Macroeconomic Vulnerabilities in the Twenty-First Century Economy: A Preliminary Taxonomy

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I. Introduction

What will the macroeconomic vulnerabilities of the twenty-first century economy be? The typical twentieth century industrial economy had five potentially catastrophic macroeconomic weak points.[1] Will the twenty-first century see the same set of macroeconomic weak points. Or will it see the development of others, as the structure of the economy shifts from industrial to post-industrial under the impact of the ongoing technological revolutions in data processing, data communications, and whatever other

[1] First, recessions and depressions could be caused by large confidence shocks that reduced the volume of investment spending. Second, recessions and depressions could be caused by overly contractionary monetary policies. Third, recessions and depressions could be caused by small shocks combined with a self-reinforcing debt-deflation mechanism--the result either of internal deflation, or of declines in the currency coupled with large-scale external harder-currency-denominated debt--that amplified adverse-selection problems in financial markets and so depressed investment spending. Fourth, high inflation could be caused by the loss of a central bank's reputation for caring about price stability. Fifth, high inflation could be caused by the interaction of persistent deficits and a politically-driven need for the central bank to be the government's deficit financer of last resort.

leading growth sectors in turn follow them? And how should public policy react--both in terms of changes in the stance of monetary policy, and in changes in the central government's orientation toward fiscal policy--to maximize the opportunities and minimize the risks?

These are large questions. I don't think I can answer them. For one thing, macroeconomists' track record at prospective rather than retrospective identification of macroeconomic vulnerabilities is not good,[2] and I see no reason to think that our collective expertise will be better at prospective analysis in the future than it has been in the past. I can, however, make preliminary (but informed) guesses.

It seems to me highly likely that five sets of factors will be most important as changes in economic structure carry with them changes in points of macroeconomic vulnerability over the next one to three decades. These five sets of factors fall into two groups: first,

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[2] For example, it is difficult to find analyses that highlight the macroeconomic dangers of large-scale downward price flexibility like that seen during the 1929-1933 American Great Contraction before Fisher (1933). Earlier writers like Keynes (1924) stressed the contractionary effects of anticipated deflation, but not the financial market failures caused by recent past deflation. Few before Friedman (1967) and Phelps (1967) understood the medium-term consequences for U.S. inflation of macroeconomic policy that attempted to fix the average unemployment rate at a level below the NAIRU. And as Krugman (2001) lamented, few in the early 1990s had any inkling that in that decade developing-country exchange-rate crises would arise not from governments' pursuing fiscal policies that were unsustainable in the long run, but from how the interaction of large-scale harder-currency-denominated debt with financial-sector adverse selection and moral hazard created the possibility for an economy to suddenly jump from a "good" high-currency-value equilibrium to a 'bad" low-currency-value equilibrium.

likely changes in the magnitude of macroeconomic shocks; second, likely changes in the ability of government to act to neutralize or damp the effects of macroeconomic shocks.

The likely changes in the magnitudes of *shocks* are two, and they work against each other:

- First, the faster productivity growth and the greater uncertainty associated with a leading sector-driven boom increases the likely magnitude of asset market shocks. Sectors or the aggregate market are more likely to find themselves substantially mispriced. Either waves of euphoria, or the reaction when it turns out that the profits flowing from technological advance have been overestimated, are likely to cause larger-than-usual shifts in the location of the IS curve.

- Second, if information technologies really are information technologies, then inventories should behave better in the future than in the past. To the extent that a large share of past business cycles have been caused by "mistakes" in inventory accumulation and decumulation because of a lack of rapid information transmission from final demand to the factory floor, information technologies should reduce the size of this inventory component of the business cycle.

Then there are the likely changes in the *responsiveness of policy* to macroeconomic shocks:

- Third, a technology-driven boom itself may well degrade the government's ability to carry out successful macroeconomic management. The end of a period of high euphoria and extravagant boom will inevitably bring a reduction in investment, and managing the resulting necessary expenditure-switching is a delicate task made more difficult because, as Larry Summers has pointed out, a euphoric boom is a period during which people stop thinking as intensely about problems of macroeconomic management.

- Fourth, faster aggregate productivity growth good not just in itself but likely to improve the functioning of the labor market. To the extent that one attributes a large part of Europe's macroeconomic problems over the past generation to the interaction of the productivity slowdown of the 1970s with labor market structure,[3] one would expect an acceleration of productivity growth to pay enormous business-cycle benefits as well--and it seems very safe to bet that the current ongoing technological revolutions will produce rapid productivity growth for quite some time to come.

- Fifth, difficulties of surveillance with increasing financial market complexity. To the extent that a principal goal of economic policy is to keep chains of large-scale bankruptcies from disrupting the financial sector, it is essential for government

[3] As does Blanchard (2000), and as did Bruno and Sachs (197?) earlier.

regulators to understand the capital structure and the portfolio risk profile of financial services firms. This appears to be becoming more and more difficult.

One necessary caveat: The past hundred and fifty years have seen immense structural changes in leading economies. They have seen technological revolutions, as one leading sector after another has taken the lead in productivity acceleration. They have seen the rise of systems of credit that allow households to smooth their spending. They have seen the modern social insurance state become a sea-anchor for the economy by virtue of the large relative size of its spending programs. They have seen the government take on responsibility for managing the macroeconomy. Yet in spite of all this, the business cycle today is--or certainly until very recently was[4]--remarkably like the cycle of a century ago.[5] This must make one cautious about forecasting that currently-ongoing structural change will produce changes in the shape of the business cycle and in the dilemmas of macroeconomic policy. They should. But then the shift from the agro-manufacturing economy of the 1880s to the industrial-paperwork economy of the 1970s should have produced changes in the shape of the business cycle as well, yet it apparently did not, or at least not large ones.[6]

[4] See, however, Blanchard and Simon (2001).

[5] Indeed, Romer (1999) traces the major changes in the business cycle over the past hundred years not to any of the major structural changes in the economy, but to changes in how the Federal Reserve has thought about issues of macroeconomic management.

