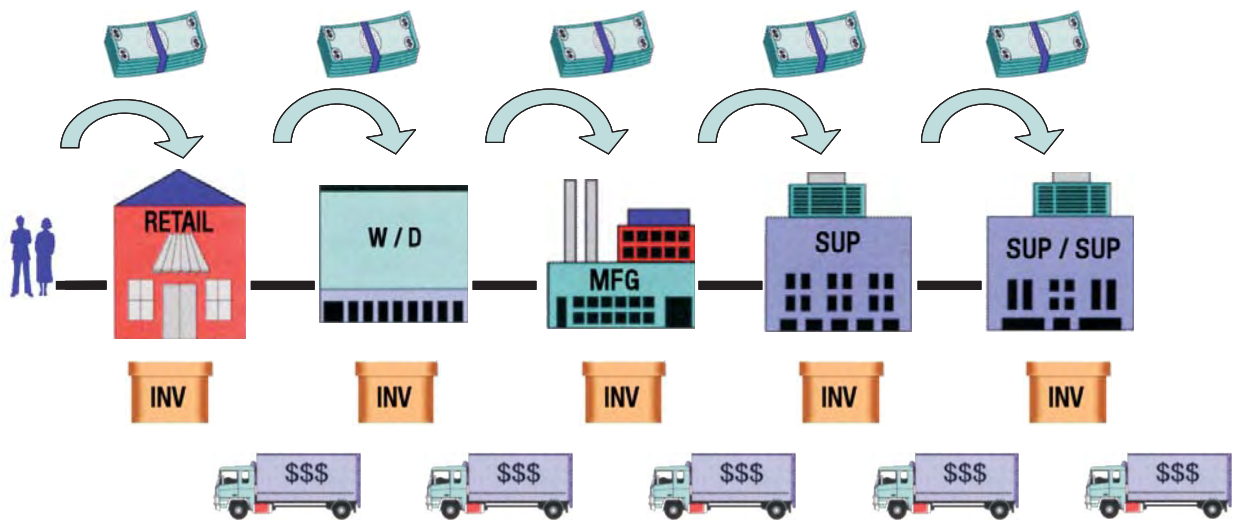


Supply Chain Management

The Science of Better, Faster, Cheaper



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Supply Chain Management: The Science of Better, Faster, Cheaper

Supply chain management is one of the most important strategic aspects of any business enterprise. Decisions must be made about how to coordinate the production of goods and services, how and where to store inventory, whom to buy materials from, and how to distribute them in the most cost-effective, timely manner.¹

Consider a typical manufacturer. The supply chain is made up of many interrelated firms (**Figure 1**). There are parts suppliers, component suppliers and subassembly suppliers. Further up the chain are the suppliers' suppliers, finally reaching the raw materials suppliers at the far end of the chain.

Going downstream, back through the producing firm, the supply chain continues through the warehousing and distribution channels, and then through the retail channels, ending with the consumer.

The supply chain encompasses all activities associated with the flow and transformation of goods and services from the raw materials stage (at one end of the supply chain) through to the customer (at the other end of the chain), including all associated information flows.

Overview

After defining and explaining supply chain management, its evolution and transforming effects on the design and structure of corporations will be reviewed. Then, specific components within the supply chain will be identified and several metrics to gauge the level of supply chain improvements over time will be examined. Of particular interest here is the impact of new information technologies on supply chain operations now and into the future. Finally, the macroeconomic benefits of improved supply chain operations will be explored.

Supply Chain Management: The Science of Better, Faster, Cheaper

Supply chain management is getting the right things to the right places at the right times, for profit (**Figure 2**). While supply chain management is as old as trade itself, new information and communications technologies have revolutionized today's supply chains, making them extraordinarily better, faster, and cheaper.

