labor inputs at the subsector level were hours, provided by the BLS.

2000 update of productivity measures

MGI updated the productivity metrics using revised 1999 data and newly available data for the year 2000 and included additional analysis of the apparel, home improvement, and electronics/furniture subsectors.

Acceleration in productivity growth

The productivity story in the retail sector does not change as a result of the update, and the observations made in the original report continue to hold true. Retail trade saw acceleration in value-added productivity growth from a growth rate of 2.0 percent between 1987-1995 to 6.5 percent between 1995-2000 (Exhibit 15).

Productivity in general merchandise grew at 5.3 percent per year from 1987-1995 and the growth rate increased significantly between 1995-2000, averaging 8.3 percent per year (Exhibit 16)[2]. As a result of revisions to 1999 BEA gross margin data (which is updated based on results of subsequent benchmark surveys for additional accuracy) this jump was not as large as that reported in the original report, which showed a growth rate of 10.1 percent from 1995-1999 and a delta of 4.8 percentage points.

The jump in general merchandise can now be entirely attributed to the jump in real sales per hour, which grew at a rate of 3.3 percent in 1987-1995 and 6.7 percent in 1995-2000. Growth in value added per unit of real sales slowed from a rate of 1.9 percent in 1987-1995 to 1.5 percent in 1995-2000.

Within the general merchandise subsector, Wal-Mart continues to gain market share and to outpace other firms in terms of productivity, but the gap is narrowing (Exhibit 17).

Examination of other subsectors within retail

In the current study, MGI broadened its investigation of the impact of IT on productivity to three other interesting subsectors in addition to general merchandise. The electronics and home furnishing, apparel, and home improvement subsectors all saw large jumps in productivity in the mid 1990s (Exhibit 18). Productivity for these subsectors was calculated using the same methodology as for GMS, based on BEA, BLS, and US Census Bureau data. An in-depth examination of the causes of productivity growth in these three subsectors was outside the scope of this study; however, some of the causal factors identified in general merchandise were also likely at work in the other subsectors. For example, interviews confirmed the importance of competitive dynamics between very large players (Best Buy and Circuit City in electronics, Home Depot and Lowe's in home improvement, and Gap and Limited in apparel) in driving productivity improvements.

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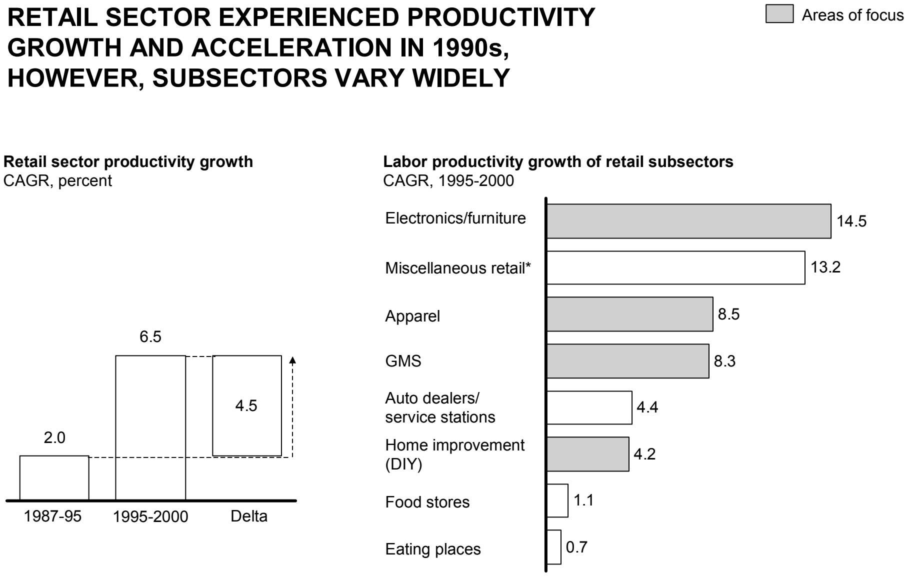
[2] Numbers do not add due to rounding.

Exhibit 15

RETAIL SECTOR EXPERIENCED PRODUCTIVITY GROWTH AND ACCELERATION IN 1990s, HOWEVER, SUBSECTORS VARY WIDELY



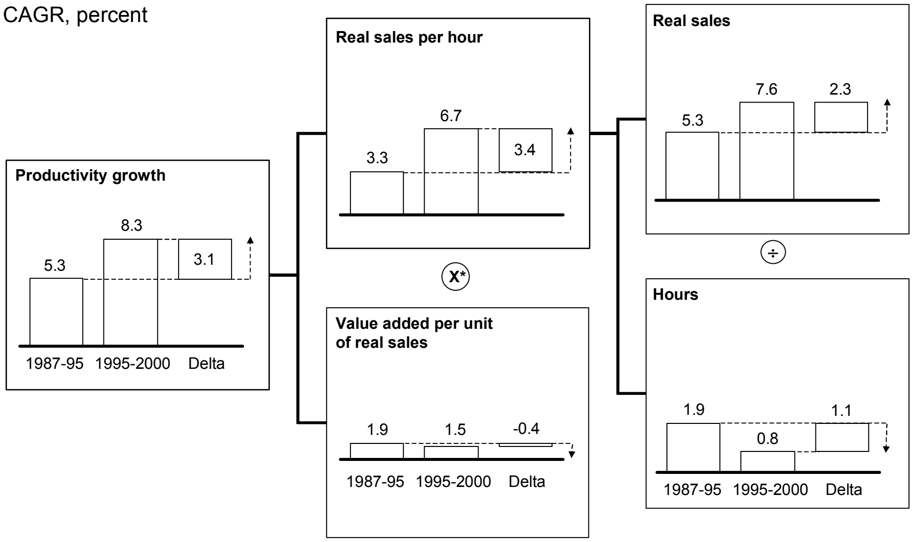
* Miscellaneous retail has the second-highest labor productivity growth rate across subsectors, but the heterogeneous nature of this subsector makes it difficult to generalize the role of IT in enabling that growth

