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**THE IMPACT OF E-BUSINESS  
TECHNOLOGIES ON  
SUPPLY CHAIN OPERATIONS:  
A MACROECONOMIC PERSPECTIVE**

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**Research Department  
Working Paper 0404**



**FEDERAL RESERVE BANK OF DALLAS**

# **The Impact of E-Business Technologies on Supply Chain Operations: A Macroeconomic Perspective**

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**November 2004**

Abstract: New information technologies and e-business solutions have transformed supply chain operations from mass production to mass customization. This paper assesses the impact of these innovations on economic productivity, focusing on the macroeconomic benefits as supply chain operations have evolved from simple production and planning systems to today's real-time performance-management information systems using advanced e-business technologies. While many factors can influence macroeconomic variables, the impact of IT-enabled supply chains should not be overlooked. We find evidence that the impact of e-business technologies on supply chain operations have resulted in a reduced "bullwhip effect," lower inventory, reduced logistics costs, and streamlined procurement processes. These improvements, in turn, have likely helped to lower inflation, reduce economic volatility, strengthen productivity growth, and improve standards of living.

JEL Classification: B22, D20, O30

Keywords: information technology, e-business, supply chain, macroeconomics, productivity.

**PRELIMINARY DRAFT  
COMMENTS WELCOME**

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# **The Impact of E-Business Technologies on Supply Chain Operations: A Macroeconomic Perspective**

## ***Introduction***

Throughout history, innovation and the adoption of new technologies have led to productivity improvements that generate stronger economic growth and higher living standards. In business, technological innovation over the past century has focused on the design and manufacturing processes that are used largely within individual firms. At the same time, the process of physically moving raw materials, components and products through a firm's value chain comprises a significant portion of the total cost of goods in many industries. Mechanized transportation, telecommunications networks and integrated information systems have significantly helped supply chain managers improve their ability to plan, order, monitor, and evaluate their processes. In particular, new information technologies and e-business solutions have transformed supply chain operations from mass production to mass customization.

This paper assesses the impact of these innovations on economic productivity. Using various empirical data, we trace the long-run economic impact from improved supply-chain management practices brought on by systems that move more accurate information faster and more cheaply. Our focus is on the macroeconomic benefits resulting from the adoption of supply chain management techniques as they have evolved from simple production and material requirements planning to today's real-time performance-management information systems using advanced e-business technologies.

Rather than focus on the individual firm as has commonly been the approach in the literature (Geoffrion and Krishnan, 2003), we adopt a macroeconomic perspective in examining how improvements from applying new e-business technologies to supply chain management processes in business may have affected the macro-economy. In particular, we explore how the implementation of e-business technologies on supply chain operations has affected prices, employment, economic output, living standards, and productivity. While our analysis is exploratory and does not consider all the potential factors that may impact these macroeconomic variables, we find evidence that strongly suggests that the impact of e-business technologies on supply chain operations has benefited consumers and the macro-economy in many significant ways.

### ***The Evolution of Supply Chain Management***

Despite the increased attention paid to supply chain management in recent years, including university courses solely devoted to the topic, it is not a new business discipline. Supply chain management is as old as trade itself. We view the purpose of supply chain operations as getting the right resources and products to the right places at the right times, while yielding the highest possible profits.

The evolution of supply chain management practices can be partitioned into four periods: the industrial revolution (1776-1900), the mass production era (1901-1974), the lean production/quality control era (1975-1995), and the mass customization era (1996-2010). During the industrial revolution, many businesses arose from the division and specialization of labor and from expanded markets and opportunities arising from the development of electricity, railroads, transportation, and communications. In the mass

production era, businesses adopted and utilized capital equipment to improve production operations, focusing their efforts on defining and improving specialized tasks through scientific management methods, operations research techniques, and mass-production moving assembly lines.

In the lean production/quality control era, businesses focused on improving internal processes, particularly by monitoring production methods and implementing lean production ideas such as just-in-time inventory systems, total quality management (TQM) programs, and enterprise resource planning (ERP) systems. Finally, during the mass customization era, firms began to develop and implement e-business technologies, such as the Internet and e-commerce systems, and started to improve service and delivery processes by integrating internal systems with external partners.

