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Abstract

It is often pointed out that the changing nature of output – that is, the increased proportion of knowledge- and information-intensive components in economic value – might have affected the accuracy of statistical measures in capturing the reality of economic growth. This paper reviews the discussion of the productivity paradox from the viewpoint of possible mismeasurement in official statistics.

Key words: Productivity Paradox, Measurement Error, Quality Adjustment, Service Sector Output

JEL classification: C43, O47

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# 1 Introduction

Good policy may be possible without good measurement, but without good measurement it is unlikely that the costs and benefits of policies can be accurately assessed. While there has been some progress in both the theory and practice of measurement (particularly for inputs), the modern economy presents some new measurement complications, and amplifies some old ones. The assessment of economic performance for countries may be seriously affected by these difficulties.

In particular, there has been much attention recently on what has become known as the "productivity paradox". Basically, the paradox is that we have not seen the expected productivity improvement from new technology in the official statistics. In fact there has been a measured productivity slowdown in industrialized countries in the last 25 years, the very time when we would have expected to see large increases in productivity growth due to rapid technological change.

Diewert and Fox (1998) reported productivity growth estimates for 18 OECD countries which showed that average total factor productivity growth fell from 3.25% for 1961–1973 to 1.09% for 1974–1992. Labour productivity growth fell from 4.41% in the earlier period to 1.81% in the latter period. These falls in productivity growth are not trivial, hence the many recent attempts to try to explain this "paradox". In particular, there has been a lot of focus on the role of computers — perhaps the most visible of technological improvements in the last 25 years — and whether or not they can produce the productivity payoff that was expected of them. In broader terms, the productivity slowdown still seems puzzling, even if computers have not contributed to productivity growth.

In this paper, we review the evidence that there may be some serious measurement problems faced by under-resourced statistical agencies. Given the nature of current technological change, these measurement difficulties are becoming more serious, leading to productivity measures being biased downwards. Possible measurement errors come from a variety of sources. Some are due to the difficulty in defining an appropriate measure of output, which is a problem particularly in service industries. Others are due to national income accounting conventions which have been traditionally used, but which are not appropriate to deal with the nature of a modern economy. The treatment of interest is one such example. However, many of the measurement problems to be examined do not have simple solutions.

This paper is organised as follows. Section 2 looks at the debate over the apparent absence of a productivity payoff from computers. Sections 3 to 6 examine various sources of economic mismeasurement which may be obscuring the true level of productivity growth.

Hence this provides a direct explanation for the paradox — we are more productive than we think, it is just that we cannot show it. Section 7 looks at reasons why we may not actually be as productive as we could be, many of which are related to measurement problems.

## 2 Where is the Productivity Payoff from Computers?

Much of the attention that has focused on the productivity paradox has been due to anecdotal evidence on the proliferation of computers, the variety of uses to which they are put, potential applications, and the enormous increase in raw computing power in a startlingly short period of time. This has occurred at the same time as measured productivity growth has been slow. Hence we are puzzled why we do not see a "productivity dividend" from the rapid spread of computer technology.

One explanation is that there has been a productivity payoff from computers, but because of the measurement problems mentioned in the following sections, we have not been able to see it. This seems to be the favoured explanation of Griliches (1994):

> "Why has this [computer investment] not translated itself into visible productivity gains? The major answer to this puzzle is very simple: .... This investment has gone into our 'unmeasurable sectors,' and thus its productivity effects, which are likely to be quite real, are largely invisible in the data." *Zvi Griliches* (1994, 11)

Triplett (1998) provides a quite comprehensive review of the arguments put forward concerning the computer productivity paradox. Among these arguments is one that measurement error is not responsible for the paradox, that in fact there is no paradox — computers are simply not (yet) as productive as we think. One example of thinking on these lines is that given by David (1990), using the comparison in the delay in the payoff seen from the use of electricity:

> "Factory electrification did not ... have an impact on productivity growth in manufacturing before the early 1920's. At that time only slightly more than half of factory mechanical drive capacity had been electrified .... This was four decades after the first central power station opened for business." *Paul A. David* (1990, 357)

Triplett (1998) argues convincingly that the pattern of price decline of computing power is such that it makes the analogy with electrification suspect. The more rapid decline in the price of computers has meant the diffusion process has also been fundamentally different.

> "In the computer diffusion process, the *initial* applications supplanted older technologies for computing. Water and steam power long survived the introduction of electricity; but old pre-computer age devices for doing calculations disappeared long ago. ... The vast continuous decline in computing prices has long since been factored into the decision to replace the computational analogy to the old mill by the stream—electric calculators, punched-card sorters, and the like–with modern computers."
>
> *Jack E. Triplett* (1998)

Another common argument for why computers may not have been able to provide a productivity payoff comes from considering growth accounting equations:

> "It is a basic rule of growth accounting that large changes in investment cause only small changes in output. The reasons for this are that investment is a small fraction of GNP and that the marginal product of capital is small. Since computers are a quite small part of total investment, a vast increase in investment in computers would yield only a small increase in measured output even if all the computers were being used productively and were generating measured output .... These calculations imply that if computers are being used productively [in the U.S.], they have raised the average annual growth rate of output over the past two decades by roughly a twenty-fifth of a percentage point." *David Romer* (1988, 427)

However, one wonders if this is the correct framework in which to think about the role of computer capital. A computer does not seem to be like any other piece of capital. It can be used to control other capital (and labour), so that the other capital (and labour) is used more efficiently, e.g., the management of a warehouse, or coordinating the movement of trucks and airplanes. Placing a new computer in a warehouse may be expected to have a similar effect as placing a better micro-chip in a computer — that extra piece of capital makes all the surrounding capital more productive. Considering only the small share of computer capital in investment seems to undervalue the capacity of computers to improve the efficient use of other resources.