Source: BEA; BLS; US Census Bureau; MGI analysis

Exhibit 16

ACCELERATION OF REAL SALES PER HOUR GROWTH DROVE PRODUCTIVITY GROWTH JUMP IN GMS IN 1995-2000

CAGR, percent



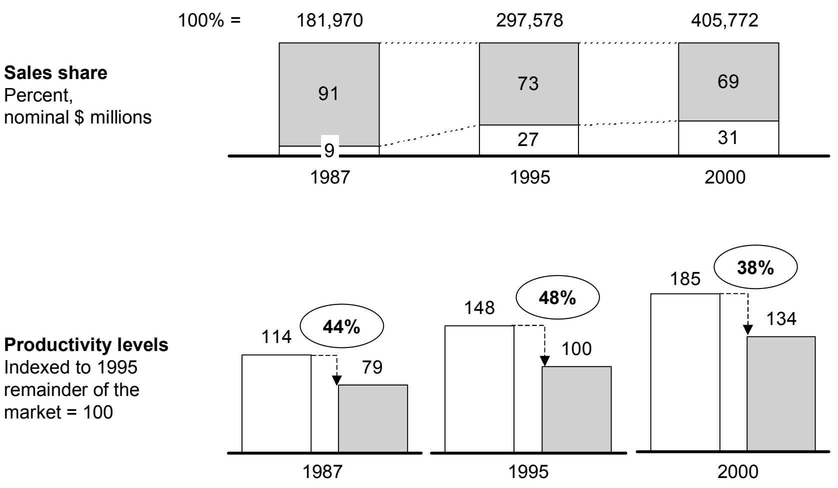
* Calculation is (1 + growth rate one) * (1 + growth rate two)

Note: Productivity growth data does not total due to rounding

Source: BEA; BLS; US Census Bureau; MGI analysis

Exhibit 17

WAL-MART CONTINUES TO GAIN SHARE AND IMPROVE PRODUCTIVITY



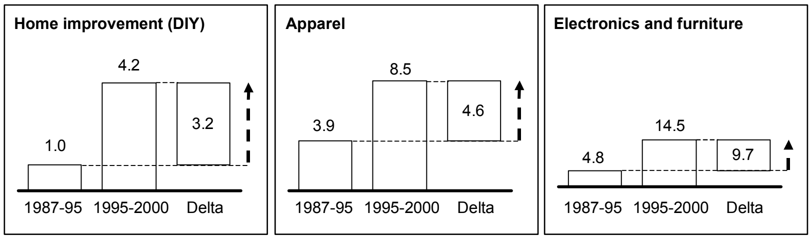
Source: BEA; US Census Bureau; 10Ks; annual reports; MGI analysis

Exhibit 18

THREE OTHER SUBSECTORS MGI INVESTIGATED ALSO SAW PRODUCTIVITY JUMP IN THE MID 1990s

CAGR, percent

Productivity growth



	1987-95	1995-2000	1987-95	1995-2000	1987-95	1995-2000
Real sales per hour	0.6	4.1	4.0	5.8	5.5	10.3
Value added per unit of real sales	0.4	0.0	-0.1	2.5	-0.7	3.8

Source: BEA; BLS; US Census Bureau; MGI analysis

SEMICONDUCTOR SECTOR LABOR PRODUCTIVITY

The jump in the productivity growth rate for 1995-2000 as compared to 1987-1995 looks very similar to the results published last year using the available 1995-1999 data. The semiconductor sector has the largest productivity growth rate of any US sector and experienced the largest acceleration in productivity during the mid-1990s. This acceleration in productivity is attributable to a change in real value added, which is in turn driven by substantial changes in the semiconductor value deflator. Interestingly, the update also shows a significant increase in the growth rate in the number of employees for the 1995-2000 period as compared to 1995-1999.

Methodology for calculating labor productivity

MGI used data from BLS, NBER, and nominal data from the US Census Bureau to measure productivity growth and jump in the semiconductor sector (Exhibit 19). The real value of shipments and the real cost of materials were determined from the nominal value of shipments and nominal cost of materials and from the input and output deflator. The real value added and total number of employees were used to determine productivity, and productivity growth and jump in the sector.

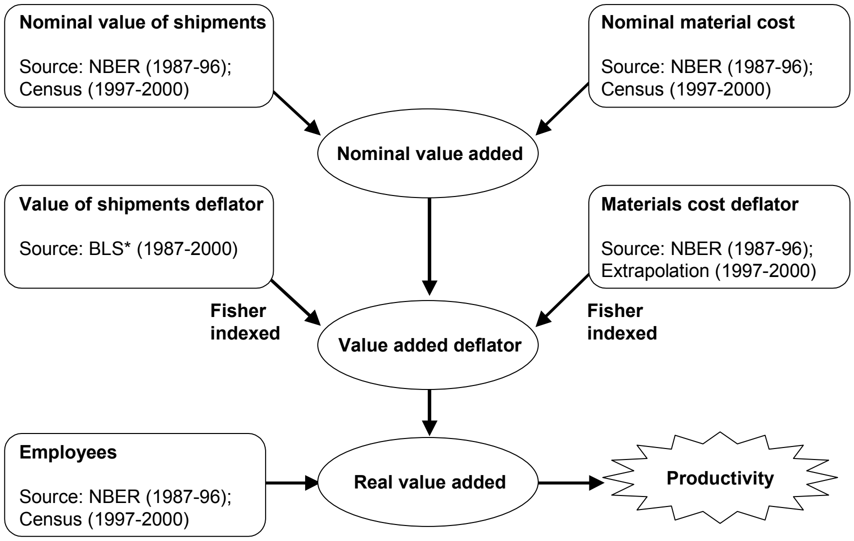
2000 update of productivity measures

The jump in productivity for 1995-2000 looks very similar to the results published last year for 1995-1999 versus 1987-1995 (Exhibits 20a and 20b). The one element of the productivity jump calculation which looks different for 1995-2000 compared to 1995-1999 is the change in number of employees, which increased from 2.8 percent CAGR for 1995-1999 to 4.1 percent CAGR in 1995-2000.

Analysis suggests that continuation of the 1990s economic boom caused leading semiconductor companies to accelerate their hiring, the leading cause for this change. For example, SEC filings from Intel indicate that they experienced a 23 percent increase in total employment from 1999 to 2000, compared to a four-year CAGR (from 1995 through 1999) of 15 percent. In addition, SEC filings from AMD indicate a 10 percent increase in their total number of employees from 1999-2000 compared to a four-year CAGR (from 1995-1999) of 5 percent.