While earlier supply chain operations improvements centered mostly on internal processes, more recent enhancements are on production and distribution channels. Improved inventory management, streamlined logistics systems, and various information-sharing technologies such as global position satellites (GPS), radio frequency identification devices (RFID), the Internet, and other wireless telecommunications platforms all greatly improved supply chain operations. In the mass customization era, information replaces inventory. The collection, analysis, and distribution of information through improved e-business technologies have become more accurate and far less expensive. As a result, lower inventory levels can be maintained throughout the supply chain, while still allowing producers and suppliers to meet anticipated demand.

Some authors have identified these improvements and proclaimed a New Economy (Shapiro and Varian, 1999; Baily, 2001; and DeLong and Summers, 2001),

where the old rules no longer apply and where productivity advancements brought on by new e-business information technologies have permanently changed the way goods and services are delivered. We agree with this assessment. The New Economy, which is perhaps more accurately termed the Real-Time Economy, allows firms to make better decisions as information flow can be separated from the product flow, thereby enabling better real-time analysis of business conditions.

### ***The Impact of E-Business Technologies on Supply Chain Operations***

In order to analyze the impact of e-business technologies on supply chain operations, we break down the supply chain into three distinct components: the business channel, the transportation/distribution channel, and the payments channel. All three channels have been transformed and have become more tightly interconnected by e-business technologies that bring more accurate information to decision-makers in real time. Information can be stripped from products/services and analyzed separately to make better decisions regarding production, distribution, marketing, sales, etc. Each of these channels is explored in greater detail below.

The business channel of supply chain operations concerns what goods or services a business should focus on producing and at what levels. This involves knowing your customer and satisfying their needs and desires. Information needed to make these decisions comes from the market as it sends out its many signals. Producing this information entails consumer and market research, and is often very data intensive to most accurately understand changing preferences, tastes, styles, etc.

The transportation/distribution channel of supply chain operations addresses what is the best way to move products to customers, essentially answering the question, “How should goods (and services) be moved and stored?” This involves understanding the entire supply chain, from the raw materials to the end consumer, and then taking advantage of the most efficient and effective logistics and inventory systems. Again, information at all points along the supply chain can be integrated using new e-business technologies, enabling better decisions regarding necessary inventory levels and efficient movement of products.

The payments channel of supply chains pertain to the best way to move money in exchange for delivered goods and services. The essential question addressed here is, “How (and when) should suppliers be paid?” Knowing and understanding the supply chain operations of all the firms involved is crucial to making the payments system flow smoothly and accurately. ERP systems that communicate and share information in real time can lead to competitive advantages.

All three of these channels have been transformed by new e-business technologies. The effective implementation of new information technologies allows firms to quickly collect and analyze important information throughout the supply chain, including monitoring demand in real-time. In short, information flows within and between businesses can be reorganized through e-business technologies, resulting in better and more timely decisions across all channels of the supply chain (Lee and Whang, 2001).

## ***Information is Everything***

The supply chain is pervaded by the need to gather and analyze important information. Firms must spend time and resources to find and acquire suppliers, to enforce contracts, to maintain appropriate inventory levels, to transport products to the next production process, and to attract and retain customers, among many other activities. All of these activities entail obtaining information that can be made available in real time through the Internet and other e-business technologies.

If easier information availability results in better management of the supply chain, then we should be able to detect noticeable improvements at various points along the supply chain. We empirically examine several time series indicators to see if such improvements have arisen. First, with respect to demand management, real-time monitoring of sales should help producers more closely match production output with sales. Second, average inventory levels should remain lower as e-business systems help move the right things to the right places at the right times. Third, logistical costs as a percentage of total output should be lower as goods are shipped more efficiently through the supply chain. And finally, procurement costs should be lower as firms utilize e-business systems to eliminate paperwork and streamline payments.

## ***Production and Sales Volatility***

With almost real-time monitoring of sales, shipments, quality and output, along with more reliable performance measures of lead times, forecast errors, etc., we expect less volatility in output when utilizing e-business systems. Information that can be shared along all points of the supply chain allows decision makers to better manage their



specialized tasks. Without being able to share this information quickly and accurately, information distortions often compound when traveling further up the supply chain from customers to suppliers.