[6] See Romer (1986).

This paper presents a preliminary taxonomy of the likely major effects on macroeconomic vulnerability of the currently-ongoing technology-driven structural changes in the American, and in the future the world, economy. Two of these effects (the likely decline in the inventory error-driven component of the business cycle, and the likely favorable impact on labor-market functioning of more rapid aggregate productivity growth) are likely to be favorable, and to reduce potential macroeconomic vulnerabilities. Three of these effects (increasing difficulties of financial market surveillance and supervision, the effects of booms on governments' institutional competence to deal with downturns, and the likely magnitude of asset market shocks) are likely to increase potential macroeconomic vulnerabilities, and thus to make life more difficult. Whether the positive or negative effects will dominate is anyone's guess.

II. Background: Technological Revolution

To begin with, consider the scope and magnitude of our ongoing technological revolutions in date processing and data communications. Compare our use of information technology today with our predecessors' use of information technology half a century ago. The decade of the 1950s saw electronic computers largely replace mechanical and electromechanical calculators and sorters as the world's automated calculating devices. By the end of the 1950s there were roughly 2000 installed computers in the world:

machines like Remington Rand UNIVACs, IBM 702s, or DEC PDP-1s. The processing power of these machines averaged perhaps 10,000 clock cycles per second. Today? Perhaps half a billion processors installed and working across the world. Clock speeds of a billion cycles per second. Computing power is not quite clock speed times installed base, and appropriately-valued real output is not computing power, but still the net increase is awesome.

The fifty years after the invention of electricity, 1880-1930, saw an increase in horsepower applied to U.S. industry of a hundredfold: an annual increase in applied horsepower of nine percent per year. In addition, those years saw an enormous increase in the flexibility of factory organization.[7] The hundred years from 1750 to 1850 saw British textile output multiply thirtyfold. In the middle of the eighteenth century it took hand-spinning workers 500 hours to spin a pound of cotton, but by the early nineteenth century it took machine-spinning workers only 3 hours to perform the same task--a rate of technological progress of ten percent per year sustained across half a century.[8] These earlier transformations were true "industrial revolutions." These earlier transformations created true "new economies."[9]

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[7] See Devine (). Paul David (1990), who argues that in the long run the increase in flexibility played as large a role in raising productivity as did the decrease in the raw cost of applied energy from the shift from steam and shafts to electrons and wires.

[8] See Freeman and Louca (2001).

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[9] The original industrial revolution itself triggered sustained increases in median standards of living for the first time, a shift to an manufacturing- and then to a services-heavy economic structure, changed what

Our current ongoing transformation looks to be larger. William Nordhaus (2002) estimates that the cost of "computation" has fallen a trillionfold since 1940--a rate of productivity increase of 46 percent per year (compounded continuously--58 percent per year compounded annually).[10] The 5 to 7 percent of American gross output invested in information technology equipment and software today is approximately three times as large a share of GDP as was invested in the "high tech" capital of steam, iron, and factory during the heyday of the British Industrial Revolution, and approximately twice as large a share of GDP as was invested in the "high tech" capital of electricity, chemicals, steel, and mass production during the heyday of America's late-nineteenth century Second Industrial Revolution.[11]

There is every reason to believe that the pace of productivity growth in today's leading sectors will continue. More than a generation ago Intel Corporation co-founder Gordon Moore noticed what has become Moore's Law--that improvements in semiconductor

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people's jobs were, how they did them, and how they lived more completely than any previous economic shift save the invention of agriculture and the discovery of fire. The economic transformations of the second industrial revolution driven by electrification and other late nineteenth-century general-purpose technologies were almost as far reaching: mass production, the large industrial enterprise, the continent- and then world-wide market in staple manufactured goods, the industrial labor union, the social insurance state, even more rapid sustained increases in median living standards, and the middle-class society.

[10] Closely related to, but conceptually separate from, the technological revolution in computation itself are analogous revolutions in storage technology and in communications bandwidth.

[11] See Crafts (2002).

fabrication allow manufacturers to double the density of transistors on a chip every eighteen months. The scale of investment needed to make Moore's Law hold has grown exponentially along with the density of transistors and circuits, but Moore's Law has continued to hold, and engineers see no immediate barriers that will bring the process of improvement to a halt anytime soon.

Moreover, the computers, switches, cables, and programs that are the products of today's leading sectors appear to be what Bresnehan and Trajtenberg (1995) call "general-purpose technologies, hence demand for them is extremely elastic. Rapidly falling prices and elastic demand imply rapidly-growing expenditure shares. And the economic salience of a leading sector--its contribution to productivity growth--is the product of the rate at which the cost of its output declines and the share of the products it makes in total demand.

The most powerful reason to believe in the long-run economic salience of today's ongoing technological revolutions comes from the underlying growth accounting of the impact of the information technology revolution. Back in the 1980s information technology capital accounted for 3.3% of income earned in the economy; today according to Oliner and Sichel (2000) it accounts for 7.0% of income earned. Back in the 1980s the economy’s stock of information technology capital was growing at 14% per year; today according to Oliner and Sichel (2000) it is growing at 20% per year. Multiply these two sets of numbers together to find that the increase in the economy’s information technology capital stock was responsible for 0.5% per year of economic growth in the late 1980s, and for 1.4% per year of economic growth today.[12] All these factors are highly persistent: the growth accounting thus implies that they will remain salient--and perhaps increase in salience as prices continue to fall, if elasticities of demand remain greater than one.

But will the speed and magnitude of these ongoing structural changes in the economy matter for macroeconomics?