However, this capacity may point to a reason for the lack of an observed productivity payoff from computers. Investment in computers not only involves substitution away from investment in other kinds of physical capital, but it may involve substitution away from human capital. Many of the roles formerly played by humans in coordinating production are now performed by computers. The myriad tasks that bank tellers used to have to perform have been reduced through the spread of ATMs. School test scores (in the U.S. at least) have fallen at the same time that schools are investing heavily in computer learning. Perhaps when we look for the productivity payoff, we are ignoring the substitution of computer capital for human capital.

Even if computers have not lead to a productivity payoff, but have just substituted for other inputs, then it is still puzzling why the rate of productivity growth in the last 25 years is relatively low compared to the 50 years previous. Hence we turn now to measurement problems which may explain this lack of observed productivity growth.

## 3 Measuring the Benefits of New Products

> "Gains and losses that result from price changes would be measurable easily enough by our regular index-number technique, if we had the facts; but the gains which result from the availability of new commodities, which were previously not available at all, would be inclined to slip through. ... The variety of goods available is increased, with all the widening of life that that entails. This is a gain which quantitative economic history which works with index-numbers of real income, is ill-fitted to measure or even describe." *John Hicks* (1969, 55–56)

The argument for a role of mismeasurement of the benefits of new products in explaining the productivity paradox hinges on there having been an increase in the number of new products. In other words, assuming that statistical agencies have not become worse at measuring economic activity, the measurement problem must have become more difficult. Triplett (1998) is skeptical that new products have appeared more rapidly in the last 25 years than in previous years. He feels that much of the perception that there has been a massive increase in new goods comes about through thinking in terms of an arithmetic scale rather than the appropriate logarithmic scale, i.e., it is the growth in new products that matters, rather than their absolute numbers. He argues that there is simply not enough evidence to put the current growth in new products in historical context. However, while definitive research on this topic would be very desirable, the anecdotal evidence presented in Baily and Gordon (1988), Nakamura (1997), Diewert and Smith (1994), and Diewert and Fox (1998) has been enough to convince us that there is a strong possibility that the rate of introduction of new products has increased. One only has to consider the enormous expansion in services over the internet, (and the difficulty in measuring the introduction of these new products), to see that this is a real possibility. Hence, we now examine how the introduction of new products may have helped to obscure actual productivity growth.

While the measurement of the costs of the development and introduction of new products does not seem to be a problem, certainly the benefits of new products pose a difficult measurement problem. It is important to be able to measure these benefits, not only for the firms which introduce them but for the economy as a whole. Consider the following:

> "Every real economy is presented with an almost incomprehensible number of new goods that can be introduced.... They would increase utility. Many others, perhaps the great majority of all possible new goods, would not be worth introducing. The fixed costs are too high and the benefits too low." *Paul Romer* (1994, 14)

Similar concerns about the trade-offs between costs and benefits of new products have been expressed by others, such as Nordhaus (1988, 423):

> "Are we better off because of all the proliferation of Corn Pops and Freakies? The issue of the optimal amount of product differentiation is a profound one, and industrial organization economists reason that even if tastes are not manipulated, a market economy can easily produce excessive quality change because of setup costs of product differentiation."

If we are measuring the costs of the introduction of new goods well, but the benefits poorly, we may well end up with the conclusion that we have been made worse off by the introduction of new goods, when the opposite is true. Statistical agencies try to deal with the expansion in the set of available goods, but run into some difficult problems, as explained by Diewert (1996, 31):

> "*Quality adjustment bias* or *linking bias* is the bias that can occur when a variety or model of a good is replaced by a new variety. Suppose that a new model appears that is more efficient in some dimension than an existing model. After two or more periods, the statistical agency places a price ratio for the new good into the relevant elementary price index, but the absolute decline in price going from the old to new variety is never reflected in the relevant elementary price index. This source of bias was recognized by Griliches (1979, 97), Gordon (1981, 130–133) (1990) (1993) and many others."

We can illustrate the above problems by using a diagram essentially due to Romer (1994; 12–14), and discussed in Diewert and Fox (1998); see Figure 1.

Prior to the introduction of the new good, the economy could produce the amount $OC$ of old goods. The fixed costs of introducing the new good can be represented by the line segment $AC$. Once these fixed costs have been incurred, the production possibilities set for the economy over old and new goods is represented by the traditionally shaped production frontier $EA$. Turning now to the consumer side of the model, we follow the example of Hicks (1940, 114) and assume that the consumer has well defined preferences over combinations of old and new goods; two representative indifference curves are indexed by $U_1$ and $U_2$ in Figure 1. In the period prior to the introduction of the new good, the amount $OC$ of old goods is consumed and the utility level $U_1$ is achieved. In the subsequent period when the new good is introduced, the consumer ends up at the point $F$ and attains the higher utility level $U_2$. The equivalent amount of old goods that attains the utility level $U_2$ is $OD$, so the consumer ends up with the net gain (in terms of old goods) of $CD$ due to the introduction of the new commodity. However, note that if the fixed costs were large enough, then it can easily happen that the point $D$ lies to the left of $C$, indicating that from the welfare point of view, it was a mistake to introduce the new commodity.

In terms of Figure 1, linking bias will lead the statistical agency to estimate the amount of old goods that is equivalent to the utility level associated with the point $F$ to be $OB$ instead of the true amount $OD$. The only way the bias $BD$ will be reduced to zero is if the consumer's indifference curve through $F$ is the straight line $FB$ instead of the curved line $FD$.