Figure 1

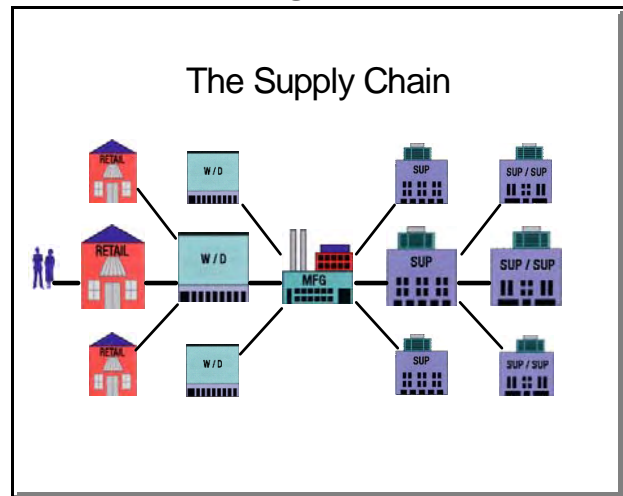
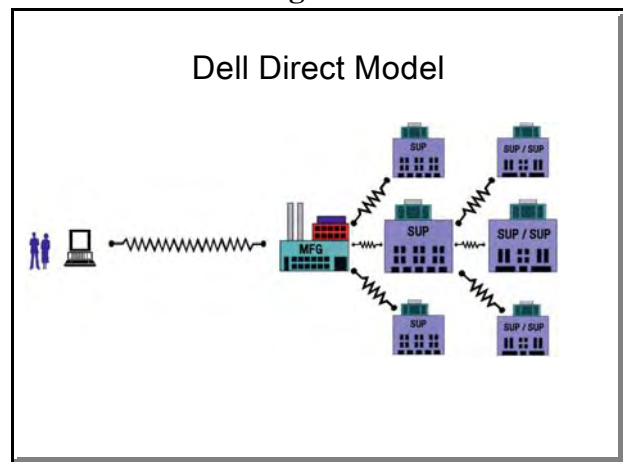


Figure 2



Figure 3

For example, one way to buy a computer today is to get on Dell's website and configure and price a system exactly as you want it (**Figure 3**). As soon as you click the mouse and submit the online order to Dell, all of Dell's global suppliers—those supplying chips, monitors, and so on—are immediately notified of the sale and react as necessary so that you receive your computer within a week.



Contrast this direct sales model with yesterday's supply chain where you went to a store in search of a product that the manufacturer thought you wanted. Now, the middlemen between you and the manufacturer can be eliminated, and Dell's upstream suppliers play a key real-time role in keeping production and distribution flowing smoothly.

Better supply chain models don't just help manufacturers of physical goods, but also service businesses, including those that require great creativity, imagination, and specialized knowledge.

For example, using a virtual reality system and ultrasound data sent through the Internet, a medical specialist in Dallas can give an opinion to a patient in Atlanta...or London...or Bombay. A virtual reality system, worn around the hand and arm, allows a physician to feel pressure sensations from computer images and make an informed diagnosis in real-time, half-way around the globe.

Using the Internet and associated information technologies, bits of information—strings of zeroes and ones—can be shipped anywhere in the world in seconds at virtually no cost, opening up a world of opportunity and rapid innovation. Moreover, with digital products there are no time-to-manufacture delays, no inventory shortages, and no delivery problems.

Supply Chain Evolution

Throughout history, new ideas and technologies have revolutionized supply chains and changed the way we work. Two hundred years ago, giant mechanical machines replaced labor to complete tasks in large factories. Railroads, electricity and new communications mediums expanded markets and also made supply chains better, faster, and cheaper.

Then, in the early 1900s, Henry Ford created the first moving assembly line, utilizing scientific management methods. This reduced the time required to build a Model T from 728 hours to 1.5 hours, and ushered in the mass production era. Over the next 60 years or so, American manufacturers became adept at mass production with the help of many operations research techniques.

But in the 1970s, U.S. manufacturing's superiority was challenged by lower costs and higher quality products from foreign firms in many industries. Global competition forced U.S. manufacturers to concentrate on improving quality by reducing defects in their supply chains.

Starting in the early 1970s, Japanese manufacturers like Toyota changed the rules of production from mass to lean. Lean manufacturing focuses on flexibility and quality more than on efficiency and quantity. Significant lean manufacturing ideas include six-sigma quality control, just-in-time inventory and total quality management.