III. A Standard Framework

When we teach our undergraduate students about the determinants of business cycles, we usually present them with a simple framework that has four components:

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[12] Oliner and Sichel's conclusions are very similar to those of Jorgenson and Stiroh (2000), and not inconsistent with Nordhaus (2000a, 2000b, 2001). Back before 1995 critics of visionaries who saw the computer as transforming the world pointed to slow and anemic growth in aggregate labor productivity. As Nobel Prize-winning MIT economist Robert Solow posed the question, if the computer is so important "how come we see the computer revolution everywhere but in the [aggregate] productivity statistics?" However, as Oliner and Sichel (1994) pointed out in the early 1990s, the then-failure to see the computer revolution in the aggregate productivity statistics should not have come as a surprise. In the 1970s and 1980s the computer industry was simply too small a share of the economy and its output was not growing fast enough for it to have a large impact on aggregate productivity.

- An IS curve that details the short-run relationship between interest rates and output levels.

- Macroeconomic shocks that push this IS curve left or right.

- A central bank that sets an interest rate in an attempt to choose that particular level of the interest rate that, when combined with the IS curve, produces a level of output equal to potential output--with neither excess unemployment nor excess demand and rising inflation.

- Lags--both "inside" lags within the government (recognition lags, implementation lags) and "outside" lags (long and variable) that limit the central bank's ability to shift the interest rate in response to shocks before a considerable period of time has elapsed.

In this framework the causes of macroeconomic instability are straightforward. It is the job of the central bank to vary interest rates in order to offset shifts in the location of the IS curve, understood as the relationship between the short-run interest rates that the central bank controls and the level of output. Any of a large number of shocks--to the term structure, to consumption demand, to invest, as a result of government policy, and so on--will change the location of the IS curve. The central bank tries to determine where the IS curve will be, for its interest-rate policies take effect only with long and variable lags. Given the central bank's guesses about what the location of the IS curve will be, it chooses the interest rate in order to set aggregate demand equal to potential output.

Thus the central bank offsets those shocks to the IS curve that it foresees, and fails to offset those that take it by surprise either because of the lags inherent in the system or because of central bank misjudgments. When central bank misjudgments are large enough, it then finds itself having to play catch-up. If its misjudgments have been long enough and prolonged enough on the inflationary side, it must find a way to reduce inflationary expectations and to change not just the bias of its policies but what outsiders perceive the inflationary bias of its policies to be. This may turn out to be a remarkably difficult task. Many of the structural changes that produce the formerly-missing inflation-fighting credibility create other macroeconomic vulnerabilities in place of those that were produced by lack of confidence in the central bank's desire to control inflation.[13]

If its misjudgments have been long enough and prolonged enough on the deflationary side, it may need considerable fiscal policy or regulatory policy help to assist it in returning autonomous spending to a level consistent with full employment. In a situation in which large components of either the banking system or of operating corporations are or are feared to be underwater, properly-measured risk and default premia are likely to

[13] Consider, for example, the recent crisis in Argentina, triggered by the incompatibility of persistent--although not overwhelmingly large--fiscal deficits with the hard exchange rate peg of the currency board that Argentina had adopted a decade ago to control inflation. See Mussa (2002).

remain very high. Thus even extraordinarily stimulative monetary policies may have limited ability to undo a persistent deflation. Regulatory policy--mandatory capital and ownership restructuring of banks and operating companies--may be essential to reduce risk and default premia.[14] Fiscal policy--direct government spending to boost aggregate demand--may once again emerge as a significant and necessary player in stabilization policy.[15]

From the perspective of this framework, ongoing structural changes can have two sets of effects on the likelihood of macroeconomic distress. First, they can change the magnitude of the shocks to the IS curve. Second, they can affect the ability of the central bank and the rest of the government to offset such shocks, either through making it more difficult for governments to find out what is going on, or through making it more difficult for governments to respond to problems and crises as they arise.

Within the first category, there are two likely sets of effects. The first is that technology-based booms increase the likely magnitude of shocks to asset markets as they try to pierce the veils of time and ignorance. The second is that this particular technology-based boom ought to--not will, but ought to--reduce the magnitude of the inventory cycle.

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[14] This is one interpretation of the current macroeconomic troubles of Japan. See Kuttner and Posen (2001).

[15] For an argument that--in the U.S. at least, at least as long as its government retains its current political-bureaucratic structure--the government is so thumb-fingered and hamstrung that fiscal policy is essentially useless as a stabilization policy tool, see Taylor (2000).

These two potentially-offsetting effects change the magnitude of the IS-curve shocks which stabilization policy is supposed to damp out.

Faster productivity growth and the additional uncertainty that are likely to be associated with a leading sector-driven economic boom are likely to increase the magnitude of shocks to asset prices. New and untried technologies are, by definition, new and untried. Either substantial sectors or the aggregate market as a whole are more likely to find themselves substantially mispriced when technological change is relatively high. Either way--whether asset price changes are the result of waves of euphoria, or of the reaction against former overoptimism when it turns out that the profits flowing from technological advance have been overestimated--a period of rapid leading sector-driven technological change is likely to cause larger-than-usual asset price shocks, which are in their turn likely to cause larger-than-usual shifts in the location of the IS curve. This factor makes stabilization policy more difficult.

On the other hand, to the extent that information technologies really are information technologies, they should make it easier for firms to gather, transmit, and use information. This has the implication that inventories should behave better in the future than they have in the past.

To the extent that a large share of past business cycles have been caused by "mistakes" in inventory accumulation and decumulation, themselves the result of a lack of rapid information transmission from final demand to the factory floor, the ongoing revolution in information technology should help matters. It should reduce the size of this inventory component of the business cycle.

Within the second category, there are three potentially interesting sets of effects. The first is the impact on the government's institutional capacity to manage the economy. The second is the impact of faster productivity growth on labor market performance. And the third is the increasing difficulty of exercising effective surveillance as the economy's financial structure becomes more complicated. All of these impact the ability of the government to *respond* to macroeconomic problems, either by affecting its ability to ascertain what is going on or the power of its economic policy tools.