Chart 1 shows the 10-year moving average of the volatility of durable goods production growth and the 10-year moving average of the volatility of durable goods sales growth. Ten-year sales growth volatility averaged about 8 percent during the 1960s, gradually rising to an average of around 12 percent during the 1970s and 1980s, and then fell back to the 8 percent range in the 1990s. In contrast, 10-year production growth volatility averaged between about 15 and 18 percent during the 1960s, 70s and 80s, but then fell sharply during the 1990s, finally settling in near an average 8 percent in the mid-1990s.

This dramatic improvement in production growth volatility occurred as improved manufacturing and quality control processes and e-business technologies brought significant improvements to supply chain operations. Indeed, information distortions in supply chains today appear to be far less of a problem. The traditional “bullwhip effect,” where information distortions accumulate and compound as one travels further up the supply chain (Lee, 1997), appears to have been tamed. In more recent years, the marriage of better production and logistics methodologies with e-business technologies that supply real-time information to all points along the supply chain is plausibly at least partly responsible for the improvement.

## *Inventory*

Unused and unsold inventory can carry burdensome costs. There are holding costs, including warehouse and 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 keep the production operations flowing as smoothly and efficiently as possible.

Better information about product demand, potential bottlenecks, change orders, and the like should allow less inventory to be needed throughout the supply chain, thereby increasing returns to shareholders as these costs are minimized and yet, at the same time, product orders are fulfilled. In essence, e-business technologies should allow firms to replace inventory with information and then use the information more productively.

Chart 2 shows the monthly inventory-to-shipments (IS) ratio for manufacturing durable goods from January 1959 to June 2004. As described in Siems (2004, p. 17), this ratio “provides more evidence that firms are becoming increasingly more sophisticated in managing industry supply chains, maintaining smoother production schedules, and holding smaller inventories and/or accurately projecting actual demand requirements.” The IS ratio bounces along in the range of about 1.85 to 2.50 from 1959 to 1992. But then, roughly corresponding to the time frame of the dramatic drop in production volatility discussed earlier, the ratio quickly improves, dropping to about 1.40 today.

Chart 2 also shows the IS ratio and its relation to recessionary periods in the economy. During most recessions (indicated by the grey bars), the IS ratio climbs and peaks very close to the end of the recession. But during the 2001 recession, the IS ratio

peaked at the start of the recession and did not grow worse. Again, better and more timely information may help explain this change in cyclic inventory levels. It appears that during the 2001 recession, producers of durable goods had better foresight of demand prior to the beginning of the downturn and took the necessary steps earlier in the business cycle to ensure that inventory levels did not get too high.

Additional evidence that firms have managed inventories better is provided by Koenig, Siems, and Wynne (2002), who follow the work of McConnell and Perez-Quiros (2000). Examining time series data from 1959 to 2001, the authors find that GDP growth volatility is about half as volatile in the post-1983 period and that 41 percent of the reduction was from inventory investment. While cause and effect are difficult to disentangle, new e-business technologies and better business practices in the supply chain have plausibly contributed to the economy's increased stability.

### ***Logistics***

Improved supply chain operations should also result in lower relative logistics costs. Just about everything that is consumed is taken from one place and transported to another. For tangible goods, this movement often involves freight transportation of some kind as raw materials are pulled from the ground, sent to facilities that convert and transform the materials into useable goods, which are then delivered as final goods to consumers.

In the past, these logistics systems focused on stored inventory. That is, the goal was to get goods shipped from point A to point B, and there was an expectation that inventory would need to be stored at each delivery endpoint. But now, with e-business

technologies that manage information flow separately from the flow of goods by connecting critical points along the supply chain, logistics are focused more on managing in-transit inventory. In other words, now the goal is to get the right goods shipped to the right places at just the right times, without storing much inventory at intermediate stages.

As a result, the role of transportation providers is changing. Today, the transportation of goods often involves great distances and requires careful coordination. According to Wilson (2004), business logistics costs in the United States were \$936 billion in 2003, roughly 8.5 percent of GDP. Chart 3 shows that reengineering logistics systems to be more efficient is a worthwhile effort. Logistics costs as a percentage of GDP has fallen steadily from 14.5 percent in 1982, with the percentage devoted to both transportation costs and inventory carrying costs contributing to the improvement. Transportation costs have declined by 20 percent since 1982 and inventory carrying costs have declined by an even more impressive 60 percent.

