CONFERENCE DRAFT: NOV 8 , 2001

DID THE U.S. HAVE A NEW ECONOMY?

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Prepared for:
Association de Comptabilite Nationale
9th Conference on National Accounting
The Measurement of the New Economy
Paris
November 21-22, 2001

The extraordinary performance of the U.S. economy in the last half of the 1990s has been characterized as the emergence of a "new economy." Unemployment fell to historically low levels, without generating the inflationary consequences many analysts predicted. Labor productivity (output per hour) emerged from its twenty-year period of stagnation, nearly doubling after 1995 its anemic 1.4% average annual growth between 1973 and 1995.

Although the business press and some economists attributed the U.S. good fortune to the idea of a new economy, exactly what the term "new economy" meant varied with the user. For some, it meant that the old rules of production and distribution, and the economics traditionally used to analyze them, were obsolete. Very little evidence exists in support of that view, but the view was not based on evidence in the first place, so it was also hard for critics to confront it.

For others, the new economy meant that the pace of technological change had accelerated, especially the rate at which new products were being introduced—shortening of product birth and death cycles, accelerating importance of quality change in both goods and services, and so on. Again, very little evidence has accumulated in support of this "accelerationist" view: Most of the reams of anecdotes that have been cited in support of it have confused numbers of changes (which indeed are probably larger) with rates of change. It might be true that the *numbers* of new products and quality changes are greater than in the past, but no credible evidence exists for the hypothesis that the *rate* of innovation is higher (Triplett, 1999).

Others by their use of the term “new economy” no doubt meant simply that the U.S. was experiencing a confluence of favorable economic trends that it had not experienced since the 1950s and 1960s. On this view, the “new economy” looked different from the old 1973-1995 economy, but similar to the “old-old economy” that prevailed in the twenty-five years following the end of World War II.

With the slowdown in economic growth that has been apparent in U.S. economic statistics since early in the year, it is increasingly important to understand what was new in the U.S. economy in the 1990s. Some of the favorable growth and productivity following 1995 must have been cyclical, as Gordon (2000) has maintained, but the unresolved question is: How much? The concern of many macroeconomists today is to discern the portion of the 1990s economic boom that will survive shocks to the U.S. economy and will translate into higher economic growth than was experienced in the previous twenty years. Indeed, media accounts of the Jackson Hole conference (The Economist, September 8, 2001) suggest belief, or perhaps hope, among economic policy makers that this will be the case.

Great interest exists as well in other countries who wish to glean from the U.S. experience policies that may be helpful in fostering economic growth. Lequiller (2001) responds in part to this interest, and also to what he calls a “debate within a debate”—the concern among economic policy makers that measurement differences across OECD countries may cloud what can be learned from international comparisons of IT.

Lastly, it is also important to understand the implications of the U.S. new economy (if there was one) for economic measurement in national accounts, the subject of this conference, and for improvements and expansions of economic statistics everywhere.

I. The New Economy and IT

Whatever the "new economy" advocates meant by that term, they almost invariably linked it with the U.S. investment boom in information and communication equipment (IT) in the 1990s. Rising IT spending coincided with rising productivity and generated a substantial amount of research on the effect of IT capital on the post-1995 U.S. productivity acceleration. Bosworth and Triplett (2001) surveyed the major studies; the following is abstracted from that paper.

Jorgenson and Stiroh (2000, hereafter, JS), and Oliner and Sichel (2000, hereafter, OS) examined contributions of IT to the late-1990s acceleration of U.S. economic growth. Although methodological differences affect their results to an extent, the two studies present closely compatible information about the growth acceleration. Both show that all the traditional major sources of growth—capital services, labor services, and multifactor productivity—contributed to accelerating U.S. economic growth in the 1990s.

The Oliner and Sichel (OS) estimates are compatible with the output concept in national accounts. In their estimates (table 1), acceleration in MFP accounts for a bit more than 40 percent of the acceleration in growth. In the Jorgenson and Stiroh (JS) estimates, MFP accounts for a little under 40 percent, partly because JS use a wider concept of output that includes the services of household durables, an extension of the SNA production boundary that is favored by many economists.

Regarding the remaining roughly 60 per cent, both studies present remarkably similar findings: Accelerations in the growth of capital services and of labor services each contributes roughly half, with capital playing a slightly greater role. The U.S. investment boom of the 1990s raised its capital stock, and increased the contribution of capital services to production (the increase was estimated at 0.58 points per year by OS and 0.64 points by JS). But the U.S. economy has also experienced a labor services "boom," and the growth in labor inputs contributed nearly as much to the acceleration (0.46 points in the OS estimate, 0.39 points using the JS numbers).

Thus, in broad summary, accelerating growth in economic inputs accounted for three-fifths or more of the step-up in U.S. economic growth, with MFP accounting for the rest. Of the contribution of productive inputs, labor and capital have each accounted for roughly half, or a little under one third each of the total acceleration in economic growth.