One such "responsiveness" factor is that a technology-driven boom may degrade the government's capabilities. The end of a period of euphoria and boom inevitably brings a reduction in confidence and thus in investment spending: that is what the end of a boom is. As desired investment spending falls, maintaining full employment requires that some other component of aggregate demand--consumption, government purchases, net exports--rise. Thus the task of macroeconomic management at the end of a boom is a delicate task of expenditure-switching. However, a euphoric boom is a period during which problems of macroeconomic management fall to lower places on the agenda. It is not clear how serious this potential reduction in macroeconomic management capabilities is. But in my judgment it is something to worry about.

Fourth, faster aggregate productivity growth good not just in itself but likely to improve the functioning of the labor market. To the extent that one attributes a large part of Europe's macroeconomic problems over the past generation to the interaction of the productivity slowdown of the 1970s with labor market structure,[16] one would expect an acceleration of productivity growth to pay enormous business-cycle benefits as well--and it seems very safe to bet that the current ongoing technological revolutions will produce rapid productivity growth for quite some time to come.

Fifth, difficulties of surveillance with increasing financial market complexity. To the extent that a principal goal of economic policy is to keep chains of large-scale bankruptcies from disrupting the financial sector, it is essential for government regulators to understand the capital structure and the portfolio risk profile of financial services firms. This appears to be becoming more and more difficult.

Which of these five factors will prove to be the most important cause or cure of potential macroeconomic distress over the next decade or two is uncertain. There is much too little evidence on any of their strength for my comfort. I believe that they all need watching.

[16] As does, for example, Blanchard (2000).

IV. Shocks to Asset Prices and Their Real Effects

The *Economist*[17] quotes Barsky and DeLong[18] as authorities for the platitude that asset prices are likely to be the most volatile--hence private sector-driven shocks to the location of the IS curve are likely to be the largest--whenever the future is most uncertain. The unknowns created by a leading sector-driven economic boom are the very essence of uncertainty about the future. New and untried technologies are, by definition, new and untried. Either substantial sectors or the aggregate market as a whole are more likely to find themselves substantially mispriced when technological change is relatively rapid and uncertain.[19] Asset price changes can be the result of waves of euphoria produced by excitement about the prospects of new technologies on the part of some and the reluctance to bear-speculate against the enthusiastic by rational agents aware of the risk that new technologies sometimes do turn out to be miraculous.[20] Asset price overshooting on the downside can result from a reaction to previous manias, when it turns out that profits from technological advance are less than anticipated.

[17] *Economist Global Agenda*, July 4, 2002.

[18] Barsky and DeLong (1993).

[19] For a model in which small changes in technology-driven expectations of future growth rates produce large swings in asset prices and in desired investment spending, see DeLong (1990).

[20] See Shleifer (), Kindleberger (1978).

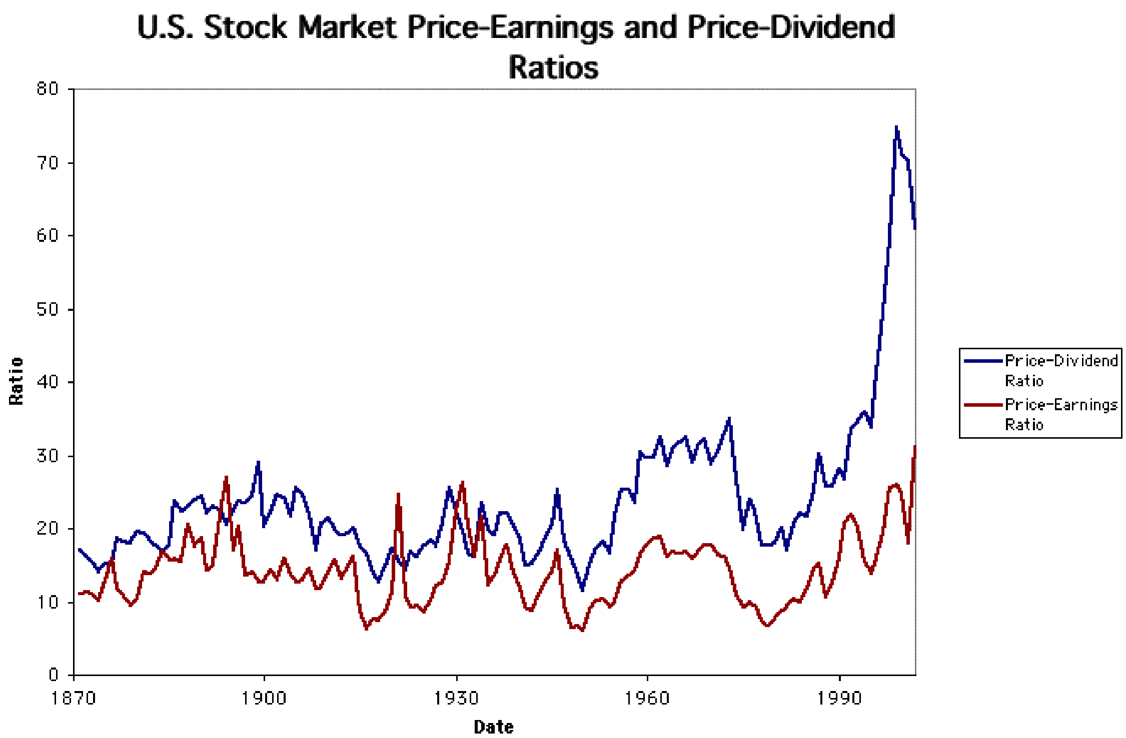
A series of large upward shocks in asset prices from favorable news about technology are also likely to transform the ecology of the stock market. In a world with agents possessing constant relative risk aversion, the stock market is a voting mechanism for deciding upon Tobin's Q, with each agent weighted by his or her wealth.[21] A period of good news increases the stock market weight of those far-sighted enough to have anticipated the news, yes. But it also increases the stock market weight of the chronically overoptimistic and--to the extent that asset price news turns out to be serially-correlated ex post--of trend-chasers who buy when prices rise and sell when prices fall.