Exhibit 19

HOW MGI MEASURED SEMICONDUCTOR MANUFACTURING PRODUCTIVITY



* BLS received deflator from GPO group at BEA, who adjusted BLS PPIs with price research done by Bruce Grimm

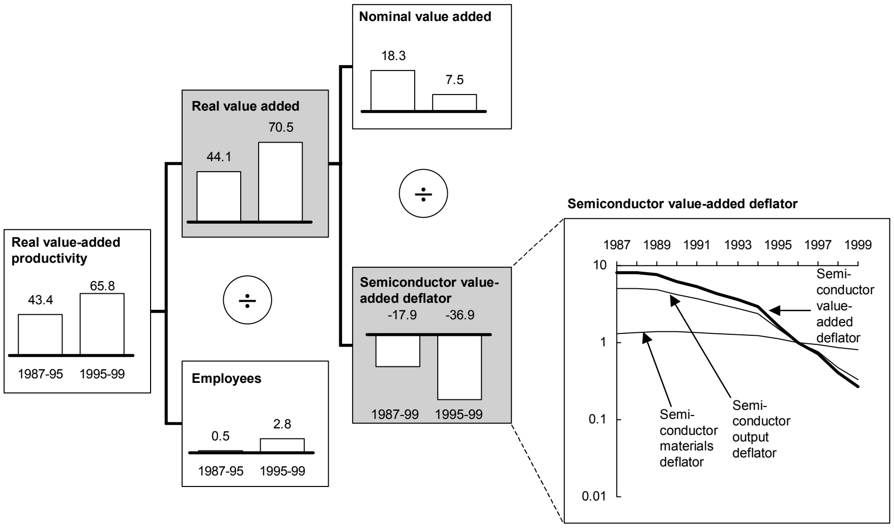
Source: MGI analysis

Exhibit 20a

VALUE-ADDED DEFLATOR WAS MAIN DRIVER OF SEMICONDUCTOR PRODUCTIVITY JUMP IN 1995-99 . . .

CAGR, percent

▨ Primary driver



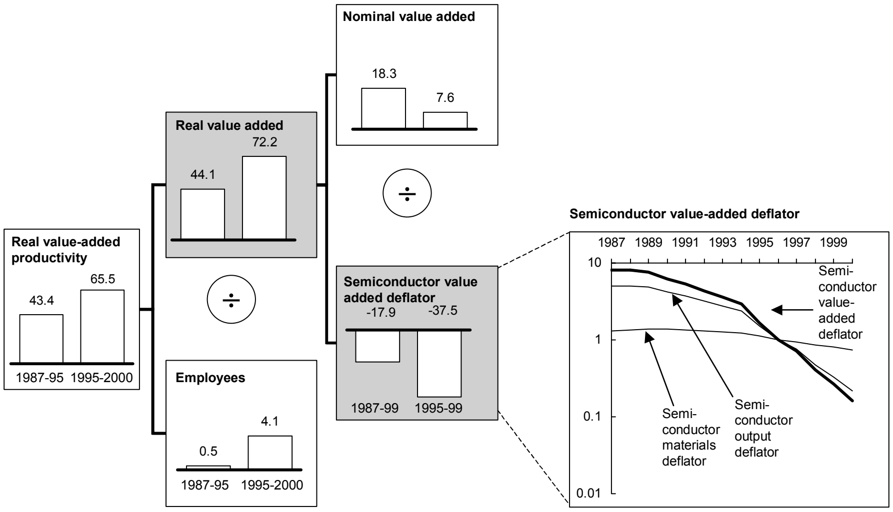
Source: BLS; Census of Manufacturing; NBER; MGI analysis

Exhibit 20b

. . . AND THE STORY REMAINS THE SAME WHEN UPDATED FOR THE PERIOD 1995-2000

CAGR, percent

▨ Primary driver



Source: BLS; Census of Manufacturing; NBER; MGI analysis

TELECOMMUNICATIONS SERVICES (MOBILE ACCESS SUBSECTOR)

The US Productivity Growth report looked at productivity growth rates between 1987-1995 and 1995-1999 for the telecom sector and noted a slight acceleration in the labor productivity growth rates between the two periods. BEA data shows that the telecom sector actually experienced a decline in productivity growth during the period 1995-2000 compared with the period 1987-1995, coinciding with the beginning of the economic downturn (Exhibit 21). In terms of contribution to the overall US productivity growth jump, the telecom services sector ranks ninth among BEA private sector categories (Exhibit 22)[3]. The sector as a whole could contribute to the jump in spite of decelerating productivity growth because its productivity level is above the US average, and it increased its share of employment during 1995-2000.

MGI studied three subsectors: local services, mobile access, and long distance. The current update focused on the mobile access subsector within the telecom sector. Labor productivity growth for mobile access showed significant acceleration during the period 1995-1999. This finding still holds true a year later. When updated with recently available 2000 data, as in the last report, productivity growth for mobile access accelerated between the periods 1987-1995 and 1995-2000, and the majority of the jump was driven by an increase in minutes of use. Rapid price decreases in mobile services continued to be the main driver for the increase in minutes of use.

Methodology for calculating of labor productivity

MGI measured output based on the number of mobile telephone subscribers and the number of call minutes of those subscribers.[4] Labor was based on the total employment of wireless service providers, plus an adjustment for major categories of outsourced labor.

2000 update on subsector's contribution to overall jump in labor productivity

Mobile communications continued to be a significant component of the overall US productivity jump, at 0.08 percent (Exhibit 23). On a standalone basis, mobile would act as the ninth highest contributor to the aggregate US productivity jump[5].

---

[3] Does not include the "holding and investment offices" (due to statistical anomalies) or farms sectors. Telecom services sector is down from being sixth highest among BEA sector categories in terms of its size of jump during 1995-1999.

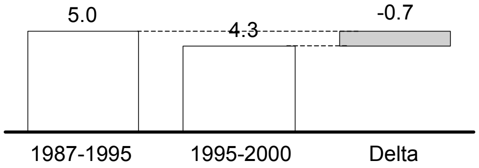
[4] These two measures were given weights based on the implied price of a calling plan with no "free" minutes – approximately $15 per month was allocated to access revenues and the remainder to usage.

[5] After computer manufacturing, retail, wholesale, semiconductors, securities, real estate, farms and health services. Difference in calculation of contribution for telecom overall and telecom mobile is the inclusion of farms and other services. Telecom would rank eleventh if farms and other services were included, while mobile ranks ninth.