The authors of the two studies separate the growth of capital services into IT capital services and non-IT capital services. They find that the services of IT capital provide all of the *acceleration* in the growth of capital services. Non-IT capital makes no contribution to the *acceleration* of growth in the late 1990s (its growth contribution, though positive, was the same before and after 1995). As the result of substantial IT investment in the U.S., IT equipment makes up a larger share of U.S. capital stock, and so IT now contributes a larger share of capital services than it once did. Additionally, the stock of IT capital grew faster in the late 1990s, so the contribution of IT capital to economic growth accelerated.

However, a finding that IT capital contributes to output growth is not new. In the 1973-95 interval, IT capital contributed 0.4 percent annually to U.S. economic growth according to JS, and 0.5 percent per year according to the OS study. What is new is that the contribution of IT is much larger than in the past (compare the IT capital line in the first and second columns of table 1).

Labor Productivity. For the new economy discussion, recent U.S. growth in productivity in the non-farm business sector is of primary interest. Labor productivity (LP) equals the output growth tabulated in table 1 divided by the index of hours, also shown in table 1. Multifactor productivity (MFP, which is actually shown separately in table 1) has the same output growth in the numerator as the labor productivity calculation, but it is divided by an index of capital and labor services.

Chart 1 shows the acceleration in U.S. labor productivity after 1995. Non-farm labor productivity in the U.S. grew about 1.4% per year between 1973 and 1995. After 1995, the productivity growth rate rose to 2.5%.

Researchers have also calculated the contributions of IT and other factors shown in table 1 to the post-1995 acceleration of labor productivity growth. Contributions estimated by four different studies are summarized in table 2, including the OS and JS studies plus labor productivity estimates by Gordon (2000) and the Council of Economic Advisors (2000).

Although methodologies and definitions of output differ to an extent among the four studies, they show broadly similar findings.[1] Around a quarter to a third of the acceleration in LP came from increased growth in capital services per worker (capital deepening), and two-thirds or more came from more rapidly growing MFP. Those studies that separated the contribution of IT capital from that of non-IT capital (OS and JS) found that IT capital is

[1] Jorgenson and Stiroh use a broad measure of output that includes housing and services of consumer durables. The Council of Economic Advisers (2000) uses an income-side measure of output growth that shows even greater acceleration than the conventional measures of nonfarm business output (from the national accounts) that are used in the other studies. Gordon (2000) bases his estimates on quarterly measures and he obtains a lower estimate of the acceleration in labor productivity and MFP because he attempts to adjust separately for cyclical influences, a factor which is not explicitly dealt with by the other studies.

responsible for all of the acceleration in the capital contribution to LP. As explained in the previous section, non-IT made the same contribution to growth before and after 1995, so its contribution to LP growth did not accelerate.

Conclusion. If the new economy meant only that IT has become an important contributor to U.S. economic growth, and so to LP, the studies confirm it. But the way they confirm it is to treat IT as just another capital good, one that is *economically* no different from capital goods that have contributed to economic growth in the past. I think that is a reasonable interpretation of the impact of IT, but it is not generally consistent with what the protagonists of the new economy view have been saying.

II. Industry and Company Effects of IT

Analysis of the economic effects of IT is turning from aggregate-level studies that use national accounts totals (such as the studies reviewed in the previous section) to industry-level and company-level studies. Less aggregative studies may help to understand better how IT affects output and productivity. If IT contributes to economy-wide growth and productivity, does it contribute in all sectors? If it does not, in which sectors does it make its contribution? And in either case, how and why does IT do what it does?

Establishment-level and firm-level studies have made a substantial contribution to the literature on the economic effects of IT. In the United States, studies by Brynjolfsson and Hitt (2000) and their collaborators are often cited, and important European research in this genre has taken place (for example, Greenan and Mairesse, 2000; Crepon and Heckel, 2001). Dedrick, Gurbaxani and Kraemer (2001) review a large number of IT studies from the management literature. Work using establishment-level data is still going on, an example being Atrostic and

Nguyen (this conference). To keep the topic relevant to national accounts, I will not say more about microdata studies, although their usefulness for the analysis of IT (and other topics) does have implications for statistical agency programs (but not primarily for national accounts). Also, most of these microdata studies have not been concerned with the post-1995 acceleration of productivity in the U.S., and a good number of them predate the recent interest in the acceleration topic.

On the other hand, industry-level studies do frequently use national accounts information. Two major ones have focused on the post-1995 productivity acceleration in the U.S. These two—Stiroh (2001a) and McKinsey Global Institute (2001)—are complementary in that they asked somewhat different questions and therefore enlighten different aspects of the productivity acceleration.

Stiroh (2001a) examined 61 industries, using data from the U.S. industry accounts produced by the Bureau of Economic Analysis as part of the U.S. national income and product accounts (NIPA) system. One can think of an industry as a group of establishments that have similar production functions, so, approximately, each industry has a different production function from some other industry. Accordingly, one can ask: Is there evidence that a large number of production functions shifted after 1995? An affirmative answer to that question indicates that some underlying technical change broadly affected the U.S. economy around 1995.