There is reason to fear that the runup in asset prices in the 1990s may have reduced American asset markets' effectiveness as part of a rational social capital allocation mechanism. If we look far back in history at the long bull runs of the American stock market—1890-1910, or 1920-1930, or 1950-1970—we see that for each 10% that the real value of dividends rose over a twenty-year period, the real value of stock prices tended to rise by half again as much--by 15 percent.[22] The runup in stock prices during the 1920s was extraordinary, but in real terms the increase in dividends paid out in the 1920s, and the increase in corporate profitability, was more than half of the increase in real stock market values. The runup in stock prices during the 1950s and 1960s was extraordinary

[21] See DeLong, Shleifer, Summers, and Waldmann (1989, 1991).

[22] Barsky and DeLong (1993).

too, but in real terms increases in dividends and in earnings were two-thirds as large as the increase in real values.



Source: Robert Shiller, Standard and Poor's.

The most recent bull market, as measured by the S&P composite index, is the largest: a more than seven-fold increase in real values from trough to peak in less than two decades.. Yet real dividends paid on a pro-rata share of the S&P composite index rose by less than 30 percent between the early 1980s and the peak. And earnings on a pro-rata share increased by less than 50 percent. During this most recent long bull market a market-wide rise in dividends of 10% produced not a 15 percent, but a 26 percent increase in stock prices. Even after two years of declining nominal values, the U.S. stock market as of the start of the summer of 2002 remained extremely high by standard dividend-ratio or earnings-ratio yardsticks.

It is certainly possible (albeit unlikely, from this observer's perspective at least) that it is the yardsticks and not the equity values that are out-of-whack. It has long been a mystery why firms in the past paid out as much in dividends as they did given their unfavorable tax treatment: perhaps firms have learned better, or perhaps investors have learned to judge firms on the basis of other, less-dissipative signals than dividends. Average price-earnings ratios in the U.S. stock market have long seemed ludicrously high from the perspective of any diversified portfolio chosen by an agent with a reasonable degree of risk aversion.[23] Perhaps investors have finally recognized what the true risk-return tradeoffs are.[24] But it seems more probable that large components of recent asset price fluctuations represent shifts in "animal spirits" that narrow-eyed sober calculating

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[23] See Mehra and Prescott (198?).

[24] Another possibility--although one that looks less likely with every passing day--is that GAAP greatly understate the magnitude of firms' investments in organizational capital associated with the ongoing technological revolutions, and thus greatly understate true corporate earnings by classifying a large component of the firm's Haig-Simons investment as an operating cost. See Hall (2000).

believers in fundamentals have been unwilling to speculate against on a sufficiently-large scale--for "the market can remain irrational longer than you can remain solvent."[25]

Odean and Barber (2001) have pointed out that experimental economists have spelled out conditions under which markets are most vulnerable to prolonged mispricing and to speculative bubbles, and that our current stock market as it has been fueled by the growth of online trading and online information appears to meet all of them. To larger asset price swings driven by increases in fundamental uncertainty must be added larger asset price swings driven by additional asset-price noise.

It would be surprising if a period of rapid leading sector-driven technological change was not the cause of large asset price shocks. It would be surprising if these large asset price shocks were not in their turn the cause of large swings in investment spending, which will in their turn generate large shifts in the location of the IS curve. Thus stabilization policy becomes more difficult, and the central bank has to be prepared for larger than usual fluctuations in interest rates to counter these unusually large shifts in animal spirits,[26] at least as long as the technological revolution continues.

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[25] See Roger Lowenstein (2000). Lowenstein attributes this quotation to John Maynard Keynes. I have not been able to verify it.

[26] The fact that such interest-rate offsets will presumably have to operate both upward and downward raises doubts about the wisdom of too-aggressive central bank pursuit of price stability in the context of a large ongoing technological revolution. See DeLong and Summers (1993).

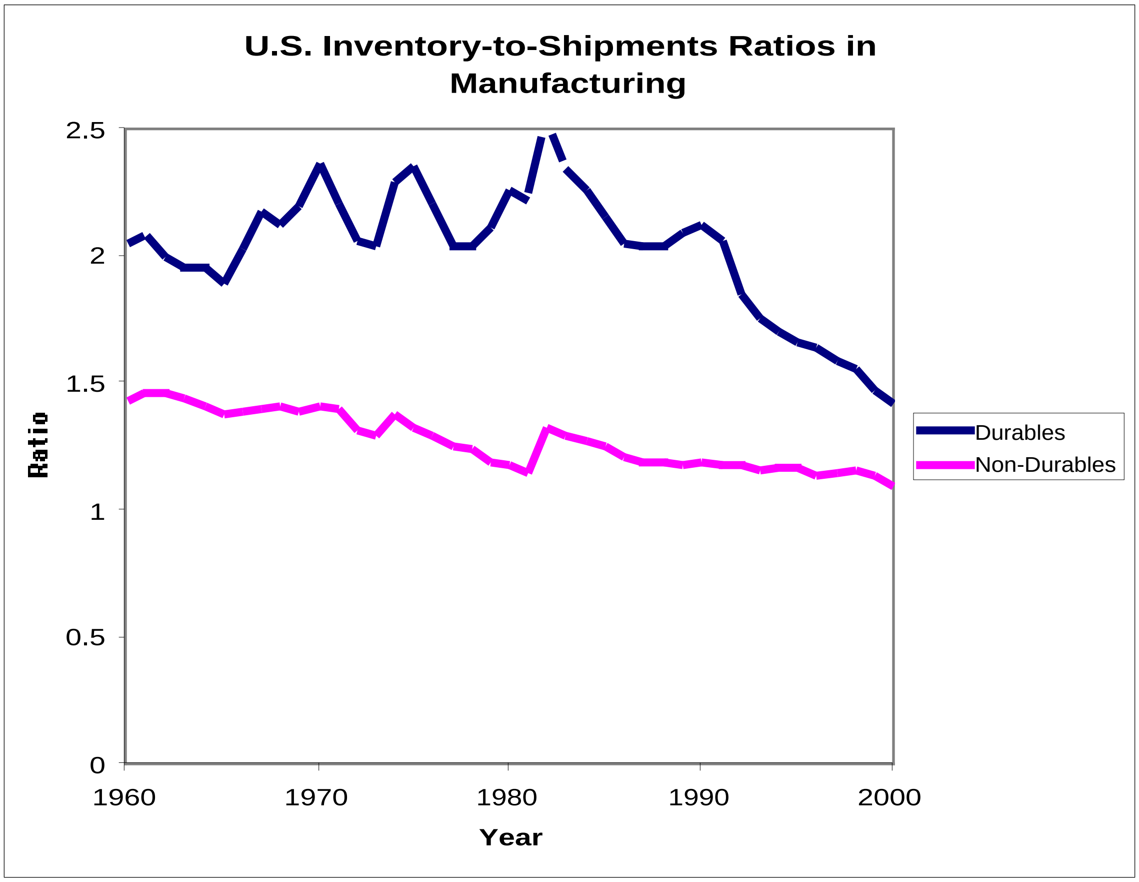
How large in magnitude will these effects of amplified asset prices shocks be? Reflect that the 911-driven and the NASDAQ bubble collapse-driven reductions in demand have already required that the Federal Reserve reduce short-term safe interest rates remarkably close to the zero nominal interest rate bound, and that neither shock was as large in its effects on demand as could easily have been envisioned. The answer to the question, "How large?" may well be, "Too large for conventional monetary policy to handle," at least in an environment of near price stability.