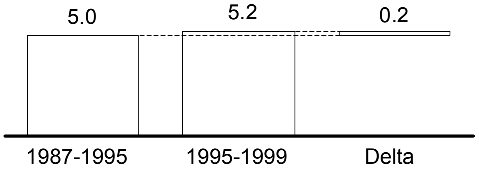
Exhibit 21

2000 DATA FROM BEA SUGGESTS THAT PRODUCTIVITY GROWTH DECCERATED IN THE TELECOM SECTOR DURING 1995-2000

Labor productivity growth, 1987-2000
CAGR, percent



Labor productivity growth, 1987-1999
CAGR, percent

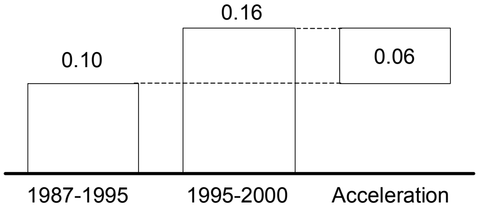


Source: BEA; MGI's "US Productivity Growth 1995-2000" report, October 2001

Exhibit 22

TELECOM SERVICES CONTRIBUTED TO THE OVERALL US PRODUCTIVITY GROWTH JUMP

Contribution to aggregate productivity growth, 1987-2000
CAGR, percent

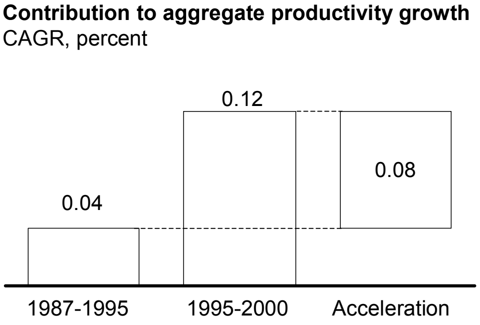


Telecom sector ranks ninth among 59 BEA private sectors in terms of its size of jump down from sixth during 1995-99

Note: Not including the "holding and investment offices" (due to statistical anomalies) or farm sectors
Source: BEA; MGI analysis

Exhibit 23

MOBILE COMMUNICATIONS CONTINUED TO BE A SIGNIFICANT COMPONENT OF THE OVERALL US PRODUCTIVITY GROWTH JUMP



On a standalone basis, mobile would rank as the sector with the ninth highest contribution to jump*

* After computer manufacturing, retail, wholesale, semiconductors, securities, real estate, farms and health services. Does not include contribution of "holdings and investment offices" because that sector's high contribution is due to statistical irregularities

Source: BEA; MGI analysis

This is particularly interesting, in light of the telecom sector's overall contribution to the jump during 1995-2000. In fact, employment in the telecom sector increased from 1999 to 2000 even as output began to slow down, contributing in part to the decreased productivity for the overall sector.

2000 update of labor productivity measures for mobile access subsector in telecom industry

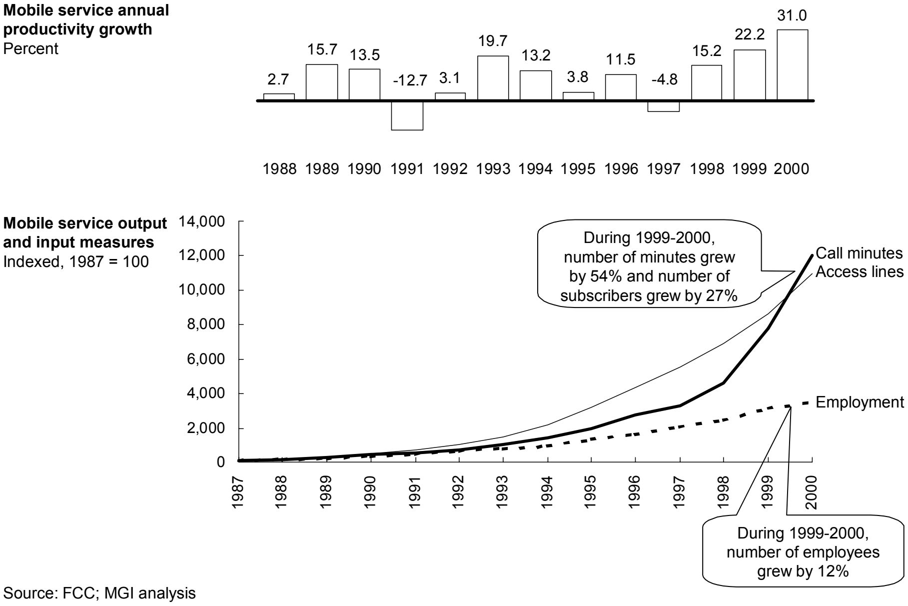
Overall productivity growth during 1995-2000 accelerated at 14.3 percent, compared with 6.9 percent during 1987-1995. Calculations using 2000 data showed that productivity grew significantly from 1999 to 2000, at the rate of 31 percent (Exhibit 24).

- ¶ **Minutes of use.** Number of minutes used increased 54 percent during 1999-2000 (Exhibit 24). Total wireless subscribers grew at 27 percent, while the number of minutes per subscriber per month grew at 21 percent.
- ¶ **Labor.** The number of people employed in the mobile access subsector grew at 12 percent, at a rate slower than the growth in the subscriber base.

Rapid price decreases in mobile services continued to be the main driver for the increase in minutes of use (Exhibit 25).

Exhibit 24

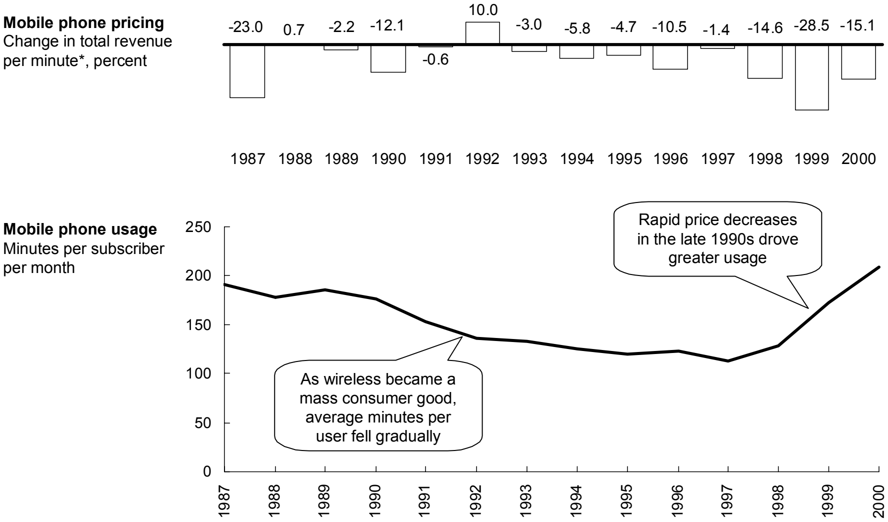
PRODUCTIVITY IN MOBILE CONTINUED TO BE DRIVEN BY RAPID INCREASES IN OUTPUT



Source: FCC; MGI analysis

Exhibit 25

LOWER PRICES FOR MOBILE CALLS PROMPTED USAGE IN LATE 1990s, BUT PRICES DECLINED LESS IN 2000 THAN IN 1999



* Simple division of total industry revenues by total call minutes

Source: CTIA; MGI analysis

WHOLESALE TRADE

The original MGI report looked at productivity growth rates between 1987-1995 and 1995-1999 for the wholesale trade sector, as it is one of the largest sectors of the US economy and made the largest contribution to the acceleration in productivity between the two periods.[6] During the course of the current study MGI updated the productivity metrics for wholesale using revised 1999 data and including newly available data for the year 2000.