Stiroh's statistical analysis indicated that two-thirds of the 61 industries showed a positive shift in labor productivity after 1995. Moreover, Stiroh found that the industries that had positive productivity shifts were more intensive users of IT capital than those industries that did not have upward productivity shifts—that is, the capital deepening effects of past IT investments on labor productivity showed up strongly in the industry data. Thus, looking across the range of industries, something changed in the U.S. economy that affected a large number of different production processes, and IT investment had a substantial role in that labor productivity change.

The McKinsey Global Institute (2001, hereafter, MGI) study asked a different question: Which industries accounted for the net U.S. acceleration in productivity after 1995? Although a large number of industries showed productivity improvement (the MGI study agreed with Stiroh's findings in this respect), many of those industries have small shares of GDP, so their contribution to the aggregate post-1995 U.S. productivity acceleration is also small. MGI found that six large industries accounted for nearly all of the net, economy-wide labor productivity acceleration, and indeed of the gross acceleration.[2] If one is interested in the cause of the *aggregate* productivity acceleration, looking at contributions is the appropriate metric. On the other hand, if one is asking whether IT makes a widespread impact, then the number of industries is the appropriate metric (as it is in the Stiroh study).

Isolating the six industries that made the major contribution to aggregate U.S. productivity acceleration suggests a research strategy for detailed studies of the major contributors. This strategy also permitted melding of economic analysis and the industry expertise generated by McKinsey's consulting practice.

MGI examined the specific technical changes that occurred in the six industries (wholesale trade, retail trade, computer manufacturing, semiconductor manufacturing, securities brokerage services, and communications). In none of these six were the major productivity changes that occurred in the 1990s primarily driven by *new developments or new investment* in IT. In all of them, effective use of IT was important, but in most cases the technical changes were associated with information technology that existed well before the 1990s.

MGI (2001) emphasized the importance of managerial innovations, where IT might be a facilitating tool, as well as competitive pressures that forced widespread imitation of managerial innovations that occurred. Rising competitive pressures arose from deregulation in two cases (securities brokerage, and communications). In the general retailing portion of the retail trade industry, the emergence of a dominant, innovative firm (Wal-Mart) precipitated either successful imitations by the firms that survived or declining market shares and exits of the less productive firms, both of which raised industry productivity. Thus, MGI emphasized that it was the constellation of IT, managerial innovation, and intensely competitive structures that caused productivity changes in these six industries, and not just the effects of IT investment alone.

Conclusion. Industry studies on the impact of IT on labor productivity complement the aggregate-level growth studies reviewed in section I. Do they show that IT makes a contribution? Yes. Is IT something that is unprecedented, either in the way it contributes to economic growth, or in its contribution post-1995? No.

The MGI (2001) study usefully reminds us that no new capital good is simply inserted into the production environment without a great amount of managerial initiative. Indeed, the managerial initiative may be more important for productivity than the new kind of equipment. Just because the U.S. now has a large stock of IT does not assure that its LP and MFP will continue in the future to grow at their post-1995 rates, contrary to at least some views of the new economy.

Taking the industry study and aggregate study evidence together, I conclude that much of what happened in the U.S. after 1995 was a continuation of processes that were as old as the Industrial Revolution itself—managerial innovations that disturbed the competitive balance in an

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[2] The net acceleration (taking account of positive, accelerating industries and also of industries that experienced decelerating productivity) was 1.4 index points, measured relative to the 1987-95 period . The gross acceleration

industry, investment in new kinds of machinery and equipment that improved labor productivity by increasing capital per worker, and the relative absence or reduction of economic regulation and monopoly power that stifles innovation.[3] Some of the writing about new economy invested a mystical, or even magical, quality to IT by holding that it was somehow "different" from past capital equipment, and therefore could not be analyzed or comprehended with the traditional economic tools. IT is, to be sure, new—or relatively new.[4] But as an approximation, it seems adequate and useful to think of IT as simply an investment good, whose impacts can be analyzed in the same way as any other investment good. Ambiguities remain that are reviewed in the following section.

III. MFP and the New Economy

The substantial contribution of IT to LP is documented in the aggregate-level and industry-level studies reviewed so far. However, the IT-related capital deepening effect discussed in the previous sections contributes only about 40 per cent of the post-1995 U.S. acceleration of LP. MFP acceleration accounted for about 60 per cent of the acceleration in labor productivity. The post-1995 acceleration in MFP growth in the United States is a crucial part of the "new economy" story.

One MFP-IT connection is well established. All existing studies have pointed to accelerating MFP in the IT producing industries, or as they have usually called it "electronics." Gordon (2000) has particularly emphasized the IT-producing industries' contribution to U.S. MFP. Because the recent studies of accelerating growth have invariably worked with "two digit"

(considering only the industries that experienced productivity accelerations) was 1.8 index points.

[3] There is an old remark that the greatest monopoly return is a quiet life (because a monopolist does not have to worry about challenges from innovators). It is notorious that regulators come to identify with the interests of the companies they regulate rather than with their customers.