V. The Inventory Cycle

Offsetting the additional potential macroeconomic vulnerability generated by the potential interaction of technological uncertainty with asset prices and investment spending, the ongoing technological revolutions promise to reduce the magnitude of macroeconomic shocks by reducing the likelihood and magnitude of large-scale shocks to inventory accumulation.

To the extent that information technologies really are *information* technologies, they should make it easier for firms to gather, transmit, and use information. One prime piece of information that firms need to know is the state of the goods and services moving through its value chain: its inventory, in all stages from goods piling up (or running bare)(

on store shelves to the likelihood that its suppliers will successfully make their just-in-time deliveries. To the extent that in the past macroeconomic instability has been driven by mistakes in inventory accumulation and decumulation, themselves the result of a lack of rapid information transmission from final demand to the factory floor, the ongoing revolution in information technology should reduce their magnitude.



Source: U.S. Department of Commerce.

American inventory-to-sales ratios have been declining for nearly a generation. Today, manufacturers of durable goods hold only two-thirds as much inventory relative to their sales as they held in the 1970s. Manufacturers of non-durable goods hold eighty percent as much inventory in proportion to sales as they did in the 1970s. Inventories have also been less volatile.[27]

However, much of this reduction in inventory-to-sales ratios is *not* due to information technology, at least not directly. Before there was a new economy, after all, there was a "Japanese challenge": American firms scrambled to develop and implement "lean production" systems that economized on inventories and achieved much greater control over materials flow and quality.[28]

Managers do claim that one of the principal benefits of new computer-and-communications technologies is better inventory control. But we will need at least a decade, if not more, of additional observations before we will be able to see to see whether and what macroeconomic benefits in terms of reduced business cycle amplitude

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[27] It is, however, hard to tell whether this reduction in volatility in the years since 1984 is cause or effect of overall macroeconomic stability. More interesting is Blanchard and Simon's (2001) finding that the covariance between inventory changes and other shifts in the business cycle has changed: before the mid-1980s the cross-term between inventories and demand amplified volatility, since the mid-1980s it appears to reduce it.

[28] See Womack *et al.* (1991).

will follow from the plausible role of better information technology in generating a leaner inventory pipeline.[29]

VI. The Institutional Capacity to Manage the Macroeconomy

These two "shocks" factors are potentially offset by "responsiveness" factors that affect the government's ability to offset macroeconomic shocks. One such "responsiveness" factor is that a technology-driven boom may degrade the government's institutional capability to manage the business cycle. The end of a period of euphoria and boom inevitably brings a reduction in confidence and thus in investment spending: that is what the end of a boom is. As desired investment spending falls, maintaining full employment requires that some other component of aggregate demand--consumption, government purchases, net exports--rise. Thus the task of macroeconomic management at the end of a boom is a delicate task of expenditure-switching.

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[29] Blinder (1981) pointed out that in a typical recession the fall in inventory investment is between 50 and 100 percent of the peak-to-trough fall in real GDP, but it is not clear that this is the most useful statistic to gauge the contribution of inventory forecast errors to macroeconomic variability. Blanchard and Simon (2001) find a change in the correlation between inventory and other fluctuations contributing to a stabilization of aggregate demand in the past two decades: it used to be that the inventory cycle reinforced the production cycle, while more recently it appears to damp it.

During a period of boom-driven euphoria countercyclical policy becomes less important. After a period of boom-driven euphoria, countercyclical policy becomes more important than at any other time. As Larry Summers has pointed out,[30] nobody in Japan in the late 1980s paid *any* attention at all to problems of business cycle management, few in Japan in the early 1990s paid *sufficient* attention to problems of business cycle management, and today, when everyone in Japan is paying attention, the fruits of a near-decade of neglect are that Japan's macroeconomic problems have grown so large as to become politically and possibly economically intractable. The Japanese and the world economies today are suffering from that lapse.

The rather bizarre and ultimately unproductive American political debate about a "stimulus package" in the wake of the 911 terror-attack on New York's World Trade Center may count as evidence of such a degradation in the government's institutional capability to carry out successful demand-management policy. In a situation in which it appeared that monetary policy might not be able to be stimulative enough to keep demand from falling sharply, the American Congress proved incapable of passing a bill until after it was clear that the recession trough had passed. It may not: it may simply be more evidence that the American government is and has been organizationally incapable of successfully carrying out discretionary fiscal policy.[31]

[30] See DeLong and Summers (2002).