Today, businesses are improving their supply chains through better information engineering. Since about 1995—around the time of the commercial application of the Internet—we have been in the mass customization era. Now, manufacturers can mass-produce customized products. It’s no longer “you can have any color Model T as long as it’s black.”

Firms are effectively using new information technologies like the Internet and wireless telecommunications to improve service and delivery processes. Through secure intranet systems and business-to-business (B2B) e-commerce platforms, the focus is on improving information management: integrating internal systems with external partners—like Amazon’s practice of giving customers the ability to track the delivery location of their purchases through Amazon’s website. Or Wal-Mart’s routine practice of sharing all sales data in real-time with its upstream suppliers and manufacturers.

Supply Chain Components

The supply chain has basically four components:

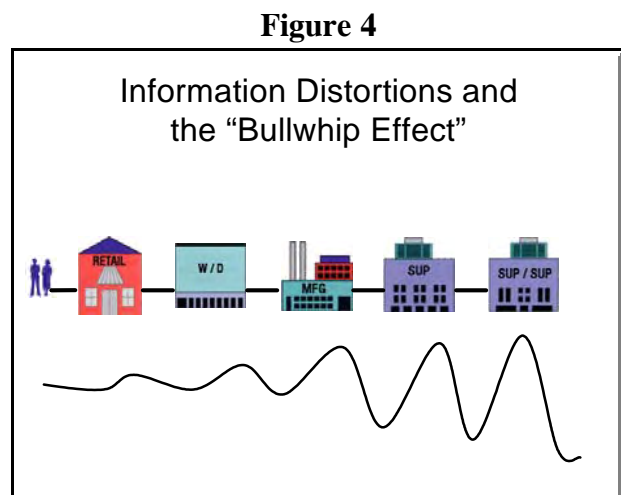
- (1) Production: where businesses focus on how much to produce, where to produce it, and what suppliers to use.
- (2) Inventory: where businesses decide where to store their products, and how much to store.
- (3) Distribution: where businesses address questions about how their products should be moved and stored.
- (4) Payments: where businesses look for the best ways to pay suppliers and get paid by customers.

The efficiency and effectiveness of a supply chain is contingent on the ability to gather and analyze important information through these components.

Information Distortions and the Supply Chain

Distorted information, or the lack of information, is the main cause of the “bullwhip effect,” named after the way the amplitude of a whip increases down its length (**Figure 4**). In essence, the bullwhip effect states that fluctuations in orders become larger at every step up the supply chain, from the customer through to the raw materials suppliers.

Proctor and Gamble (P&G) executives coined the term after studying the demand for disposable diapers (**Figure 5**). As expected, babies use diapers at a fairly steady and predictable rate, and retail sales are quite uniform. But, P&G found that each retailer bases his own orders on his own slightly exaggerated forecast, thereby distorting the information about real demand. Wholesaler’s orders to the P&G diaper factory fluctuated even more. And P&G’s orders to 3M and other materials suppliers fluctuated even more.



The bullwhip effect phenomenon has been observed in many different industries and occurs whenever demand uncertainties and variability become magnified when viewed by managers at each link in the supply chain. It's one of the most important causes of inefficiency in a supply chain.

Production

One way to see how severe the bullwhip effect is in production is to examine sales growth volatility at the customer end of the supply chain and compare it with production growth volatility at the opposite end of the supply chain (Figure 6). Supply chains that use real-time information effectively should have an information distortion bullwhip that looks more like the shallower red line.

Figure 7 shows that for durable goods, production growth volatility is now much closer to sales growth volatility. The dramatic improvement in production growth volatility occurred as improved manufacturing and quality control processes combined with new information technologies to bring significant improvements to supply chain operations.

For example, JC Penney has implemented a revolutionary computer system that directly captures sales data for each of its products at the cash-register level. Rather than making forecasts on what corporate managers think they will sell, forecasts are now based on real-time point-of-sale data.

For certain men's dress shirts, JC Penney has gone a step further and has outsourced the sales forecasting and inventory management functions to the shirt maker in Hong Kong. So now, a supplier in Hong Kong decides how many shirts to make, and in what styles, colors and sizes, and then sends the shirts directly to each JC Penney store—bypassing JC Penney's corporate decision makers and its warehouses.