While most of the general observations made in the original report continue to hold true, there are some significant departures in the detailed metrics as a result of the update. Wholesale trade did experience an acceleration in productivity from 1995-2000 versus 1987-1995, but the jump is considerably smaller than that reported on the basis of original 1995-1999 data. This change comes as a result of both a revision of 1999 BEA data and a continuing decline in the productivity growth rate in the year 2000.

Methodology for calculating labor productivity

MGI calculated productivity for the wholesale sector overall based on real value added per persons engaged in production (PEP) using BEA data. Value added is calculated as gross margin minus purchased services and PEP includes full-time and part-time employees as well as self-employed workers.

2000 update of labor productivity

MGI updated the productivity metrics for wholesale using revised 1999 data and to include newly available data for the year 2000. While most of the general observations made in the original report continue to hold true, there are some significant departures in the detailed metrics as a result of the update. Primarily, wholesale trade does experience acceleration in productivity from 2.9 percent in 1987-1995 to 6.2 percent in 1995-2000, representing a jump of 3.3 percentage points. This jump is considerably smaller than reported on the basis of original data, with a 1995-1999 growth rate of 8.2 percent and a delta of 5.3 percentage points. The change comes as a result of both a revision of 1999 BEA data and a continuing decline in the productivity growth rate in the year 2000. BEA gross margin data is revised over several past years based on results of subsequent benchmark surveys for additional accuracy.

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[6] The difference in the growth rates between the two periods constituted the productivity jump or acceleration.

Overall sector contribution to US productivity

According to the revised BEA data, productivity growth peaked in 1998, with 9.1 percent CAGR for 1995-1998 and has declined ever since, with 7.4 percent for 1995-1999 and 6.2 percent for 1995-2000 (Exhibit 26). As a result wholesale trade is no longer the largest contributor to the productivity growth jump experienced by the US economy overall. Slower productivity growth evident in revised 1999 data and 2000 data means that wholesale made a significantly smaller contribution to the productivity acceleration of the US economy and in fact has been overtaken by the retail and securities sectors.

Wholesale trade's subsector productivity

Wholesale trade is a very fragmented sector, made up of 18 subsectors with widely varied profiles (Exhibit 27). While one can calculate value added productivity for the sector as a whole, it is not possible to calculate it by subsector because several critical pieces of data are not available on the subsector level.[7] Thus, it is not possible to make a determination of the causes of productivity growth in a way comparable to other sector cases.

The most recent available data for wholesale subsectors is a release published by the BLS, which calculates productivity indexes based on real sales per hour. This productivity measure is based purely on output and does not subtract inputs such as cost of goods sold or purchased services. Acknowledging this limitation and the inability to compare output productivity with value added productivity, we observed that real sales per hour growth declined for wholesale trade overall between 1999 and 2000 (Exhibit 28). Both the durable goods and nondurable goods segments show the same pattern (Exhibit 29). Employment in the sector and the durable and nondurable goods segments has continued to grow so that the 1995-1999 and 1995-2000 growth rates are very similar (Exhibit 30).

Growth in real sales per hour differs considerably among subsectors (Exhibits 31a, 31b, and 31c). The subsectors are ordered in terms of their size by employment. Groceries and related products, the largest subsector, has seen continuing improvement in output productivity. Professional and commercial equipment, the second largest subsector, has experienced the highest productivity growth rates of all the wholesale subsectors. However, its productivity growth between 1999 and 2000 slowed. In fact, 10 of the 18, subsectors accounting for 41 percent of employment, experienced slower output productivity growth in 2000. It is clear that wholesale sales have slowed for many goods including computers, motor vehicles, drugs, and petroleum between 1999-2000.

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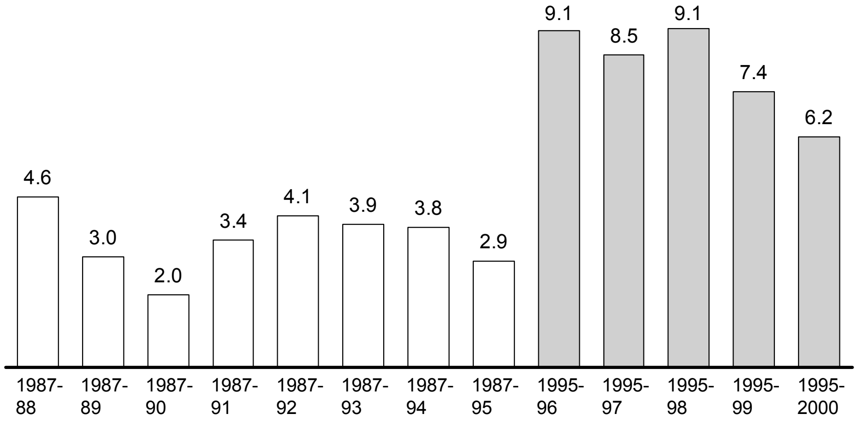
[7] Both purchased services and sales data are not available annually by subsector. Sales data is reported by the US Census Bureau every five years by subsector, and the BEA reports gross margin data annually. Purchased services data is not available for wholesale by subsector.