U.S. industry detail , and in the old U.S. industry classification system there was no electronics sector, the studies have actually shown accelerating MFP in the electrical and nonelectrical machinery producing industries.[5]

Nevertheless, it is undoubtedly the case that the electronics portions of the machinery producing industries are the ones with rapidly growing MFP. In Triplett (1996a), I estimated MFP growth in semiconductor manufacturing on the order of 30 per cent per year, which was several orders of magnitude greater than computer manufacturing MFP growth.

Some have suggested that MFP acceleration outside the electronics producing sectors was the mark of a new economy. If so, existing studies of IT have not illuminated it very much.

In part, this is the nature of MFP. It is a residual. MFP is the part of output growth that cannot be explained by growth in productive inputs. Twenty years of economic research has never succeeded in explaining the mysterious slowdown in MFP that occurred around 1973 and extended to 1995. Consequently, it is not so surprising that we have yet little insight into the causes of the post-1995 restoration of the rate of MFP growth.

Was the acceleration of MFP the evidence of the new economy? Was it the effect of IT?

Whether IT has contributed to the MFP expansion after 1995 is in doubt, as indeed are the causes of the post-1995 acceleration in MFP. Some of the public discussion has been clouded by confusion over what MFP and LP measure. To many observers, the image of "capital deepening" and substitution of capital for labor seems inconsistent with what IT does, or an inadequate representation of what IT does. This has led to the notion that productivity accounting is an inadequate way to account for the economic effects of IT. In part, this is confusion caused by language, or perhaps by incomplete language.

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[4] The first successful commercial computer was introduced around 1954, so the "computer age" is now approaching a half century.

Consider a stylized example. Suppose that one worker with one machine produces two units of output per hour. Adding a second machine (which we can call IT) permits the worker to produce three units per hour. This is capital deepening—the capital-labor ratio has increased. It is also a growth in labor productivity (output per hour). The example also represents expanding output. Moreover, the labor saving in this case (labor per unit of output drops from one-half hour to one-third hour) indicates an increase in the return to capital (return to IT investment). The output enhancement that IT permits is fully within the conceptual framework of productivity.

In the simple example, output expansion implicitly takes the form of more units of identical products. The principle shown by the example is not vitally changed if, instead, the output enhancement shows up in proliferating the kinds of outputs that are produced (new products and new services), or in quality improvements to existing products, and so forth.

IT capital changes the way things are done—it changes business processes and it results in new products and services. If economic statistics correctly measure these new goods and services, then what computers do will show up in the output measure, and hence what computers do will be included in the numerator of productivity statistics, both LP and MFP. This also means that what computers do will show up as a return to computers, that is, as a return to a productive input, provided computer prices are measured correctly and economic statistics also measure correctly the computer input to production.

Thus, if output and computer inputs are correctly measured, the new things that computers do will *not* show up in economic statistics in the form of enhanced MFP. MFP is the change in output that is *not* associated with input usage, it is by definition the change in output that is not caused by IT (or by any other kind of capital). The MFP framework applies to the

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[5]The Electrical machinery industry includes semiconductors, it is true, but it also includes Christmas tree lights!

economic effects of IT, contrary to assertions sometimes made in the business press and elsewhere.

Even so, there is much speculation among economists that IT affects MFP. The major source of this speculation involves alleged "spillovers" from IT investment.

The Spillovers Dialog: I have considerable sympathy with Stiroh's (2001b) remark that "it is unclear conceptually what production spillovers really are." The idea comes from the R&D literature, where research by one economic unit might result in knowledge that can be used by another one "for free." Technological change thus spills over from the firms or sectors that do it to firms or sectors that do not do it, enhancing the productivity of the latter because it is an unpaid input to the sector that receives the free research (uncompensated inputs are not normally included in calculating the denominator of MFP because data on them is not available from the accounts of the firms that benefit).

In the case of IT, much of the spillovers discussion concerns network effects. Suppose three companies, A, B, and C, all of which need to communicate with one another. Companies A and B decide to set up an internet connection to reduce their communication (ordering, billing and so forth) costs, presuming that they must still communicate with C by "snail mail." But then C decides to emulate. A and B then find that the value of their internet is larger than what they thought it would be *when they made their IT investment decision*. This is the network effect—IT will be more valuable the larger the network available to IT users.

Some economists believe that IT is different from other capital goods because IT produces impacts that are external to the user of the IT. They conclude that the economy-wide effects of IT will accordingly be greater than the impacts that are attributed to users of IT.

However, these network effects—though real and important—will be internal to the group of IT users. The extra and unanticipated benefits (cost saving or whatever) that accrue to A and B when C joins the network will be accounted for in any study that estimates the impact of *installed* IT on A and B's productivity. *Ex ante*, network effects mean that the benefits of IT may be underestimated by investors in it. But *ex post*, the benefits will be captured in (say) a regression of output on inputs, including the services of IT capital. For the most part, economic research is carried out on *ex post* data, we have little information on the *ex ante* expectations that resulted in the decision to invest in IT.[6]

The network effect of IT is an important issue, but further discussion ranges too far afield for the present paper.