Wilson (2004) concludes that logistics costs have declined primarily because inventories are managed more efficiently, warehousing expenses have been reduced, and risks have been minimized. Third party logistics (3PLs) providers that furnish specialized and customized end-to-end solutions are becoming more common and are better able to respond to shifts and changes in our global economy. In short, this sort of specialization and trade helps make industry supply chains more efficient because these specialists can provide expertise, reach, reliability and flexibility. This is consistent with Gupta and Basu (1989) who argue that IT-induced reductions in transactions costs will motivate companies to parcel out or outsource, many economic activities currently done within firms.

## ***Procurement***

As technology costs continue to fall 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/or a trail of paperwork. And such electronic transactions can now be accomplished faster and cheaper, thereby enhancing the efficiency of the supply chain.

All of these improvements in the supply chain—production volatility, inventory, logistics, and procurement—have this common characteristic: they use better methodologies and new e-business technologies to use information more efficiently and effectively. Improved information management and better information engineering help lower transactions costs, whether in procurement, production, logistics, or inventory. The bottom line is that new information technologies make more and better information available in real-time at lower costs to those who need it. And the end result is that consumers benefit from lower prices, higher quality products and services, and an improved variety and selection of goods.

## ***Macroeconomic Evidence***

One place where we can identify macroeconomic benefits from the impact of new e-business technologies on supply chain operations is on prices. In a competitive economic environment, supply chain improvements should help lower prices by reducing production volatility, inventory levels, and logistics costs, and by introducing more efficient procurement methods as described above. While better monetary policy,

globalization of industries and markets, and other factors have also resulted in lower prices, Chart 4 shows that consumer price inflation for core commodities and services has generally declined the past two decades, when supply chain improvements were more widely adopted, particularly those using newer e-business technologies.

Moreover, prices for core commodities have actually *fallen* since 2001, with the annual percent change less than 2 percent per year since the early 1990s. In fact, core commodity prices have risen only 3.4 percent since 1993, averaging less than 0.3 percent per year. In contrast, core services prices have continued to rise over the past decade at between 2.5 to 4 percent annually.

Another macroeconomic variable where we would expect to see improvement from streamlined supply chain operations is the growth of productivity, measured as output per hour. As e-business technologies help firms to move quickly and inexpensively collect, analyze and process information, industry supply chains become more efficient. That is, supply chains become more productive. Chart 5 shows that the 5-year moving average of productivity growth has surged in recent years to an average level experienced only briefly in the mid-1960s.

Additionally, the 2001 recession is the only recession on record since World War II where productivity growth continued to grow by at least 2 percent annually. In other words, productivity growth continued throughout the 2001 recession as firms quickly adjusted labor hours to the lower output levels. Clearly, this can have a negative impact on employment, and perhaps that should also be expected as new e-business technologies often provide labor-saving solutions to supply chain problems.

New technology solutions frequently eliminate the need for labor, whether it is counting inventory, processing orders, streamlining production operations, or moving stuff from one location to another. Moreover, as information is collected and processed in real-time, businesses have a better understanding of the demand for their products and can take necessary actions quicker to reduce production output (and labor resources). And there are signs that these benefits are spreading to the service sector, whose productivity growth has recently picked up, particularly in retail and wholesale trade (Alm, Cox, and Duca, 2004). Chart 6 shows that employment growth was very slow to recover following the 2001 recession. However, as shown in Chart 7, GDP growth is much more stable today than 20 or 30 years ago, and this increased stability is at least partially attributable to better management (Siems, 2004). The good news is that, in the end, stronger productivity growth directly translates into higher standards of living for an economy's citizens.

Many factors can influence macroeconomic variables such as inflation, employment, output, and the like. Higher productivity growth, more stable economic output, and lower inflation might result from good monetary policies, better fiscal policies, or luck (fewer external shocks). We believe, however, that the impact of e-business technologies on supply chain operations should not be overlooked. The macroeconomic benefits highlighted above might also partly stem from better management of technology, supply chain operations, and risk. Moreover, the effective implementation of e-business technologies in a competitive environment that demands economic efficiency in order to maximize shareholder wealth should lead to stronger productivity growth.