Exhibit 26

WHOLESALE SECTOR PRODUCTIVITY* GROWTH PEAKED IN 1998 AND SLOWED BETWEEN 1999 AND 2000

CAGR, percent



* Productivity is defined by the BEA as real gross domestic product (GDP, a value-added measure) per PEP (persons engaged in production)

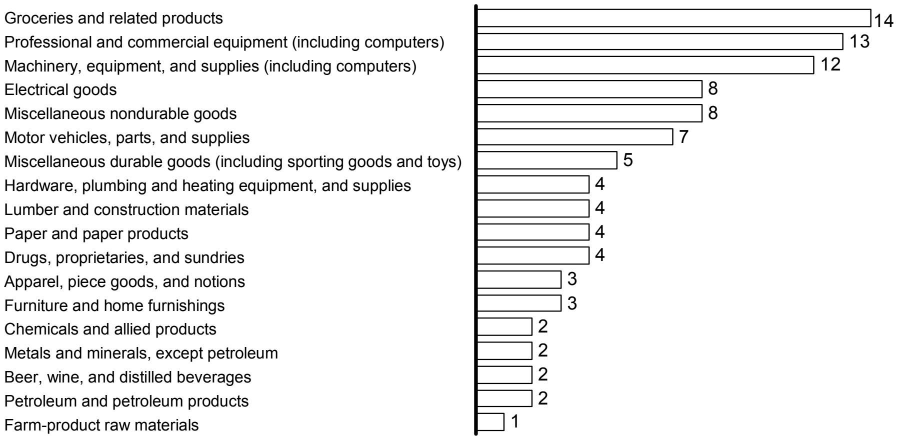
Source: BEA; BLS; MGI analysis

Exhibit 27

EMPLOYMENT IN WHOLESALE TRADE IS FRAGMENTED

2000 employment

Percent (100% = 1.3 million)



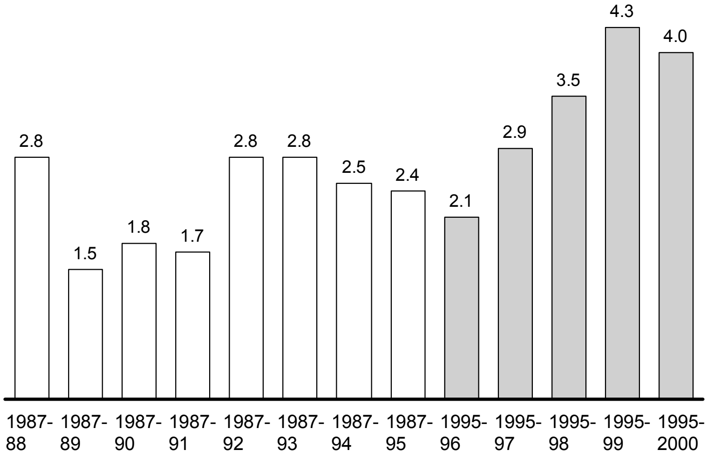
Source: BLS

Exhibit 28

WHOLESALE TRADE PRODUCTIVITY GROWTH SLOWED 1999-2000

Real sales per hour

CAGR, percent

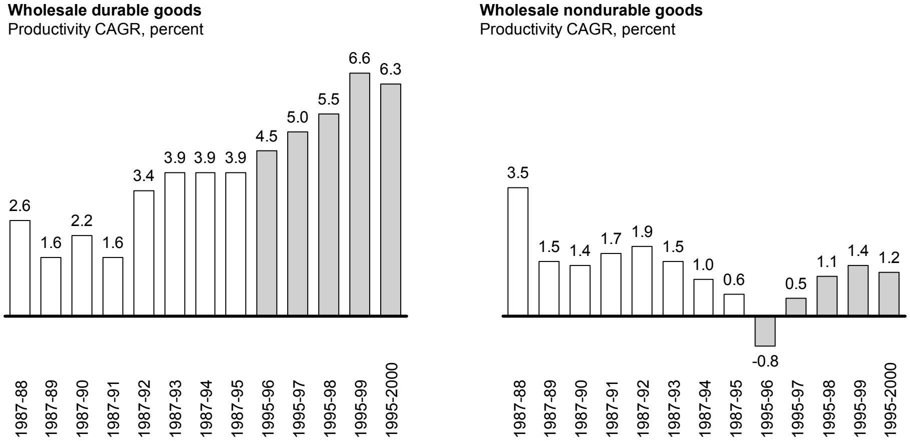


Note: BEA productivity numbers based on value added PEP per hour also show a decline but starting in 1998 (Exhibit 26)