As already noted, standard accounting practices will recognize the costs of introducing new products. Now we see that *existing statistical agency practices ensure that the benefits of new products are biased downwards* by the amount of curvature in consumers' indifference curves. This leads to the underestimation of productivity gains.

Hicks (1940, 114) proposed a theoretical solution to the problem of measuring the benefits of new products: if we could estimate the slope of the (dashed) line that is just tangent to the indifference curve that passes through the consumer's initial consumption point $C$, then a shadow or reservation price for the new good could be constructed for the new commodity in the period prior to its introduction and then normal index number theory could be applied. Of course, the problem facing a statistical agency is how can it produce estimated reservation prices on a large scale and on a timely basis.

While this is a complex problem, perhaps some progress has been made. Diewert (1980, 501–503) proposed an econometric approach to the estimation of the relevant shadow prices. Recently, Hausman (1996) utilised such an approach for breakfast cereals using supermarket scanner data. The fact that statistical agencies seem reluctant to follow Hausman's lead, and broadly implement the estimation of shadow prices suggests that there are still significant practical difficulties involved.

# 4 Service Sector Outputs

Baily and Gordon (1988) and the contributors in Griliches (1992) discussed many of the problems involved in measuring the outputs of certain service industries. For the most part, these problems are still with us today. In this section, we shall review some of these measurement problems for nine service sectors.

(i) *Real Estate.* In the U.S., the real and nominal output of the real estate industry was defined as follows:

> "The real estate industry's output is the rental income it receives and the commissions of realtors. This nominal output is deflated using rental cost indexes for residential and commercial rents. The problem in using the available rent indexes as deflators is that they do not adjust for changes in the quality of the property being rented." *Martin N. Baily and Robert J. Gordon*(1988, 396-7)

In addition to the likely downward bias in measuring the real output of the rental segment of real estate output identified by Baily and Gordon, it is likely that the commissions part of real estate deflated output is also biased downwards. Real estate agents assist in the buying and selling of real property. This portion of real estate output should be measured in real terms as either the number of completed transactions or as the real value of the property transacted. The nominal value of this part of real estate output is equal to the commissions received by real estate agents, which is correctly measured by statistical agencies. Note that this part of the output of the real estate industry can be viewed as a margin industry, like retailing and wholesaling: the price of the output of a margin industry is the difference between the selling price of the vendor and the purchase price of the buyer. A little algebra may help to clarify the measurement of the real output of a margin industry. Thus, let $p_t$ denote the average purchase price of the real property sold during period $t$ and let $q_t$ denote the corresponding quantity sold. Let $m_t$ denote the period $t$ commission rate that real estate agents received. Then period $t$ nominal output is $m_t p_t q_t$ and the period $t$ price and quantity indexes relative to period 0 should be $(m_t/m_0)(p_t/p_0)$ and $q_t/q_0$ respectively. However, if the statistical agency uses an inappropriate price index $P_t/P_0$ in order to deflate the ratio of nominal commissions in period $t$ relative to period 0, then the following incorrect quantity index will be obtained:

$$Q_t/Q_0 = [(p_t/p_0)/(P_t/P_0)][m_t/m_0][q_t/q_0], \tag{1}$$

which should be compared to the correct quantity index, $q_t/q_0$. Baily and Gordon (1988, 397) hypothesized that the term $[(p_t/p_0)/(P_t/P_0)]$ was less than one for the U.S. real estate industry; i.e., that the official statistical agency deflator $P_t/P_0$ was greater than the quality adjusted selling price index, $p_t/p_0$. Our additional hypothesis is that the margin ratio, $m_t/m_0$, is likely to be less than one in recent years due to increased competition placing pressure on margins. For example, many properties in North America and Australia are now listed on the internet. This means that internet connected potential buyers of real estate can now do a preliminary screening of properties over the internet and this screening saves some time and effort for real estate agents who in turn can offer lower commission rates to customers. Thus the Baily and Gordon hypothesis and our hypothesis both lead to a downward bias in the official output growth measure $Q_t/Q_0$ defined by (1) relative to the "true" real output index, $q_t/q_0$.

(ii) *Retailing and Wholesaling.* These industries are straightforward margin type industries; i.e., they buy goods $q$ in period $t$ at the price $(1 - m_t)p_t$ and sell them at the price $p_t$, where $m_t$ is the period $t$ margin rate. As was the case with property sales, the correct period $t$ price and quantity indexes are $(m_t/m_0)(p_t/p_0)$ and $q_t/q_0$ respectively. If the statistical agency constructs its quantity index $Q_t/Q_0$ by deflating industry value added by the price index $P_t/P_0$ in place of the "true" price index, $(m_t/m_0)(p_t/p_0)$, then the official index $Q_t/Q_0$ will again be defined by (1) above. Typically, $P_t/P_0$ will be greater than $p_t/p_0$ due to outlet substitution bias; i.e., the statistical agency will tend to follow prices in established high cost outlets and fail to adequately weight the lower prices that appear in newer discount outlets.[1] Secondly, the use of deflated value added by the statistical agency as an output measure will again lead to a downward bias in output growth because any declines in margins due to increased efficiencies in marketing and inventory management will be missed; i.e., as in the case of real estate, $m_t/m_0$ will tend to be less than one.[2] However, statistical agencies are often unable to calculate the value added for the distribution trades, except for sporadic census years. Thus, they are unable to calculate the margins $m_t$ for each period $t$ and they are forced to assume that the base period margin rate $m_0$ is still applicable in period $t$. In

[1] For some evidence at higher levels of aggregation that this effect occurs, see Reinsdorf (1993), McDonald (1995) and Triplett (1997, 17). For evidence at lower levels of aggregation, many scanner data studies have recently been done that track market transactions data for specific commodities. These studies (which are reviewed in Diewert (1998, 54-55)) tend to show that unit values or superlative price indexes (which are constructed using detailed price and quantity data rather than a few sampled prices) show lower rates of price increase than the corresponding consumer price index inflation rates.