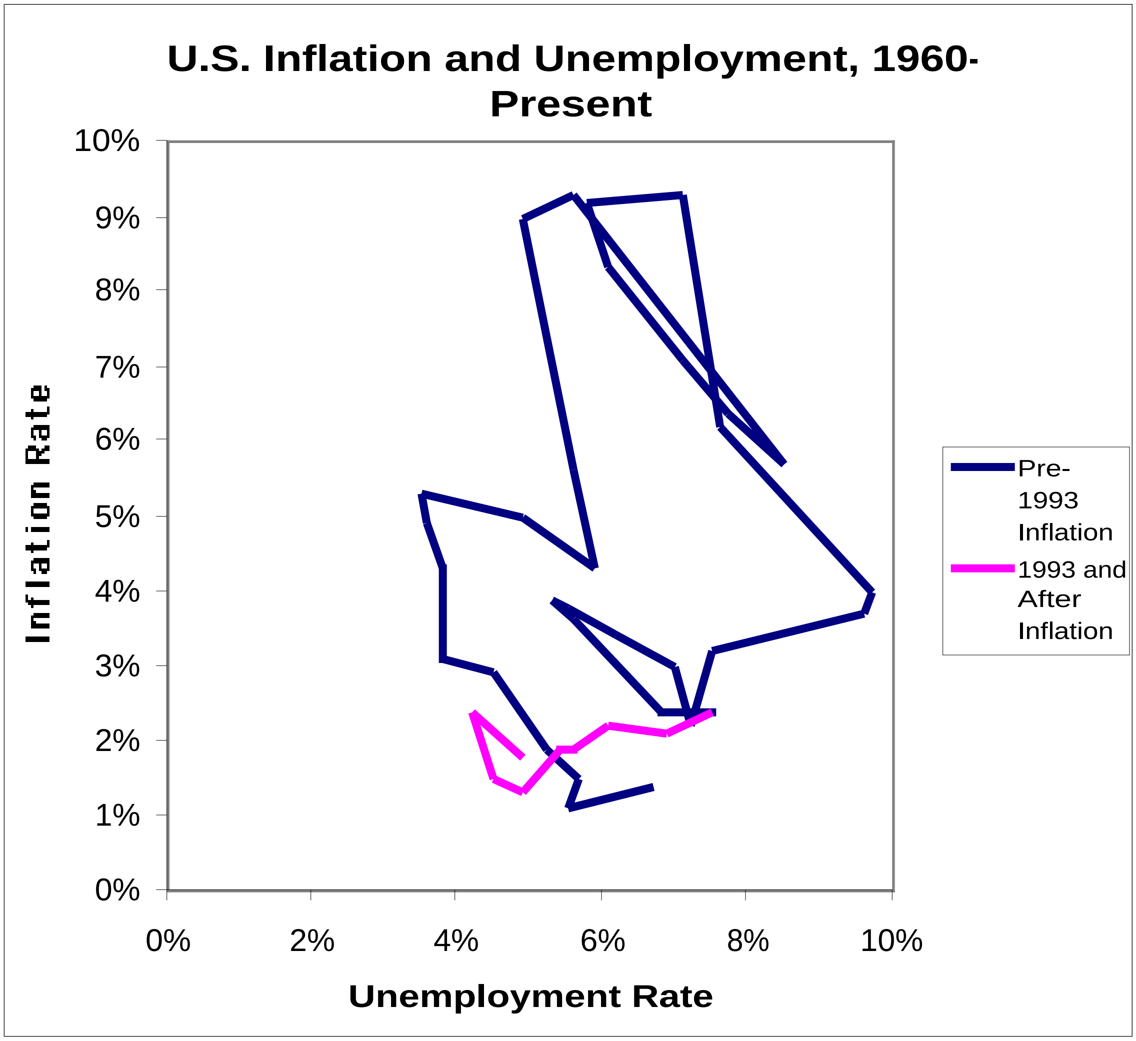
[31] See Taylor (2000), DeLong (1996).

Of the five factors surveyed in this paper, this is surely the weakest--and also the one that is most within our collective control. To a large extent, to be forewarned against this possibility is to be forearmed.

VII. Productivity Growth and the Labor Market

An offsetting "responsiveness" factor is that faster aggregate productivity growth may well have collateral benefits. It produces not just faster growth in real incomes, but it also eases the macroeconomic management dilemmas produced by labor market structure. To the extent that one attributes a large part of Europe's macroeconomic problems over the past generation to the interaction of the productivity slowdown of the 1970s with labor market structure, one would expect an acceleration of productivity growth to pay enormous business-cycle benefits as well--and it seems very safe to bet that the current ongoing technological revolutions will produce rapid productivity growth for quite some time to come.[32]

[32] See Blanchard (2000), Bruno and Sachs (1985).



Source: 2002 edition of the *Economic Report of the President.*

In the United States, the boom of the 1990s is a prime candidate for the responsibility for the remarkable favorable shifts in the Phillips curve that the U.S. economy exhibited in the 1990s. At the end of the 1980s the conventional wisdom among American macroeconomists estimated the economy's natural rate of unemployment as somewhere above six percent. These estimates were based on long historical experience: In the 1960s inflation increased when the unemployment rate fell below 5.5%. In the early 1970s, it seemed as though inflation fell when the unemployment rate rose above 5.5%. By the late 1970s it seemed as though it required an unemployment rate of 6.5% or more to put downward pressure on inflation.

In the 1980s, it seemed as though the workings of the labor market were worse: only when unemployment rose above 7% did inflation fall noticeably. And in the late 1980s and early 1990s it seemed as though inflation rose whenever the unemployment rate fell below 6.5%, and fell when the unemployment rate rose above 6.5% percent.[33]

Yet starting in the mid-1990s the comovements of inflation and unemployment went off the historical track. The fall in unemployment to 6% in the mid-1990s did not lead to any acceleration in inflation, nor did the fall in unemployment to 5% and then 4.5% in the late 1990s. Only as the unemployment rate fell to 4% at the end of the 1990s were there signs of rising inflation. This recent apparent shift in the NAIRU is very small in the context of the European experience, but it is remarkably large in the context of the American experience.