Knowledge Gaps. Three gaps in knowledge prevent our gaining from the MFP framework the information we need to assess the new economy idea.

First, the assessment requires more information about MFP at the industry- and sector-level among IT using industries, especially services industries. Stiroh (2001a) and MGI (2001) show the post-1995 LP effects, and some of what they found implies MFP effects. MFP research on the post-1995 acceleration in the IT-intensive services industries has yet to be carried out.

For manufacturing industries, Stiroh (2001b) reports that no association exists between IT and MFP acceleration at the (two-digit) industry level. That finding is consistent with what one expects from the MFP model (see the above discussion), when IT has effects like any other capital good—that is, no spillovers and no extra-normal returns to IT. He also finds lower (and sometimes negative) effects from the communications equipment components of IT.

[6] On the above logic, if network effects are important, they should result in ex post returns that are larger than ex ante expected returns to investment in IT. Interestingly, the predicted IT cost savings from consulting firms are often very large, not too small.

The second issue concerns lags. IT investment no doubt affects output and productivity growth with a lag. All investments do. For this reason, post-1995 IT investment in the U.S. may not yet have all made its full presence felt on the economy. Contributions to growth studies, like those reviewed in section I of this paper, assume that IT makes its impact without lags (because of the lack of information about the lag structure).

Great current interest exists in the future impact of IT—see for example, Litan and Rivlin (2001). Unfortunately, much of the economic analysis that has been done at present relies on crucial cost impact "guesstimates" from various consulting companies. One suspects these sources have a tendency to exaggerate, rather than understate. Even if the raw cost numbers are themselves correct, it is sometimes difficult to determine what portion of total costs are affected. Bosworth and Triplett (2001) discuss examples of such overstatements of the impact of IT.[7] MGI (2001) cites some cases (including hotels) where cost saving from substantial IT investment has not been realized. There are no doubt others.

Regardless of the magnitude of the ultimate effects, we have little information on the lengths of the lags. Some speculations in the literature seems too extreme. For example, the idea that IT might have 20 to 40-year lags (an idea that was popularized by uncritical acceptance of a superficially appealing analogy with electricity) has little plausibility for a product, like computers, whose average service life is only 5-6 years.

Third, some of the output improvements that IT makes possible may not be measured in economic statistics. IT use is heaviest in some of the industries whose output is not measured very well (banking and finance, for example). As noted earlier, IT permits doing things in new

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[7] The press gave a great amount of attention to a consulting company's prediction of 50% cost saving in U.K. trucking that it projected from use of IT to improve truck scheduling and reduce the number of trucks that were operating with partial loads. The U.K. projection, however, was out of line substantially with a U.S. study of exactly the effect of IT on truck scheduling and actual truck costs (Hubbard, 2001).

ways and facilitates new and improved products. For both of these reasons, the impact of IT on the economy is likely to fall into areas where measurement of output is particularly difficult. Economic accounts may have understated output in a number of these industries. If so, statistics will also understate labor productivity improvement, understate the return to IT, and understate MFP. Indeed, McGuckin and Stiroh (2001a) contend that increasing mismeasurement of output in the U.S. economy amounts to half a percentage point in economic growth.[8] An assessment of output measurement in some of the services industries that are IT intensive is Triplett and Bosworth (2000). See also the various papers and workshop agendas on the website for the Brookings Program on Output and Productivity Measurement in the Services Sectors (http://www.brook.edu/es/research/projects/productivity/productivity.htm), and the discussions of services measurement issues in the new Eurostat handbook on price and output measures in national accounts (Eurostat, 2001).

Conclusion on MFP. Understanding the post-1995 MFP acceleration is crucial for understanding the sense that the U.S. had a new economy, and the extent of it. Research has not yet shown very much about the MFP acceleration in the crucial IT-using services industries. Major unresolved research issues include the following:[9]

(1) Was the capital-deepening effect of IT on LP temporary or permanent? Robert Gordon refers to a number of temporary factors, such as the "Y2K" problem, the ramp up for the Internet, and so forth. The greater was the temporary IT impact (and the lower the permanent), the greater was the MFP acceleration.

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[8] However, they do introduce the implicit assumption that improving the measurement of output will raise output growth rates. This has sometimes been the case, empirically. But I am not convinced that services sector output was measured better in the U.S. in the 1950's and 1960's, as this assumption must imply if it is applied to the 1973-95 era.

[9] I am indebted to Robert Gordon for helpful discussions, and for his presentations to the New York Federal Reserve conference "Productivity Growth: A New Era?," November, 2001, and The Brookings Workshop on Communications Output and Productivity, February l, 2001.

(2) How much of the MFP acceleration was trend, and how much merely cyclical? Again, Gordon (2000) has emphasized the cyclical part of the story, and has taken a stronger position than most other economists, but nearly everyone agrees that a cyclical component must have been present in the post-1995 MFP acceleration. The greater the cyclical part, the less is the MFP acceleration evidence of a new economy.