[2] For some limited evidence of productivity gains due to more efficient management of inventories, see Diewert and Smith (1994).

this case, the statistical agency will estimate period $t$ real output as (incorrectly) deflated period $t$ sales, $p_t q_t / P_t$, and the resulting official statistical agency output quantity index becomes (2) below instead of (1) above:

$$Q_t/Q_0 = [(p_t/p_0)/(P_t/P_0)][q_t/q_0]. \tag{2}$$

Assuming that $m_t/m_0$ is less than one, it can be seen that the downward bias in the measurement of real output growth in the distributive trades will generally be lower if the statistical agency uses formula (2) in place of (1). However, in both cases, the term $[(p_t/p_0)/(P_t/P_0)]$ will tend to be less than one due to outlet substitution bias and so official output growth will be understated.

(iii) *Financial Services.* Stock market trading can be viewed as another margin type industry. The period $t$ nominal output for this industry can be represented approximately by the formula $m_t p_t n_t$ where $m_t$ is the average transactions cost for trading one share of a stock during period $t$, $p_t$ is the average purchase price of a stock and $n_t$ is the number of shares traded during period $t$. To convert the industry period $t$ nominal value into a real value, divide by the period $t$ price for a representative basket of goods, $P_t$ say. Then we can decompose the period $t$ nominal output value as follows:

$$m_t p_t n_t = [m_t P_t][(p_t/P_t)n_t] \tag{3}$$

and we identify $m_t P_t$ as the period $t$ output price and $(p_t/P_t)n_t$ as the period $t$ real output of the stock trading industry. Thus the period $t$ real output index for this industry can be defined as

$$q_t/q_0 = [p_t/p_0][n_t/n_0]/[P_t/P_0]. \tag{4}$$

For most industrialized countries, the value of stock market trading $p_t n_t$ has increased tremendously, driven by the large declines in commission rates $m_t$ that have been stimulated by the growth of discount brokers and cheap internet trading in stocks. Thus the "true" $q_t/q_0$ defined by (4) above has grown tremendously relative to official statistical agency estimates of financial services output growth, which tend to be based on the growth of labour input.[3] Baily and Gordon (1988, 398) indicate that the number of shares traded in U.S. stock exchanges increased from 2 billion shares in 1961 to 10.8 billion in 1979 and then to 63.8 billion shares in 1987. Baily and Gordon (1988, 399) go on to show that official statistics do not reflect the tremendous productivity gains that have taken place in this industry.

It is possible to treat investing in risky securities as a form of gambling.[4] We discuss the

[3] "The output of the financial service industry is measured on the basis of labor input and thus ignores any output per hour gain by definition." (Bailey and Gordon, 1988).

[4] See Diewert (1993, 427-432).

gambling industry in (viii) below.

(iv) *Transportation.* Baily and Gordon (1988, 416) noted that U.S. measures of airline output were biased downwards because statistical agencies forgot to take account of discount airline fares.[5] In recent years, the problems faced by statistical agencies in measuring airline fares have probably become more difficult than ever due to airline deregulation. For example, a typical midday, midweek return flight from Vancouver to Toronto in early June, 1998 will have passengers travelling on at least six different discount fares, ranging from $379 to $1813. Business class passengers will pay $2682 but 10 to 15% of the passengers in both business and economy seats will fly "free" on frequent flyer plans. Some airlines now auction off seats, with prices rising as the flight fills. There are also additional measurement complications due to the new availability of nonstop direct flights between cities that were not directly connected before the advent of deregulation. For example, during the past year, one of us was able to take a nonstop flight between Vancouver and Washington D.C. for the first time, with a resulting increase in utility at no extra cost. To work out an accurate price index for air travel under the above conditions is a very difficult problem, but simply pricing out a few fares without taking into account discount fares, the increased availability of direct flights and the increased popularity of frequent flyer plans will tend to underestimate real output growth in this industry.

(v) *Telecommunications.* This industry is similar to airline transportation in that the worldwide introduction of competition and deregulation has led to an incredible array of different discount plans and rate systems. Thus the usual statistical agency procedure of pricing out a few local calls and a few long distance calls at standard rates will again miss out on the effects of discount plans. Another complication is the increased use of the internet. Internet rates are very low and so an increasing volume of communication that used to take place by ordinary mail and traditional telephone services is now taking place via the internet. The resulting drop in the average price of communication services is simply missed by statistical agencies due to the difficulties in determining precisely how much substitution from traditional services has taken place.[6]

[5]See also Gordon (1992, 377) for additional material on biases in U.S. transportation indexes.

[6]This problem is similar to the problem faced by statistical agencies when the methods of delivering light (in lumens) changed over the years due to technological progress. As new delivery systems were introduced, agencies tended to ignore the new method until it became very important. Finally, prices for the new commodity were collected for two periods and then the resulting price relative for the new delivery system was averaged together with the price relatives for the old existing commodities, so that the absolute drop in the price per lumen never showed up in the official indexes; see Nordhaus (1997, 46–47 ).