Inventory

Information distortions and the bullwhip effect also unnecessarily increase inventory at all points along the supply chain. In many respects, inventory is insurance against supply chain uncertainties. Unused and unsold inventory can carry burdensome costs: holding costs, warehouse and

Figure 5

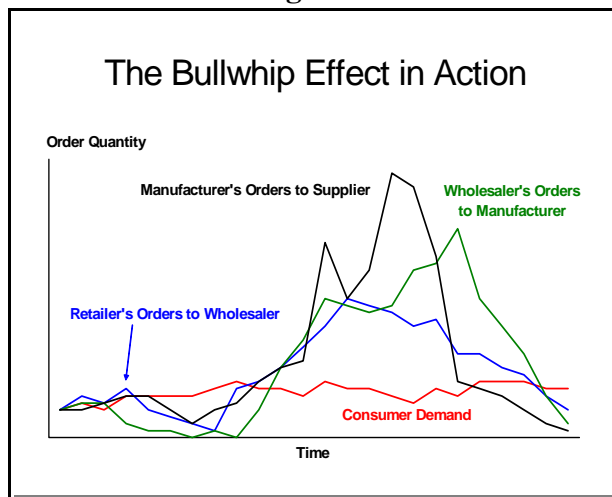


Figure 6

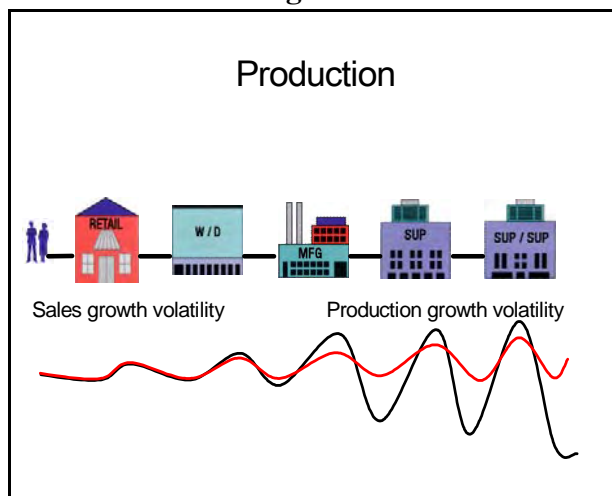
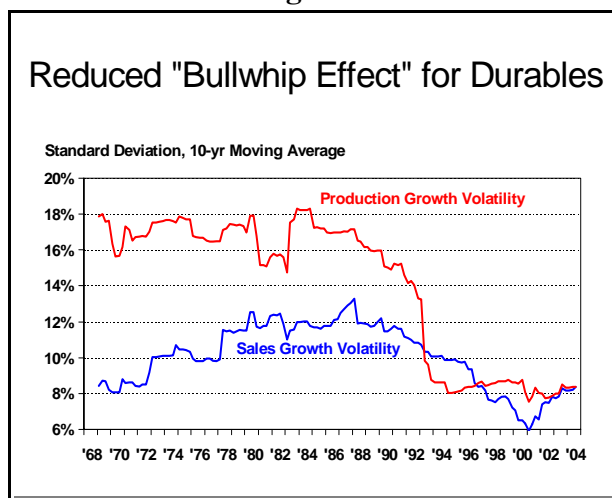


Figure 7



production-line storage costs, insurance costs, and costs due to obsolescence and spoilage. At the same time, however, sufficient inventory must be maintained to meet demand and to keep production flowing as smoothly as possible.

As shown in **Figure 8**, producers have streamlined their operations to hold less inventory. The inventory-to-shipments ratio dropped markedly during the 1990s and is now near its all-time low. In essence, new technologies have allowed firms to replace inventory with information and then use that information more productively.

Indeed, Dell has turned traditional manufacturing thinking on its head by saying that it will not make anything until it receives an order from a customer. In 1996, Dell held 31 days of inventory—today they hold 4 days of inventory.