(3) What part of the MFP expansion, cyclical or trend, is associated with IT? This connection between IT and using-industry MFP (if any) would arise either because IT creates output that is not fully measured (in which case there is MFP associated with IT that we have missed) or because of spillovers from IT, such as network effects. It is also possible that IT earns a greater return than other kinds of investment, which implies that IT's contribution to output is understated in current data. But if this is true (it is debatable) then it must be temporary.

IV. Analyzing IT in Other Countries

The substantial contributions of IT to recent U.S. economic growth can be estimated and analyzed because the U.S. has a well-established (but by no means fully adequate) system of deflators for IT equipment that allow for the very rapid technological advances in these products. The U.S. IT deflator system began with a collaboration between the Bureau of Economic Analysis and economists at the IBM Corporation on price indexes for computers and peripheral equipment that resulted in the first introduction of hedonic computer price indexes into the national accounts of any country (Cole, et al., 1986; Cartwright, 1986). This work was probably the most far-reaching innovation world wide in national accounts in the decade of the 1980s. The innovation has now been extended in the U.S. to price indexes for semiconductors and to other IT equipment, but by no means all of IT. Indeed, measures of U.S. telecommunications equipment prices are probably still in need of improvement (Jorgenson, 2001), as are deflators for software (added to the IT investment numbers in the 1999 benchmark revision to the U.S. national accounts). Triplett and Gunter (2001) point out that data for high-tech medical equipment—another set of technological products that are transforming the outputs of using industries—are by no means as adequate as are data on IT, so many tasks are as yet uncompleted in the U.S. high-tech measurement program.

Because IT has been so important a contributor to recent U.S. economic growth, economists want to determine the contribution of IT in other economies. Determining the contributions of IT in other economies is far more difficult because the basic analytic statistics on IT are not always available, mainly because of inadequate IT deflators. Some other countries measure IT prices using hedonic indexes: France, Sweden, Canada and Japan produce their own hedonic computer price indexes, and Australia and Denmark use U.S. indexes, exchange rate adjusted, as investment deflators in their own national accounts. But measures of IT investment across OECD countries are not compatible.

A number of recent studies (Schreyer, 2000; Daveri, 2001; Oulton, 2001; Colecchia and Schreyer, 2001) employ U.S. price indexes as proxies for IT equipment deflators for groups of OECD countries. The great and implausible international variations documented in Wyckoff (1995) and Eurostat (1999) have convinced scholars that extrapolation of U.S. price indexes is better than accepting the measures that are now published by statistical agencies of many OECD countries. Their decision is supported by fragmentary research that suggests substantial corrolations among hedonic price indexes estimated for different countries. A preliminary study of German computer prices (Moch, 1999) suggests that German personal computer prices are declining as rapidly as those in the United States, which is comparable to a similar finding some time ago for France by Moreau (1996), and also to a computer price index for Taiwan (Jang, et al., 1996). In a preliminary study of international computer price movements, Moch and Triplett (2001) report similar price indexes for PC's in France and Germany.

However, exchange rate adjusted U.S. IT price indexes are undoubtedly not as good as quality-adjusted indexes that measure countries' own IT price experiences. Lequiller (2001) reports that the U.S. IT deflator, exchange rate adjusted for France, fell by about 19 per cent per year for 1995-98; over the same period, France's own hedonic index for IT fell by 16 per cent. There may be composition differences that affect such comparisons, but it is undoubtedly the case that obtaining better price measures for IT, and for other high technology capital goods—as well as for the services that use this capital equipment—will be as essential for accounting for the new economy in other countries as they have been in the U.S. Initiatives in this direction are underway, sponsored by Eurostat and the OECD.

V. Implications for National Accounts.

Did the U.S. have a new economy? The answer depends a bit on what one means by new economy. If new economy just meant that IT capital had become an important contributor to U.S. economic growth, within the normal capital deepening model, then the evidence is overwhelmingly in favor of it. If new economy meant that the U.S. economy had experienced a new surge of MFP growth that was not related to IT, then the evidence is also consistent with this interpretation.[10] But if new economy meant that IT was the source of post-1995 U.S. MFP growth, there is little evidence in favor of this position, though the evidence is not all in.

[10] On the other hand, if acceleration in MFP is the mark of a new economy, then the new economy may not be so new. The rate of MFP growth after 1995 was about equal to its growth in the old-old economy of 1949-1973.

But whatever one's position on the new economy, the controversy surrounding the new economy idea has thrown new attention on measurements in some parts of national accounts. What implications can one draw for national accounts from the research on the new economy?

In this section, I sketch out an ambitious program for the data we need to analyze the new economy. National accounts are at the middle of it, though to be sure they are usually at the mercy of source data provided by other statistical programs. Priorities, of course, will have to be set. No program for improving statistics can be put in place immediately. Additionally, the implementation plans will differ from country to country for unique factors, such as the statistical programs already in place, the ease that extensions can be made from existing programs to new statistical programs, differences in institutions and information available from respondents to statistical surveys, and so forth. However, it is better to impose feasibility considerations on a more ambitious program than to attempt to guess what will be feasible and let the merely adequate be the enemy of the comprehensive.