(vi) *Banking.* The treatment of interest in the system of national accounts leads to a rather flawed measure of banking output. Basically, banks produce two main classes of outputs: (a) checking and deposit services and (b) financial intermediation services; i.e., banks have access to funds at relatively low rates of interest and they loan these funds out at higher rates of interest. Thus, with respect to this second class of outputs, banks act like a margin type industry: their nominal period $t$ output is the value of loans $v_t$ times the period $t$ markup rate $m_t$ (which is the difference between the average period $t$ lending and borrowing rates). The corresponding period $t$ output price index can be defined as $[P_t/P_0][m_t/m_0]$ where $P_t/P_0$ is the consumer price index and the corresponding real output index can be defined as

$$q_t/q_0 = [v_t/v_0]/[P_t/P_0]. \tag{5}$$

For a more rigorous approach to measuring the output of banks, see Fixler and Zieschang (1991) (1992), who draw on the various user costs of money proposed by Diewert (1974), Barnett (1978), Donovan (1978) and Hancock (1985).[7]

More recently, Fixler and Zieschang (1998) have compared the traditional (flawed) national accounts measure of real output growth for the U.S. banking industry with their user cost approach for the years 1977-1994. They found that the real output growth using their user cost approach averaged about 7.4% per year while the traditional measure grew about 0.7% per year over this period. This is a rather substantial difference in rates of growth!

(vii) *Insurance.* In some ways, insurance can be viewed as another margin type industry: individuals pay premiums to an insurance company and the company returns to claimants much of the money collected. The margin rate in this industry is premiums minus claims divided by premiums. The lower the margin rate is, the more efficient is the industry. Premiums less claims is known as the net premiums measure of nominal insurance output. How do statistical agencies measure the corresponding real output? Baily and Gordon describe the U.S. method as follows:

> "The deflators used for the insurance industry are those developed for the industries being covered by the insurance. The auto repair cost index is used for auto insurance, medical costs for medical insurance, and so on. ... Thus, the productivity weakness in the insurance sector is being driven by the escalation of cost indexes in the medical care area and in repair services, even though the insurance industry is

[7] The user cost idea dates back to the economist Walras (1954, 269) and the industrial engineer Church (1901, 907–908).

engaged in an entirely different productive activity."

*Martin N. Baily and Robert J. Gordon*(1988, 395)

The nature of the insurance industry's productive activity requires some discussion. Note that defining the nominal output of the insurance industry as premiums less claims has the rather unpalatable implication that a perfectly efficient industry that had no transactions costs would end up contributing nothing to national output. To avoid this unpleasant implication, Denny (1980), Ruggles (1983, 67) and Hornstein and Prescott (1991) suggested that gross premiums paid (rather than net premiums or premiums less claims) is a more appropriate measure of the nominal output of the insurance industry. In this view, consumers are buying protection services rather than forming a club to pool risk. In the gross-premiums view, the payment of claims by insurance companies appears on the balance sheets of households as offsets to their insured losses. This protection services view of insurance services will give rise to a much larger nominal gross output for the insurance industry than the traditional net claims approach, which leads to zero or negative nominal output in years when claims are large.[8]

There are some additional difficult conceptual issues that need to be resolved when measuring the output of the insurance industry. One such difficulty is the fact that consumers must pay for insurance protection services at the beginning of the protected period. If we view the protection services as being delivered in equal increments over the entire period, then the consumer's premium payments for each increment of protection services (except perhaps the first increment) can be viewed as an intertemporal prepayment for services to be delivered in the future and the consumer should add an (implicit) opportunity cost of interest foregone to each incremental premium payment. On the other hand, the insurance company receives premium revenues well in advance of any claim costs and thus can earn (explicit) interest on these premium prepayments. Thus a major output of the insurance industry is interest and investment income earned.[9] The need for the insurance industry to have reserves to cover abnormal claim years will increase this financial component of insurance industry output.

Another difficult conceptual problem is the deflation of the nominal insurance output measure into a real measure. If we take the insurance as protection services point of view,

[8]However, the nominal value added of the insurance industry will still be approximately equal to net claims, since claims must be viewed as an intermediate input cost.

[9]Sherwood (1998) notes the importance of including this financial output of the insurance industry in the nominal output of the industry since if it is not included, net claims in the U.S. insurance industry are negative for some years.

then premiums should be deflated by the real value of the insurance coverage. However, this approach neglects any changes in risk. In order to deal with changes in risk, we could use the expected utility model to work out the incremental utility gain provided by insurance.[10] However, Diewert (1993, 418-9) (1995) proposed a more flexible nonexpected utility approach to modeling the demand for insurance and this approach could also be used to develop a measure for the real output of the protection services part of insurance industry output that would be valid under conditions of changing risk. All of these alternative approaches to measuring insurance outputs will lead to larger estimates of output growth than the traditional deflated net premiums approach.

(viii) *Gambling.* Gambling is another industry that could be viewed as a margin type industry. Consumers wager a certain amount of funds and get a fraction back as prizes or winnings; the difference between wagers and prizes divided by wagers is the average margin rate. The smaller the margin rate is, the more efficient is the industry.[11] On the other hand, the national accounts treatment of nominal gambling output is similar to insurance; namely, output is approximately equal to transactions cost. Hence, again we have the anomalous result that a fully efficient industry would have zero nominal output. The counterpart to the gross premiums approach to measuring insurance output is the gross wagers approach: the nominal output of the gambling industry is the total amount wagered during the accounting period and the service being provided by the industry is entertainment. Prize money paid out is treated as an intermediate input expense just as claims paid out were treated as an intermediate expense in the gross premiums approach to measuring insurance output. If we followed the insurance industry analogy completely, then on the household accounts, prize money won would appear in the household balance sheets as an increase in assets. However, the case for putting winnings in the balance sheets is not as persuasive as in the insurance case where claims paid were simply a balance sheet offset for insured losses. However, the alternative net wagers approach (where nominal gambling output is set equal to wagers less winnings) is not particularly attractive either due to the problem of a zero nominal output for a fully efficient industry.