Distribution

Just about everything that we consume is taken from the earth, processed, and transported, often with many processing and transportation steps before it is available to consumers. Today, the transportation and distribution of goods often involves greater distances and better coordination.

Yet, as **Figure 9** shows, logistics costs have trended downward: from about 16 percent of GDP in 1981 to around 8.5 percent today. Transportation costs have declined by nearly 25 percent, whereas inventory carrying costs have declined by more than 65 percent. Logistics costs have declined primarily because inventories are managed more efficiently: warehousing expenses have been reduced, and risks have been minimized as third-party providers increasingly furnish specialized and customized logistics solutions that are more efficient.

Payments

Furthermore, as technology costs have fallen and electronic connections between companies increase, more firms are adopting digital technologies and eliminating paper transactions and human contact. Automatic order placement, billing, and payment can all be triggered and performed by a computer without requiring human intervention and a trail of paperwork. And more and more companies have developed B2B e-commerce systems to streamline payments and create a sense of community for communicating with suppliers. Such systems also guarantee faster payment and result in fewer losses. Progressive Insurance uses satellites, camera phones, software, and the Internet to issue final settlement checks on the spot within minutes of being called to an accident scene.

Figure 8

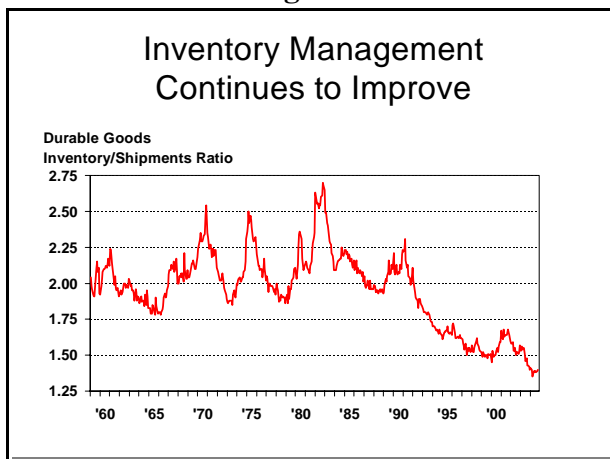
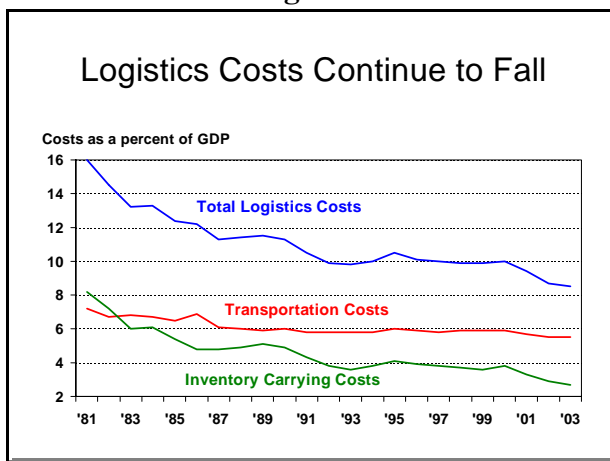


Figure 9



All of these improvements—reduced production volatility, lower inventory levels, less expensive logistics, and streamlined payments systems—have a common characteristic: they all use better methodologies and better technologies to manage information more efficiently and effectively. Successful businesses are reorganizing to take advantage of IT and rethink the way work is done. The end result, of course, is that consumers benefit from lower prices, higher quality products, and a greater variety and selection of goods.

Macroeconomic Benefits of Improved Supply Chains

But have there also been improvements to the macro-economy as a result of better supply chain operations? **Figure 10** may look like an ordinary bar code, but a closer scan reveals that it's actually a bar code of U.S. business cycle expansions and contractions. Each black bar represents a recession; the fatter the bar, the longer the recession. The timeline starts in 1855, the earliest year for such records using NBER data. For perspective, the Great Depression is shown here in red. The large white spaces on the right side of the figure indicate that the U.S. economy is in recession far less often today.