First, IT has been at the center of the discussion of the new economy, for good reasons. To analyze the new economy, we need comprehensive programs for measuring IT investment in national accounts. IT investment data has the usual specification—current-price outlays or expenditures and deflators to convert them into constant-price (quantity or volume) measures.

The IT agenda is difficult because it is so demanding in detail. Computer prices have received much justifiable attention in the press and elsewhere. Computer prices are only a fraction of the measurement task.

Abundant evidence exists that prices for different kinds of IT equipment do not move together. This is apparent from the historical record (reviewed in my old survey of computer research, Triplett, 1989). The message has been repeated in the price trends over the last decade.

The communications equipment part of IT is as important as the computer equipment part, and may have different price trends (Doms and Forman, 2001). Advances in miniaturization technology that are not electronic (hard drives are an example) are also driving the decline in IT equipment prices, and one should not expect those changes necessarily to move with the price of electronic inputs to IT equipment.

Moreover, it is interesting that, systematically, the IT equipment that experiences the most rapid price declines exhibits the greatest increases in market shares. Another way of putting it: Relative prices work, and cause substitution toward items of equipment that have the greatest declines in relative prices. Accordingly, the deflated quantity indexes (constant-price investment in national accounts) do not move together either. Aggregation effects within the IT equipment category are major.

We can check whether these differences in relative price movements are plausible. Price changes for many electronic equipment products are driven by price changes in semiconductor inputs. We know that different types of semiconductors have different price movements (sometimes very different). We also know that the mix of semiconductors differs by items of IT equipment. Aizcorbe and Flamm (forthcoming) calculate the cost implications of differences in semiconductor prices and mixes on six different using-industry categories (e.g., computer equipment, communications equipment, and so forth), and find markedly different cost implications.

Thus, we can't analyze IT in the new economy with just some aggregate measure of IT investment, we will have to build up the aggregate from detailed IT equipment categories. This is a much bigger job than simply measuring computer prices, difficult as that job is in itself.

Second, because productivity is an important part of the new economy discussion, these IT investment numbers need to be formed into IT capital stock estimates. Again, the detail is a necessary part of the statistical program.

Detail on producing the capital stock numbers is necessary partly for the differential price and quantity movements discussed above. Aggregation may create a misleading total and loses too much valuable information about changes in prices and quantities. In addition, IT equipment has the character that its depreciation is very rapid, largely because of rapid obsolescence. However, IT equipment's rate of deterioration (the ability of the equipment to contribute to production, to generate capital services) falls much more slowly. For this reason, it is important to estimate the *productive* stock of capital in addition to the usual wealth stock that is normally produced for national accounting purposes (on the distinction between the productive stock and the wealth stock, see Hulten, 1990, Triplett, 1996b, and Schreyer, 2001). For many countries, this vital part of the program for IT statistics is probably well down the road.

Indeed, estimating productivity by statistical agencies is a North American and South Pacific phenomenon. In Europe, productivity seems to be regarded as a research activity, and not an activity of statistical agencies. Perhaps that division of responsibilities will continue (it does not matter that much). But the task of producing statistical measures for productivity analysis, including estimating productive capital stocks, is well within the province of statistical agencies, and will increasingly be demanded by their clients who need information for productivity comparisons.

Third, understanding the new economy and the impact of IT requires enhancements of capital information, not just aggregate, economy-wide investment and capital stock data. We want to understand the effects of technology that are embodied in capital equipment. That requires better information on the flows of capital equipment to using industries. Though the capital flow information is just part of the input-output tables that are produced by many countries, much more detail in needed than is usually produced in I-O tables, partly because price change and quantity change trends in IT differ so greatly. Detail is also needed because the impacts we ultimately need to study are impacts of IT on particular using sectors, not just on the aggregate economy, and down the road, perhaps, the impacts of, e.g., cell phones and computer processors, not of an aggregation of IT capital. Any aggregation tends to hide the important elements, and even though aggregation is necessary in statistics, the study of IT requires as much detail as possible.

In summary, on the capital equipment end the message is more investment detail, more deflator detail, more capital stock detail, and more information on capital flows. The resouce implications are great.

Finally, improving the measures of services output deserves heightened priority. To estimate the impact of IT on using industries requires good measures of the output of the using industries. A very high proportion of IT capital equipment goes into services, many of which fall into the "hard to measure" category. Examples are banking and finance and insurance (for both, I have long believed that we need to reconsider the SNA conventions) and business services. The latter is a large, growing and heterogeneous category on which too little information and research exists. See the Brookings Workshop on this topic, at: http://www.brook.edu/es/research/projects/productivity/workshops/19990514.htm. Services output measurement is already high on the agendas of statistical agencies almost everywhere, so this need is widely appreciated. That does not mean it does not deserve emphasis here.