Source: BLS; MGI analysis

Exhibit 29

BOTH DURABLE AND NONDURABLE GOODS SAW A SLOWDOWN IN PRODUCTIVITY IN 1999



Wholesale durable goods

Productivity CAGR, percent

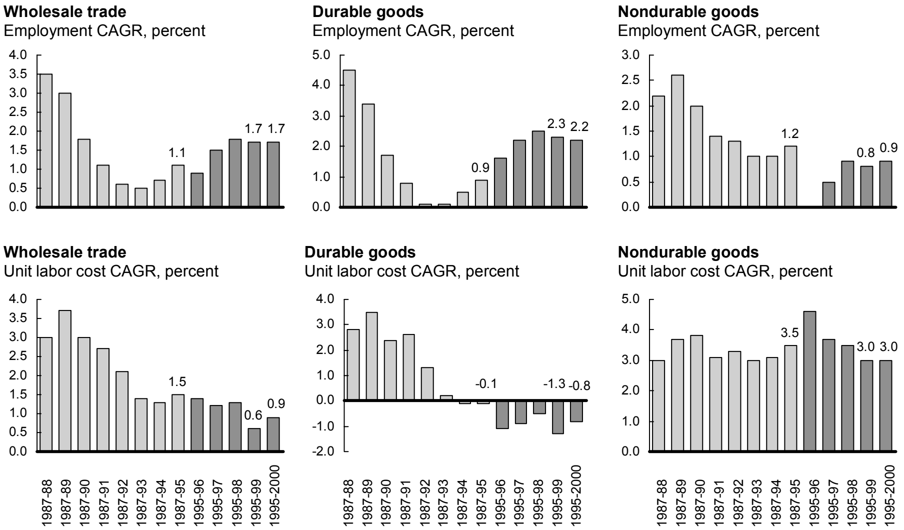
Wholesale nondurable goods

Productivity CAGR, percent

Source: BLS; MGI analysis

Exhibit 30

EMPLOYMENT GROWTH RATE WAS FLAT 1999-2000



Wholesale trade
Employment CAGR, percent

Durable goods
Employment CAGR, percent

Nondurable goods
Employment CAGR, percent

Wholesale trade
Unit labor cost CAGR, percent

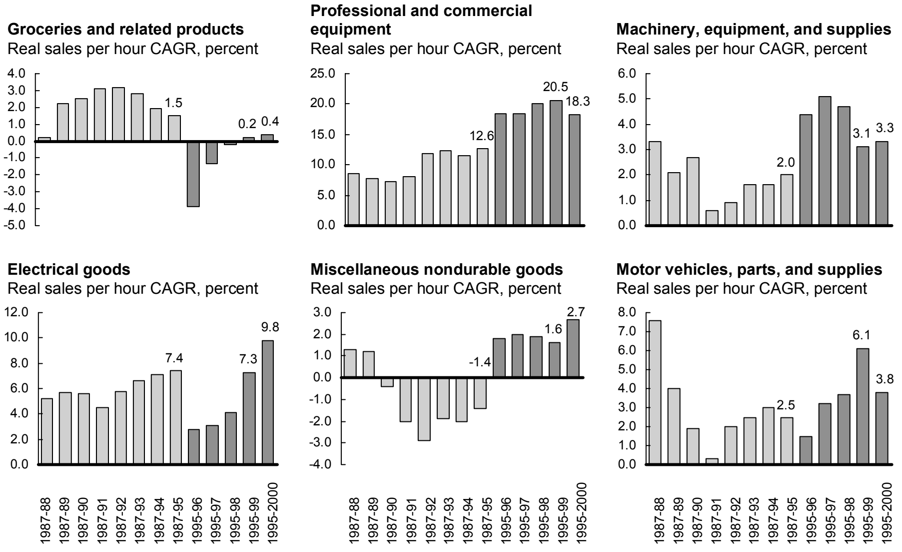
Durable goods
Unit labor cost CAGR, percent

Nondurable goods
Unit labor cost CAGR, percent

Source: BLS; MGI analysis

Exhibit 31a

PROFESSIONAL EQUIPMENT AND MOTOR VEHICLE PARTS SUBSEGMENTS SAW A SIGNIFICANT DECLINE IN PRODUCTIVITY



Groceries and related products
Real sales per hour CAGR, percent

Professional and commercial equipment
Real sales per hour CAGR, percent

Machinery, equipment, and supplies
Real sales per hour CAGR, percent

Electrical goods
Real sales per hour CAGR, percent

Miscellaneous nondurable goods
Real sales per hour CAGR, percent

Motor vehicles, parts, and supplies
Real sales per hour CAGR, percent

Source: BLS; MGI analysis

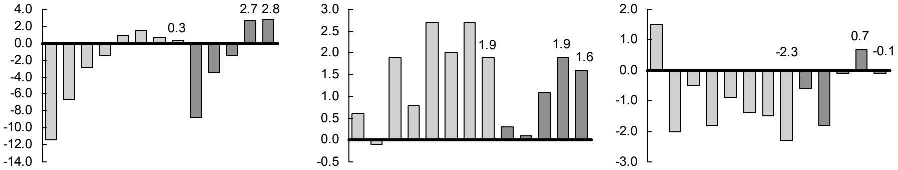
Exhibit 31b

AS DID MOST OTHER SUBSEGMENTS IN WHOLESALE TRADE (CONTINUED)

Miscellaneous durable goods
Real sales per hour CAGR, percent

Hardware, plumbing and heating equipment, and supplies
Real sales per hour CAGR, percent

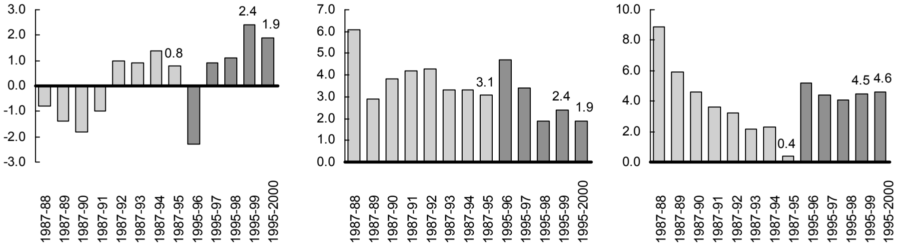
Lumber and construction materials
Real sales per hour CAGR, percent



Paper and paper products
Real sales per hour CAGR, percent

Drugs, proprietaries, and sundries
Real sales per hour CAGR, percent

Apparel, piece goods, and notions
Real sales per hour CAGR, percent



Source: BLS; MGI analysis

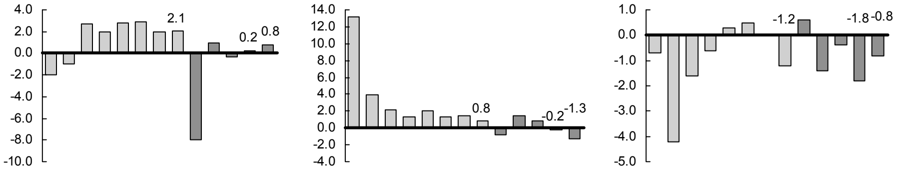
Exhibit 31c

AS DID MOST OTHER SUBSEGMENTS IN WHOLESALE TRADE (CONTINUED)

Furniture and home furnishings
Real sales per hour CAGR, percent

Chemicals and allied products
Real sales per hour CAGR, percent

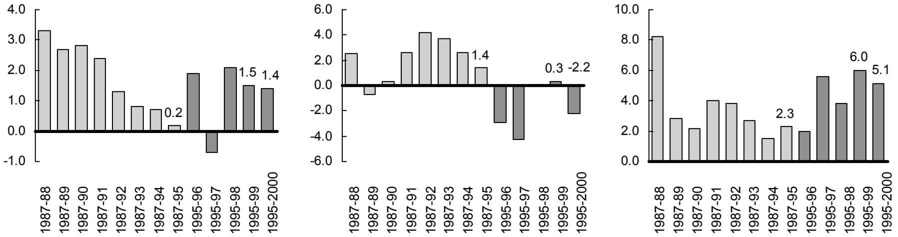
Metals and minerals
Real sales per hour CAGR, percent



Beer, wine and distilled beverages
Real sales per hour CAGR, percent

Petroleum and petroleum products
Real sales per hour CAGR, percent

Farm-product raw materials
Real sales per hour CAGR, percent



Source: BLS; MGI analysis

One year is a short time period and reported data fluctuates considerably year-to-year and should be viewed with caution. Productivity trends over multiple years are more reliable. Thus, it remains to be seen if the very late 1990s mark the beginning of a slowdown in productivity growth for the wholesale trade and some of its constituent subsectors.

Glossary of terms used in productivity updates

Term	**Definition**
Acceleration	Increase in the annual growth rate of labor productivity from one time period to other. The acceleration is typically measured in terms of percent point difference between the labor productivity growth rates in the two time periods. In this report, the words “acceleration” and “jump” are used interchangeably.
ACH	Automated clearing house.
ATM	Automated teller machines.
BEA	Bureau of Economic Analysis, US Department of Commerce.
BLS	Bureau of Labor Statistics, US Department of Labor.
Contract manufacturer	Third party companies that provide manufacturing services.
Contribution	The portion of aggregate (sector) productivity growth or growth acceleration that is attributable to a specific industry (subsector or firm).
CRM	Customer relationship management; refers to tools and software for automating and improving effectiveness of sales, marketing and customer service functions.
Deflator	A price index; used to convert nominal numbers to quality adjusted output measures.
EFTPOS	Electronic funds transfer at point-of-sale.
Fisher index	Calculates the change in real quantity between two time periods and is the geometric mean of the Laspeyres quantity index and the Paasche quantity index.
FTE	Full-time equivalent employees.