Figure 10

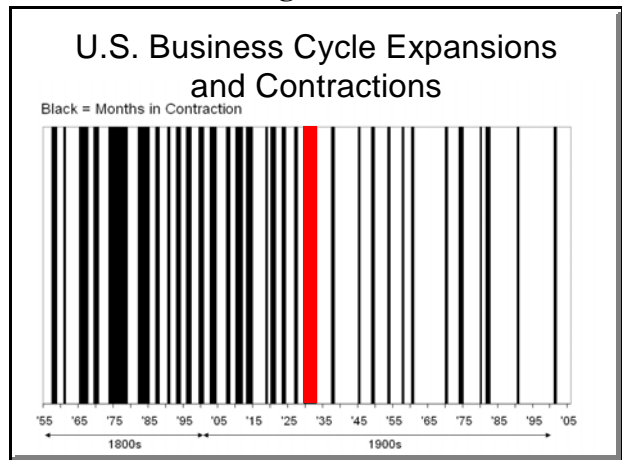
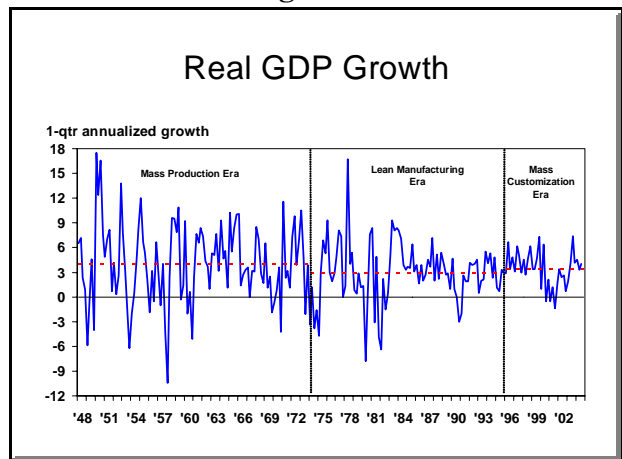


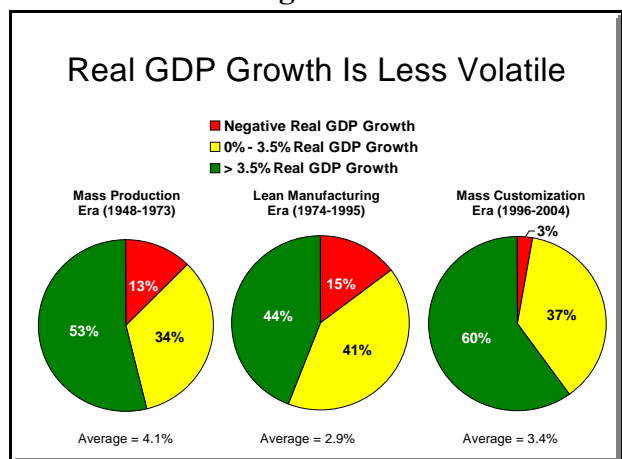
Figure 11 takes a closer look and shows GDP growth since 1948, and also shows the economy becoming increasingly more stable. For perspective, the time line is subdivided into the three supply chain eras discussed earlier: mass production, lean manufacturing, and mass customization. GDP growth has averaged 3.4 percent per year since 1995, but without all of the big swings up and down.

Figure 11



The pie charts in **Figure 12** provide more evidence that GDP growth has been less volatile recently. The three pie charts correspond to the three supply chain eras. The red areas show the percentage of time when annual GDP growth was negative, which roughly corresponds to recessionary periods. The yellow areas show the percentage of time when annual GDP growth was between 0 and 3.5 percent, and the green areas when annual GDP growth exceeded 3.5 percent. During the mass customization era, we see more green and little red.

Figure 12



Better inventory management is a key reason behind the economy’s increased stability. Inventory investment is the largest contributor to reduced GDP growth volatility across the three eras.

Productivity growth tells a similar story: it has become less volatile and has been trending upward for several years (**Figure 13**). Again, we see more green in the mass customization era, where productivity growth exceeds 2.5 percent, and little red, where productivity growth was negative. As new technologies help companies streamline supply chain operations, it makes sense that productivity, measured as output per hour, would improve.