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Table 1

Contributions to Output Growth, U.S. Nonfarm Business

Annual Rates of Change

Category	1973-95	1996-99	Acceleration
Growth of Output	2.99	4.82	1.83
Capital Services	1.27	1.85	0.58
Of which: ICT	0.51	1.10	0.59
Other capital	0.76	0.75	-0.01
Labor services	1.35	1.81	0.46
Of which: hours	1.08	1.50	0.42
Labor quality	0.27	0.31	0.04
MFP	0.36	1.16	0.80

Source: Oliner and Sichel (2000), Table 1

Table 2

Alternative Estimates of the Acceleration of Productivity Growth, Post-1995

Annual Rates of Change

Category	Jorgenson and Stiroh	Oliner and Sichel	Council of Economic Advisors	Gordon
Labor Productivity	0.9	1.2	1.5	1.4
Cycle	n.a.	n.a.	n.a.	0.7
Trend	0.9	1.2	1.5	0.7
Contribution of:				
Capital per worker	0.3	0.3	0.5	0.3
IT capital	0.3	0.5	n.a.	n.a.
Other capital	0.0	-0.2	n.a.	n.a.
Labor Quality	0.0	0.0	0.1	0.1
Multi-factor Productivity	0.7	0.8	0.9	0.3
Production of IT	0.3	0.3	0.2	0.3
Other sectors	0.4	0.5	0.7	0.0

The post-1995 acceleration is measured relative to a base of 1973-95. The estimates of Jorgenson-Stiroh extend only through 1998.
Sources: see text.

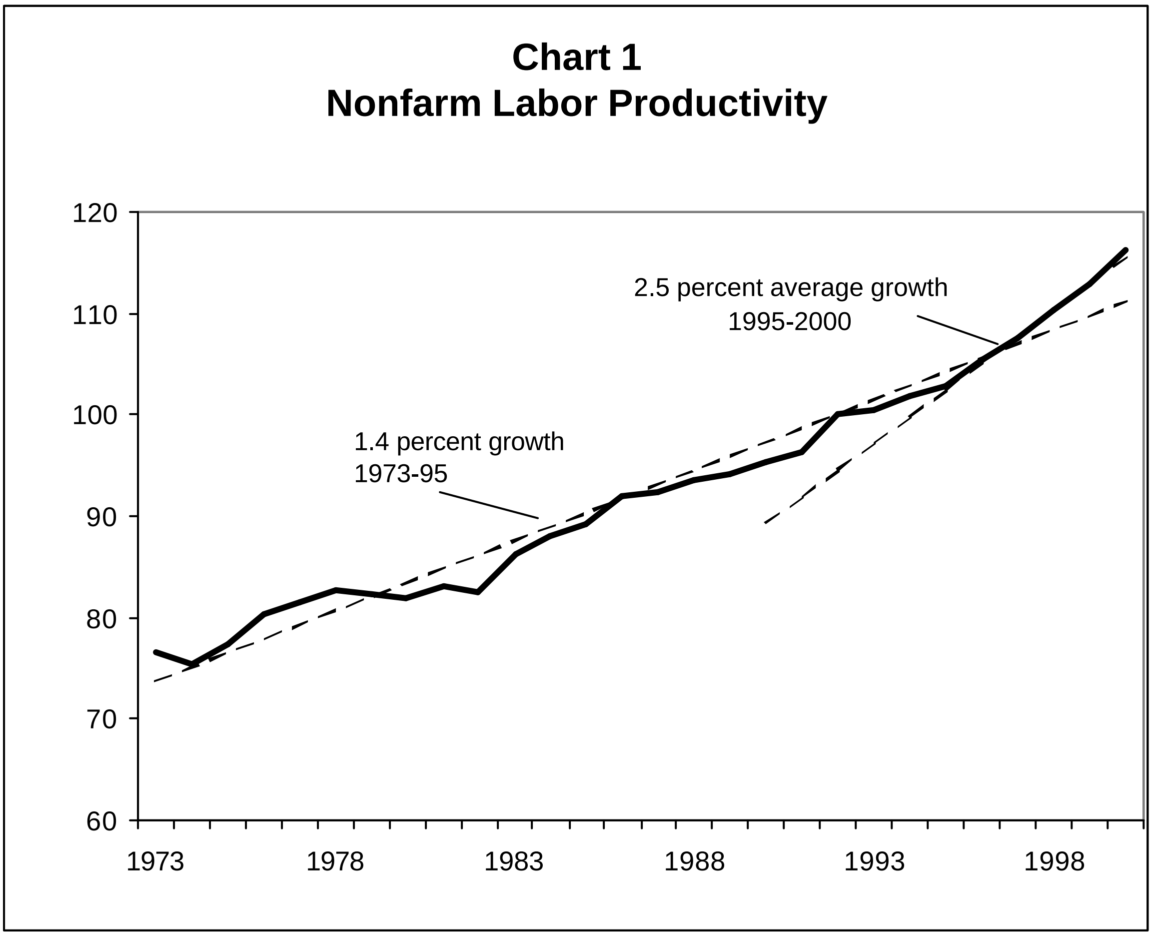
Chart 1
Nonfarm Labor Productivity
2.5 percent average growth
1995-2000
1.4 percent growth
1973-95
120
110
100
90
80
70
60
1973
1978
1983
1988
1993
1998