How should the real output of the gambling industry be measured? If we take the gross wagers approach, then nominal wagers should be deflated by a general measure of

[10]See von Neumann and Morgenstern (1947), Arrow (1951)(1984) and Mossin (1968). The modern actuarial literature uses the expected utility approach to model the demand for insurance; see Bowers, Gerber, Hickman, Jones and Nesbitt (1986).

[11]However, we note that this does not take account of the entertainment value of the gambling experience, such as free drinks and lavish settings.

purchasing power such as the consumer price index. This approach will be satisfactory if the probability of winning remains constant (or alternatively, if the average margin rate remains constant). However, as the gambling industry has grown rapidly in recent years, so too has competition. Thus the gambling industry today (like most industries) faces competitive pressures to increase payouts and reduce margins. As in the case of insurance, we could appeal to the expected utility approach to gambling to determine the incremental gain in utility that gambling provides to (nonaddicted) consumers under changing risk conditions. However, the expected utility approach to modeling the demand to gamble does not provide an adequate approximation to empirical behavior; hence, nonexpected utility models will have to be used to measure the real output of the gambling industry.[12] It is likely that these new approaches to measuring the output of the gambling industry will give higher rates of growth in real output than the traditional approach.

(ix) *Business Services.* A final problem industry where actual real output growth is likely to be greater than measured real growth is business services. For example, the effective price of accounting services will probably drop dramatically in the future as small businesses adopt computer driven accounting packages like Quicken, Quickbooks and Simply Accounting. However, it is likely that this effective drop in price will be missed by traditional statistical agency procedures.[13] Another example of a class of new business services that has the potential to lower prices dramatically is the development of internet sites that compare prices for the same product from different suppliers. Such services exist for computers, standard insurance policies, airline fares, autos and many other commodities.[14] The effect of these sites will be to expand the sales of the most efficient suppliers and to eventually bankrupt the suppliers who are unable to compete effectively. However, existing statistical agency pricing procedures will tend to miss this shift to low cost suppliers; i.e., the sampled prices of the efficient suppliers will not be weighted according to sales and it is not until the inefficient suppliers disappear that their price quotes will be dropped. Thus the growth of internet sites that compare prices and the growth of internet sales for the low cost suppliers will lead to large outlet substitution biases unless statistical agencies are given additional funds to take remedial action.

We believe that it is possible for statistical agencies to measure the outputs of service sector industries more accurately but the resources that will be required to accomplish this are considerable . Because statistical agencies have not stressed these measurement difficul-

[12]See Diewert (1993, 424–427)(1995, 143–144) for nonexpected utility theory approaches to gambling.

[13]Recall the Nordhaus (1997) price of light problem.

[14]There are also internet auction sites that deal with a wide variety of goods.

ties, the public at large remains unaware of the problems and has not insisted on having governments make the required resource investments. As a result, output growth is almost surely greatly underestimated due to: (a) the difficulties in measuring outputs that involve uncertainty or interest; (b) the pervasive presence of new goods and services and (c) the outlet substitution biases that have been stimulated by the computer and the internet.

# 5 Have Consumption Expenditures become Business Expenses?

Consumption expenditures are final "goods" and hence appear as part of GDP. Business expenses are intermediate "goods" and do not appear as a positive part of GDP. The expansion of business expense accounts, and various fringe benefits, may have caused many consumption items to now be classified as intermediate goods. Entertainment expenses, as well as company gyms, daycare centers, cars, home loans and parts of business travel, are all former consumption expenditures which will not appear in final aggregate demand (Triplett, 1997; Diewert and Fox, 1998).[15]

A recent Japanese study (reported in the Asahi Shimbun, 1995) hinted at the extent that such a re-classification of consumption expenditures had taken place. An index of economic activity was found to be very highly correlated with blood sugar levels of Japanese businessmen. When there was a decline in the economic-activity index around 1990, blood sugar levels fell correspondingly. A possible reason for this remarkable correlation is that entertainment expense accounts expand with economic growth, and dietary habits change as a result. If Japanese businessmen consume more and richer food, (perhaps Western food), when they dine out than when they eat at home, then this could explain this correlation. Larger expense accounts means more entertaining of guests and more dining out, hence higher blood sugar levels. If this is indeed the reason behind the correlation, then this suggests that actual GDP is growing faster than measured during economic booms, and slower than measured during downturns — cuts in expense accounts result in a re-classification of

[15] "Salary sacrifice" schemes are becoming an increasingly common way to avoid taxes in many countries. Under these schemes, employees may give up salary and be compensated in kind through, e.g., the use of a company car. The expansion of these schemes has attracted the attention of the Australian Government recently: "Salary packaging, elaborate tax schemes used by the wealthy and increasing numbers of multinational companies, have been cited as some of the prime risks to the tax system. ...The Treasury did not give any indication of the numbers of people involved in these schemes, but the mention of salary sacrifice schemes indicates that they pose a significant threat to revenue," (Sydney Morning Herald, May 14 1998).

consumption back to final demand expenditures, which would contribute to measured GDP growth.