We live far better today than did earlier generations because of the power of productivity. Our ability to continuously innovate—to improve production processes, to implement new technologies, to better manage product and information flows, to engage in more specialization and trade, and to further upgrade our skills—allows us to get more for less.

Indeed, productivity growth has accelerated in recent years, despite several negative shocks to the economy (**Figure 14**). Strong productivity growth and greater economic stability have helped make the Fed’s job easier. Higher productivity growth into the future is likely, as the primary drivers of productivity gains—including continued rapid innovation, the effective implementation of new information technologies, and a more competitive and deregulated global economy—remain firmly in place.

The Future

Other new information technologies, like global position satellites and radio frequency identification devices (RFIDs), will continue to greatly improve supply chains. This is true not just for manufacturing, but also in retail, insurance, healthcare, and so on. We are likely just beginning to see the power of productivity play out as firms effectively implement these new technologies.

For example, RFIDs can be embedded into products to transmit information without it having to be physically scanned in any way. In its simplest form, an RFID tag allows an object to be tracked and for it to carry a set of pre-determined information about the product it is embedded in.

The productivity gains from RFIDs could be substantial. Imagine knowing the contents of boxes and boxes of things, or truckloads of things, without having to open them—or a grocery cart filled with items wheeled through a checkout area with an instant total.

Figure 13

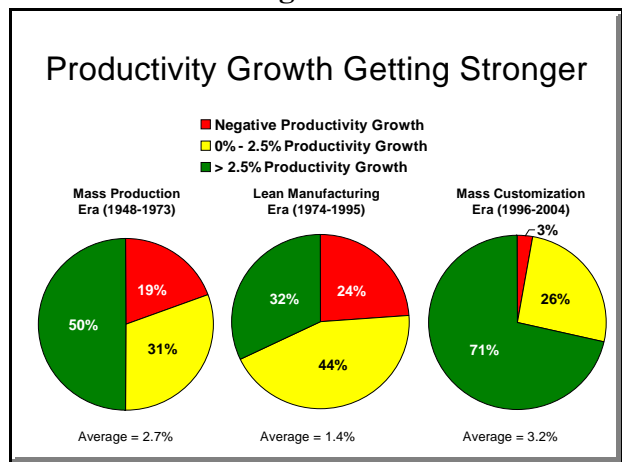
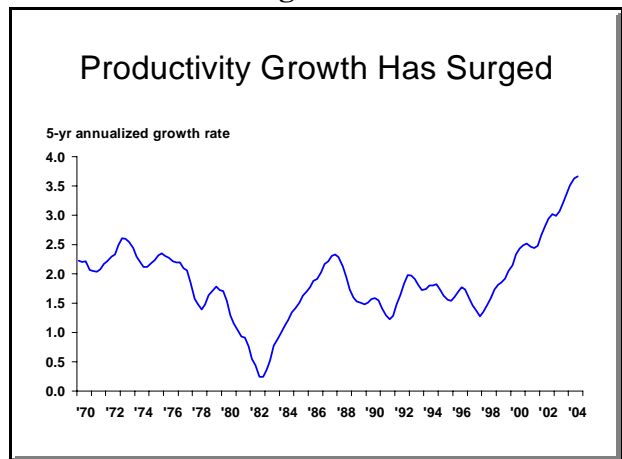


Figure 14



As an aside, the Dallas area's infrastructure of distribution warehouses and supply-chain experts is helping make RFID an economic catalyst for the region. Wal-Mart recently used some of its area stores for testing RFIDs, and the National RFID Center located in Richardson is studying many uses for RFIDs, with a big emphasis on homeland security.

Conclusion

Through better information engineering, supply chain improvements have resulted in a reduced bullwhip effect, lower inventory levels, reduced logistics costs, and streamlined payments. These improvements appear to have helped produce macroeconomic benefits such as more stable economic output and higher productivity growth.

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¹This presentation is based largely on "The Impact of E-business Technologies on Supply Chain Operations: A Macroeconomic Perspective," by Amit Basu and Thomas F. Siems, Federal Reserve Bank of Dallas Working Paper 0404, November 2004. See <http://www.dallasfed.org/research/papers/2004/wp0404.pdf>.