## **Conclusion**

While improved supply chain management principles combined with new information (e-business) technologies may not have been given much macroeconomic attention in the past, its effective implementation can help firms reduce costs, increase revenues, boost efficiencies, and expand market opportunities. We find evidence that these improvements have resulted in a reduced bullwhip effect (production volatility that more closely resembles sales volatility), lower inventory levels, reduced logistical costs, and streamlined procurement processes. Taken one step further, we show evidence that strongly suggests that these improvements are linked to macroeconomic benefits such as lower inflation, more stable economic output, higher productivity growth, and better standards of living. Furthermore, these improvements have occurred even in the face of powerful economic shocks, including the post-Y2K stock market bubble and IT investment bust, the 2001 recession, the September 11 terrorist attacks, corporate governance scandals, and rising energy costs, among other developments.

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Chart 1

**Reduced "Bullwhip Effect" for Durables  
Production Growth Volatility Closer to Sales Growth Volatility**

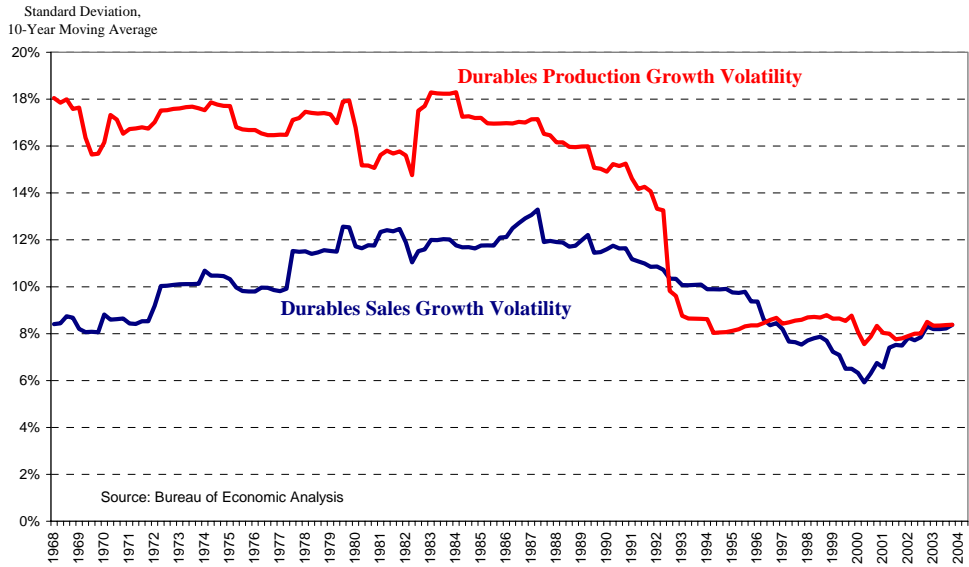


Chart 2

**Lower Inventory  
Durables Inventory-to-Shipments Ratio Fell Dramatically in the 1990s**

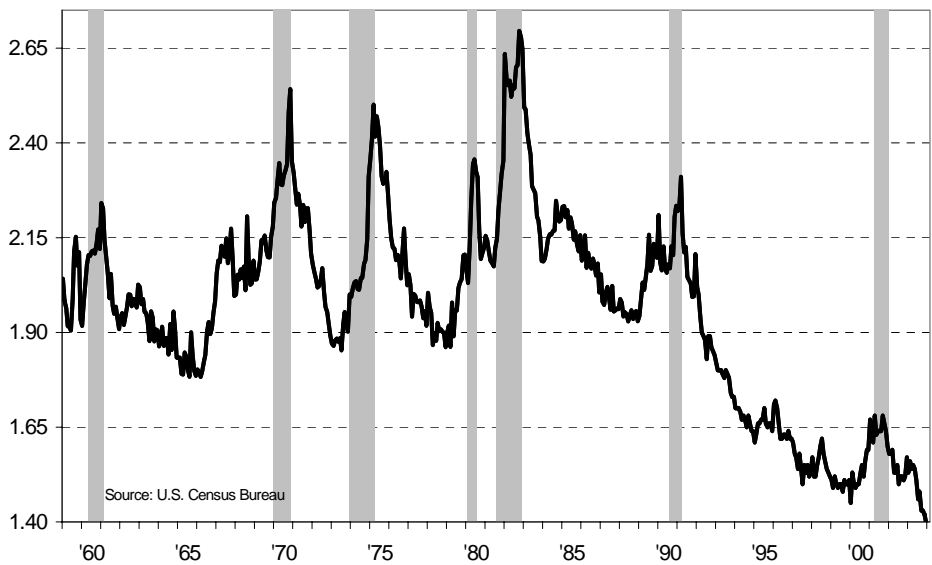


Chart 3

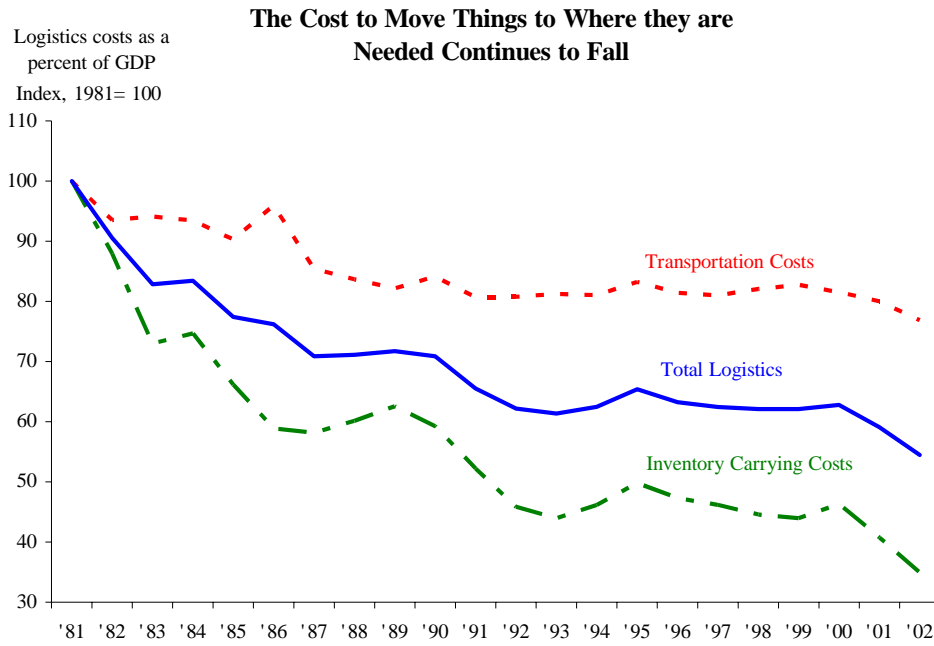


Chart 4

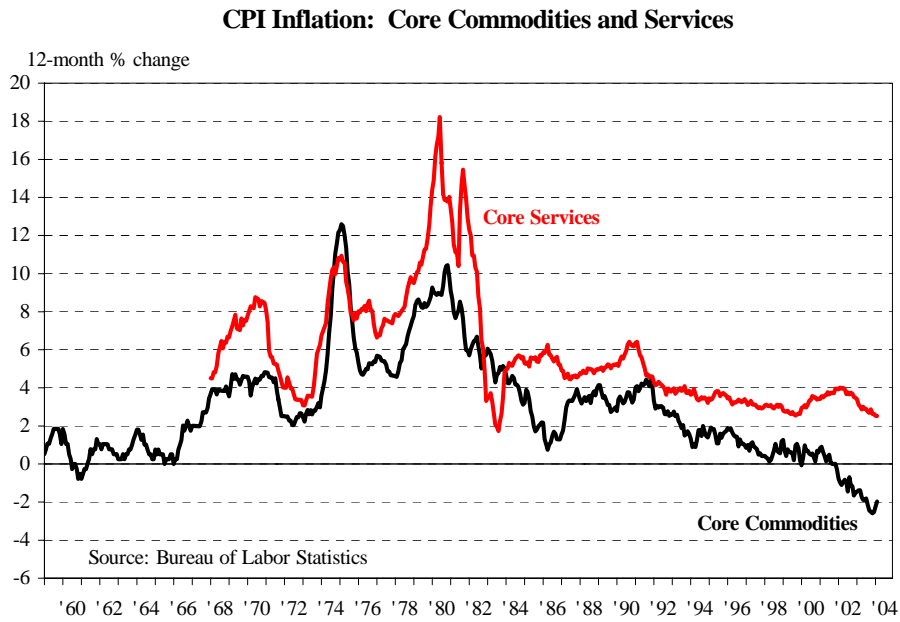


Chart 5

### Productivity Growth has Surged in Recent Years

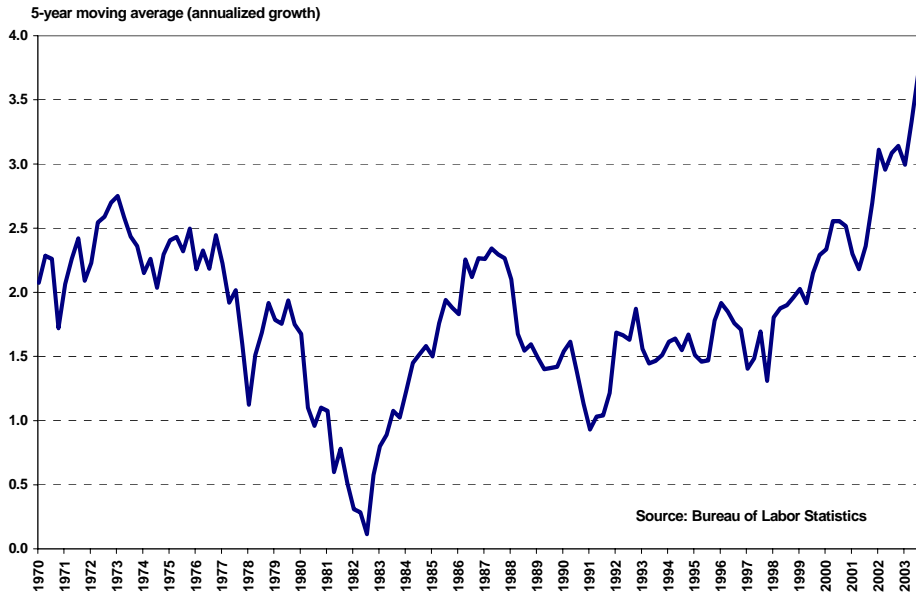


Chart 6

### Private nonfarm payrolls growth

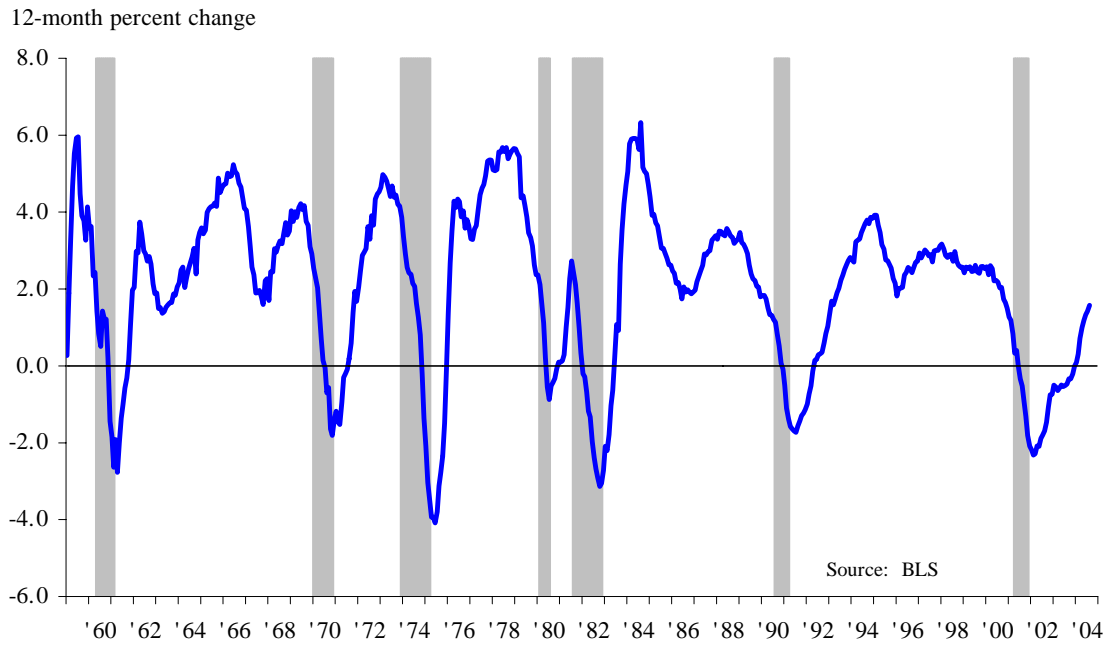


Chart 7

### U.S. Real GDP Growth Has Become More Stable