There are other examples of such misclassification of final demand expenditures as business intermediate expenditures. The impact of pollution control and environmental preservation regulations on productivity have been examined by, e.g., McConnell (1979, 44), Malkiel (1979, 83–84), Nordhous (1982, 138), Mairesse (1982, 161), and Bailey and Gordon (1988, 362). Estimates of the contribution to the productivity slowdown from these sources range from 0.2% to 0.5% per year. We can note that these results are related to the much publicised arguments put forward primarily by Porter (1990), and Porter and van der Linde (1995) on the possibility of productivity-improving environmental regulation. It may be more appropriate for expenses that firms incur in preserving the environment to be treated as final demand expenditures, rather than as intermediate business expenses. At least, if these expenditures are to be classified as costs for firms, there should be appropriate measures of the "output", i.e., the resulting improvement in the environment. Taking this into account would increase the productivity growth measures for the sectors subject to such regulation, and the economy as a whole.

Similarly, improvements in workplace safety and amenities have been suggested as practical explanations of the productivity slowdown by Summers (1982, 167), and Bailey and Gordon (1988, 409).

## 6 Land and Productivity

The current system of national accounts has no role for land as a factor of production, perhaps because it is thought that the quantity of land in use remains roughly constant across time, and hence it can be treated as a fixed unchanging factor in the analysis of production. However, the quantity of land in use by any particular firm or industry does change over time. Moreover, the price of land can change dramatically over time and thus the user cost of land will also change over time. This changing user cost will, in general, affect correctly measured productivity. For example, during the period 1955-1987, the price of land (nonreproducible tangible assets) in Japan grew approximately 16% per year. Inserting an appropriate user cost of land into the aggregate productivity (index number) formula for Japan (versus just omitting land from the computation) leads to a 0.5% per year increase in Japanese total factor productivity. Thus it is important not to neglect the role of land when computing the total factor productivity of a producer unit.

There are other important issues related to the treatment of land as a factor of production.

Land ties up capital just like inventories (both are zero depreciation assets). Hence, when computing *ex post* rates of return earned by a production unit, it is important to account for the opportunity cost of capital tied up in land. Neglect of this factor can lead to very biased rates of return on financial capital employed.

Also, property taxes that fall on land must be included as part of the user cost of land. It may not be easy to separate the land part of property taxes from the structures part. Note that in the national accounts, property taxes (which are input taxes) are lumped together with other indirect taxes that fall on outputs. This is another shortcoming of the current system of accounts.

# 7 Price and Regulatory Distortions and Productivity

Individual firms or establishments could be operating efficiently (i.e., be on the frontiers of their production possibilities sets) but yet, the economy as a whole may not be operating efficiently. The explanation for this phenomenon was given by Gerard Debreu (1951): there is a loss of system wide output (or waste, to use Debreu's term) due to the imperfection of economic organization; i.e., different production units, while technically efficient, face different prices for the same input or output, and this causes net outputs aggregated across production units to fall below what is attainable if the economic system as a whole, were efficient. In other words, a condition for system-wide efficiency is that all production units face the same price for each separate input or output that is produced by the economy as a whole. Thus, if producers face different prices for the same commodity and if production functions exhibit some substitutability, then producers will be induced to jointly supply an inefficient economy-wide net output vector. Some sources of system-wide waste are as follows.

1. Industry specific taxes or subsidies that create differences in prices faced by production units for the same commodity; e.g., an industry specific subsidy for an output or a tax on the output of one industry where that output is used as an input by other industries (an example of the latter is a gasoline tax).

2. Tariffs on imports or subsidies or taxes on exports.

3. Monopolistic or monopsonistic markups on commodities by firms or any kind of price discrimination on the part of firms.

4. A source of commodity price wedges that is related to the last source above is the difficulty that multiproduct firms have in pricing their outputs, particularly when there are large fixed costs involved in producing new (or old) products (Romer, 1994) and particularly when there is high inflation and historical cost accounting techniques for pricing products break down (Diewert and Fox, 1998).

5. Imperfect regulation; it is very difficult for government regulators to set "optimal" prices for the commodities that are regulated. If the regulators are unable to determine the "optimal" prices for regulated commodities, then the other producers that use the regulated outputs as inputs will generate system wide waste. Examples of imperfect regulation might include marketing boards, telecommunications, environmental protection and health and safety regulations, regulation of labor markets including the collective bargaining framework, regulation of the radio/TV spectrum, municipal zoning and building code regulations, and the patent system.

6. Another source of market imperfections between economic agents might be the legal system: are property rights well defined and enforceable? If not, the resulting uncertainty prevents the market from assigning a definite value to the asset or resource under dispute and this uncertainty will generally prevent the asset from being utilized in its most profitable use.

7. A related source of price wedges between economic agents is the existence of widespread bribery and corruption. A bribe has roughly the same effect as an uncertain tax on a transaction and will create distortion wedges between business units.

8. A final source of Allais-Debreu intersectoral waste is the system of business income taxation that is in place in most countries. The lack of indexation of depreciation allowances for inflation causes a divergence between the value of a depreciable asset to the producer of the asset and the value to the purchaser of the asset: in periods of high inflation, the discounted value of the depreciation allowances allowed for tax purposes will be much less than the purchase price of the asset and thus the using firm will have to charge itself a much higher price than the purchase price for the asset to overcome this tax induced penalty for using the asset (Diewert and Fox, 1998). The higher internal (to the firm) price of capital will cause firms to economize on its use. This may help to explain the investment slowdown and the subsequent rise in the average age of capital in many countries that experienced high inflation in the 1970s. See, e.g., Wolff (1996) for a possible explanation for the productivity paradox through the

increased average age of capital. There are many other distortions between sectors and assets that the typical system of business income taxation induces. Some references to the literature include Harberger (1974), Jorgenson and Yun (1986), Feldstein (1978), Ballard, Shoven and Whalley (1985), and Shoven and J. Whalley (1984)

Note that the above sources of intersectoral waste are mostly induced by governments (nonoptimal taxes and nonoptimal regulations and institutions) but some waste is induced by the fixed costs of establishing new plants and developing new products and processes which in turn leads to monopolistic (or somewhat random) pricing of outputs on the part of business units. However, it is difficult for governments to determine "optimal" taxes or "optimal" prices for the outputs of regulated businesses and it is just as difficult for multiproduct firms that are constantly developing new products or experimenting with new processes to price their products at the socially efficient levels.