Term	**Definition**
GDP	Gross domestic product. Calculated by the BEA as the sum of value added across all the sectors of the economy.
GMS	General merchandise stores; a subsegment of retail trade.
Gross margin	Revenues minus cost of goods sold.
Jump	See “acceleration.”
Long distance	Refers to carriage of voice and data from one access provider to another.
Local services	Refers to transport of voice and data within a metro area over physical links (rather than through airwaves).
Mobile access	Refers to wireless voice communications, including cellular, personal communication service, and specialized mobile radio communications.
Nominal	Measured in current dollars; not adjusted for inflation.
NBER	National Bureau of Economic Research; private, non-profit research organization.
Payment transaction	Refers to payments via checks, credit cards, debit cards, electronic transfers, and automated teller machines.
POS	Point-of-sale debit card transactions.
Productivity	Productivity in this report refers to labor productivity.
Purchased services	Intermediate services (as opposed to direct cost of goods sold) bought by firms in generating output (e.g., rent, utilities, marketing expenses).
Real	Measured in constant dollars; adjusted for inflation.
Sector	As defined by the Bureau of Economic Analysis. The BEA lists 60 individual sectors in the US private sector.
SEC	Securities and exchange commission; financial regulatory body in the US.
SIC	Standard Industrial Classification, a system used by the US Census Bureau to categorize firms by business type.

Term	**Definition**
Value added	Value of a firm’s output minus the value of the intermediate goods the firm purchased. Corresponds to the sum of operating profits and wages.
Y2K	Software changes and IT system modifications to assure compliance with the "Year 2000" date change.

Appendix B

Measurement issues in evaluating split among various classes of IT capital stock and spend

To test the theory that productivity acceleration could be correlated with investment in a particular type of capital stock, MGI analyzed whether jumping sectors exhibited a pattern of capital stock ownership and/or spend distinct from that of paradox sectors. For example, we assessed whether jumping sectors invested a higher percentage of their capital spend in software rather than hardware, or if they invested proportionally more in communications equipment versus other types of capital stock. MGI ultimately concluded that it was not possible to conduct meaningful analysis on types of capital stock due to the limitations of the available data.

MGI scrutinized the BEA's IT capital stock figures as part of its 2001 productivity report, and concluded that the aggregate IT data by sector was appropriate for making overall, cross-sector IT intensity comparisons. In this study, MGI also hoped to analyze the sub-components of IT stock by sector. Capturing this data poses enormous challenges for the BEA, which bases its post-1992[1] data on survey-based interpolation/distribution, and is unable to capture leased IT.

For these numbers to be significantly off in an industry, the share of IT in the productive assets of an industry must have changed significantly since 1992 and in a way different than the aggregate share of IT in productive assets. Unfortunately this is exactly the kind of change that might explain differences in IT spend type between sectors. Since it is difficult to know whether such a change actually occurred, it is also difficult to know how meaningful is a split among various types of IT capital stock that is influenced by the split of IT capital stock in the sector in 1992. Furthermore, since software (except for own-account[2]) is extrapolated based on hardware spend, there is no way to identify differences among sectors based on different levels of software spend.

Therefore, we have concluded that further analysis of the allocation of type of IT capital stock as reported by the BEA as a way to explain performance differentials

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[1] See below for more details on methodology of raw data collection.

[2] Own-account software refers to software developed internally by the company for their own use.

across sectors is not useful. While the BEA methodology is completely reasonable given data and resource constraints, it is not sensitive enough to look at differences in asset split across sectors, particularly over time.

Below, we describe in more detail the BEA methodology for calculating IT capital asset stock and spend.

Determination of US aggregate numbers for all types of IT assets (except own-account software)

Aggregate hardware, communications equipment, and software (except own-account software) spend for the US economy is determined from the supply side. The total supply side numbers are determined from the sales figures of the various suppliers. The aggregate supply side number is adjusted for intermediate consumption, imports and exports, and for changes in inventory. Consumer surveys and US Census numbers are used to determine and eliminate consumer consumption; the leftover residue is the total investment spend for the US economy.

Determination of spend in various types of IT assets (except own-account software) by the various sectors

IT spend per type of asset per sector is determined based on the capital flow table. The capital flow table is derived from the input/output (I/O) table developed on basis of the 1992 Census. In 1992 software was not considered as an investment, so software is assumed to have the same distribution as computers among sectors in that year. The capital flow table is updated yearly based on capital equipment survey numbers, which include industry total capital expenditure, and reconciled with NIPA[3] numbers, which include aggregate capital expenditure by type. Spend on various asset categories (e.g., PCs, mainframes, printers) for the 62 sectors is determined based on an updated capital flow table.

Determination of spend in own-account software numbers by the various sectors

The own-account software spend data for each sector is determined from BLS and census data. BLS data is used to determine the number of system analysts and computer programmers in nine major sectors (mining and construction, manufacturing durable goods, manufacturing nondurable goods, transportation, communication, utilities, trade, FIRE[4], and services) as a percent of the total employment numbers in these sectors. Data for the manufacturing and business

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[3] National income product account (NIPA) data from the BEA

[4] Finance, insurance and real estate sector (FIRE)

services sectors is normalized to the other nonmanufacturing sectors numbers to remove the effect of embedded software development and the development of software for sale.

Normalized percentages of system analysts and computer programmers are applied against each sector's employment numbers to arrive at the number of system analysts and computer programmers in that sector. National average salaries for computer programmers and systems analysts are applied against the total number of programmers and system analysts in that sector to get sector-level total spend on in-house developers. This number is then adjusted for other compensation to employees and for consumption of other inputs (overhead, depreciation of computers, etc.). Half of this number is considered as equal to sector-specific own-account software spend numbers, since it is assumed that, per sector, programmers and systems analysts spend 50 percent of their time developing in-house applications.

Determination of stock numbers for various types of assets in all sectors

Stock data per type of asset per sector is determined by using the depreciation schedule against spend per asset type in that sector in the previous years and then adding in the current year's spend for that asset in that sector.