[33] See Staiger, Stock and Watson (1997), who stress the uncertainty surrounding our estimate of the natural rate at any moment in time.

It is not possible to trace the fall in the NAIRU directly to high-tech driven structural change. It is simply not plausible to argue that online job searches have made the labor market's frictions less important.[34] On the other hand, it is equally difficult to trace the fall in the NAIRU to demographic factors affecting the composition of the labor force or to changes in work organization. Demographic factors' plausible effects are an order of magnitude too small. And the timing is wrong to account for a large, sudden fall in the NAIRU in less than a decade.[35]

It is, however, possible that the natural rate of unemployment is linked to the rate of economy-wide productivity growth. The era of slow productivity growth from the mid-1970s to the mid-1990s saw a relatively high natural rate. By contrast, rapid productivity growth before 1973 and after 1995 has been associated with a lower natural rate. If workers' aspirations for real wage growth themselves depend on the rate of unemployment and do not depend directly on productivity growth, then a speedup in productivity growth will appear reduce the natural rate, for a while at least.[36] With a higher rate of productivity growth, firms can afford to pay higher real wage increases without going bankrupt. The unemployment rate consistent with real wage growth aspirations that match productivity growth is lower, as long as real wage growth

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[34] See Autor (2001).

[35] See Katz and Krueger (1999).

[36] See Ball and Mankiw (forthcoming); Blanchard and Katz (199?).

aspirations are formed naively--as a function of the unemployment rate, but without knowledge of economy-wide productivity growth.

There is no strong microeconomic evidence for this model in any form. The attribution of the fall in the NAIRU in the 1990s to the “new economy”—as an indirect consequence of the acceleration in productivity growth—is plausible and enticing, but far from proven.

VIII. Financial Market Surveillance

Fifth come the difficulties of financial market surveillance and regulation that come with the increasing complexity of financial markets and of the financial instruments traded upon them. To the extent that a principal goal of economic policy is to keep chains of large-scale bankruptcies from disrupting the financial sector, it is essential for government regulators to understand the capital structure and the portfolio risk profile of financial services firms. This may become more and more difficult in the future as the complexity of the financial instruments that financial services firms can design outrun the ability of regulators and other actors to quickly and reliably determine the risks of financial firms' portfolios and the consequences of their distress.

This potential danger was highlighted in 1998 by the sudden and unexpected collapse of the highly-leveraged hedge fund Long Term Capital Management.[37] LTCM's creditors, in spite of being on the hook to the firm for amounts in the tens of billions, found themselves unable to evaluate its portfolio in the time necessary for making decisions about whether and on what terms to lend it money. The reliability of the firm's risk-management tools--thought to be among the most sophisticated--was undermined by whispered rumors that according to LTCM's models its losses during August 1998 had been "a nine standard deviation event."[38]

It is unclear whether to attribute such possible future difficulties in regulation to minimize systemic risk to the information technology revolution. If there is one constant in financial history, it is that financial markets always contain some participants who are very good at figuring out previously-unthought of ways of gambling for resurrection with other people's money, or following trading strategies that turn out to destabilize prices, or to evade previously established internal and external controls. Nevertheless, the inability of outside private or public-sector analysts to quickly get a handle on LTCM's risks and liabilities in the summer of 1998 is a datapoint suggesting that, once again, the capacity of large private firms to find ways to run large risks had outrun the capacity of regulatory surveillance to identify and monitor them before things go wrong.

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[37] See Lowenstein (2000).

[38] Under a normal distribution, the expected time before one draws a nine standard deviation event if one draws once a second is on the order of two trillion years.

IX. Conclusion

This paper simply raises questions: it does not give answers. The extraordinary pace of the technological revolutions in data processing and data communications that are ongoing raise the possibility that the resulting structural shifts will have significant albeit cross-cutting effects on macroeonomic vulnerabilities. Three things seem clear:

First of all, as long as the ongoing technological revolutions and their associated uncertainty proceed, we should expect to see larger proportional asset price fluctuations. These raise the stakes and raise the magnitude of required actions by central banks and other participants in stabilization policy. Confronted with larger shocks arising in asset markets, macroeconomic policy will in all likelihood have to be more aggressive in response.

Second, to the extent that the business cycle in the past was driven by "mistakes" in inventories, there is good reason to believe that this source of volatility will decline in the future. Problems of inventory overaccumulation and overdecumulation have always been problems of information--of forecasting errors that are not discovered and corrected in a timely fashion. Better information technologies cannot help but lead to better inventory management systems, and firms that succeed in managing their own inventory chains better should aggregate up to smaller shocks arising from shifts in inventories.

Third, there is reason to hope that the faster productivity growth in the aggregate associated with the ongoing technological revolutions will produce faster average real wage growth, which will grease the wheels of the labor market. There is good reason to believe that labor market frictions and structural rigidities will play a smaller role in the macroeconomic disturbances of vulnerabilities of the next generation than they have played in the past.

But there are at least three things that are not clear:

First, the quantitative magnitudes of all three of the effects listed above are up for grabs.

Second, it is not clear whether or not the pattern of boom and bust likely to be generated by an ongoing technological revolution will degrade governments' institutional competence at managing the business cycle.

Third, it is not clear how much more difficult problems of financial market surveillance are going to be made by the increasing complexity of financial instruments and transactions made possible by the revolution in information technology. And it is not clear to what degree future financial crises will be blameable on the information technology revolution, as opposed to the long-recognized human propensity to try to raise the stakes and go double-or-nothing a few too many times.

The answers to these questions are unknown, and up for grabs. But we will start to see the answers to them in the next decade.

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