What are the implications of intersectoral waste for statistical agencies? The current input-output system of industry accounts is two dimensional: current and constant dollar value flows are classified by industry and by commodity. There is an urgent need to make the classification three dimensional and add a table that lists taxes paid (or subsidies received) by industry and by commodity. This would enable applied general equilibrium modelers to calculate estimates of the waste or excess burdens that are induced by the tax-subsidy wedges that are pervasive in most economies. The present system of national income accounts just adds a row to the usual input-output table that simply sums up all indirect commodity taxes paid by the industry without telling users what the incidence of the taxes are by commodity. For regulated industries, there is a need for statistical agencies to provide estimated marginal costs (or producer prices) for the regulated commodities and estimated user values (or consumer prices) as well as quantities supplied. This is a somewhat utopian request given the limited resources that statistical agencies have at their disposal at present and given the practical and conceptual difficulties in constructing producer and consumer prices for regulated commodities. Perhaps this is a fruitful area for the academic community to till.

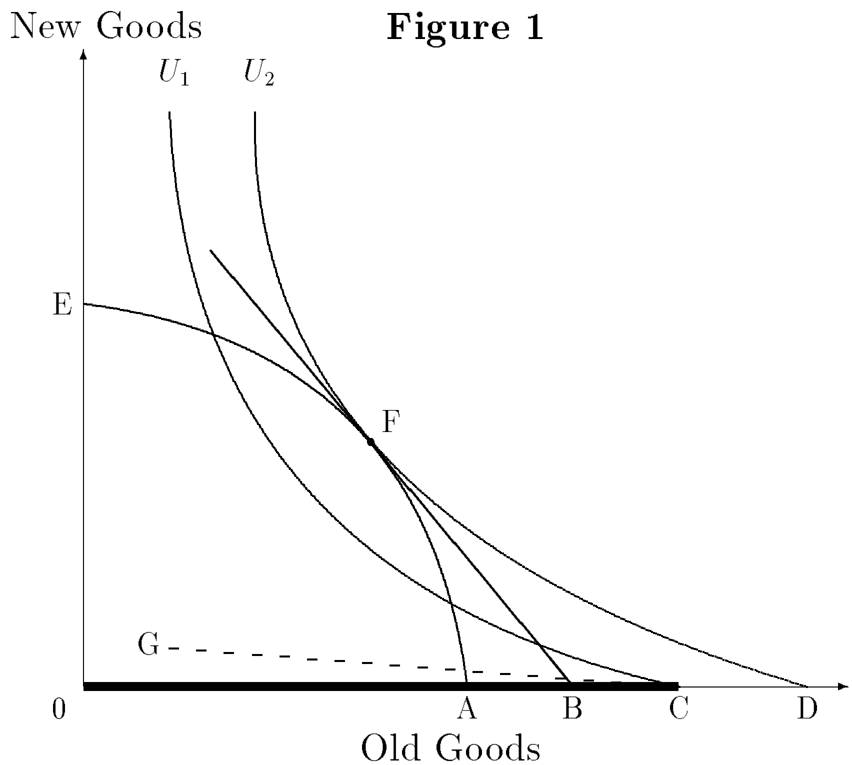
# 8 Conclusion

This paper has reviewed the productivity paradox from the point of view of economic measurement. Our tentative conclusion is that various measurement problems could explain the productivity slowdown that has occurred in most advanced industrial economies during the past 25 years.

In section 3, we argued that economic growth during the past two decades has been driven by the development of new products, and since current statistical agency procedures do not capture the full benefits of new products (or outlets, for that matter), actual growth has been much higher than measured growth. In section 4, we followed the example of Griliches (1994) in noting that in recent decades, growth has been concentrated in the service sectors of advanced economies and that outputs are difficult to measure in many of these sectors. In particular, service sectors involving margins, complex products, interest payments and uncertainty tend to be poorly measured. We gave several examples where the poor measurement resulted in output measures that were biased downwards. In section 5, we noted that the growth of white collar employment may have led to an increase in business intermediate expenditures (which reduces measured productivity) which were in fact consumption expenditures. In part, this growth of consumption-type intermediate expenditures may have been driven by increasing rates of personal income taxation. In section 6, we noted that current statistical agency methods for measuring productivity (with a few exceptions) ignore the role of land as a productive input, and hence if land prices are rising rapidly (as they did in many countries during the 1970s and 1980s), then measured productivity will be biased downward. In section 7, we argued that increased government spending during the 1970s and 1980s eventually lead to increased taxes which in turn led to an economy wide loss of productive efficiency.

Putting together all of the above measurement problems could explain the productivity slowdown. However, in order to obtain definitive proof of this, governments will have to allocate more funds so that statistical agencies can better measure the benefits of new products, and can better measure service sector outputs. Thus, it seems essentially that the "data constraint" be relaxed by providing statistical agencies with the support and resources necessary for producing more accurate statistics which are useful for policy analysis.

**Figure 1**



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