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***PROFILE***

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**Number 137**

**Resolving the Productivity Paradox**

**The Digital Revolution, Productivity Growth, and Living Standards**



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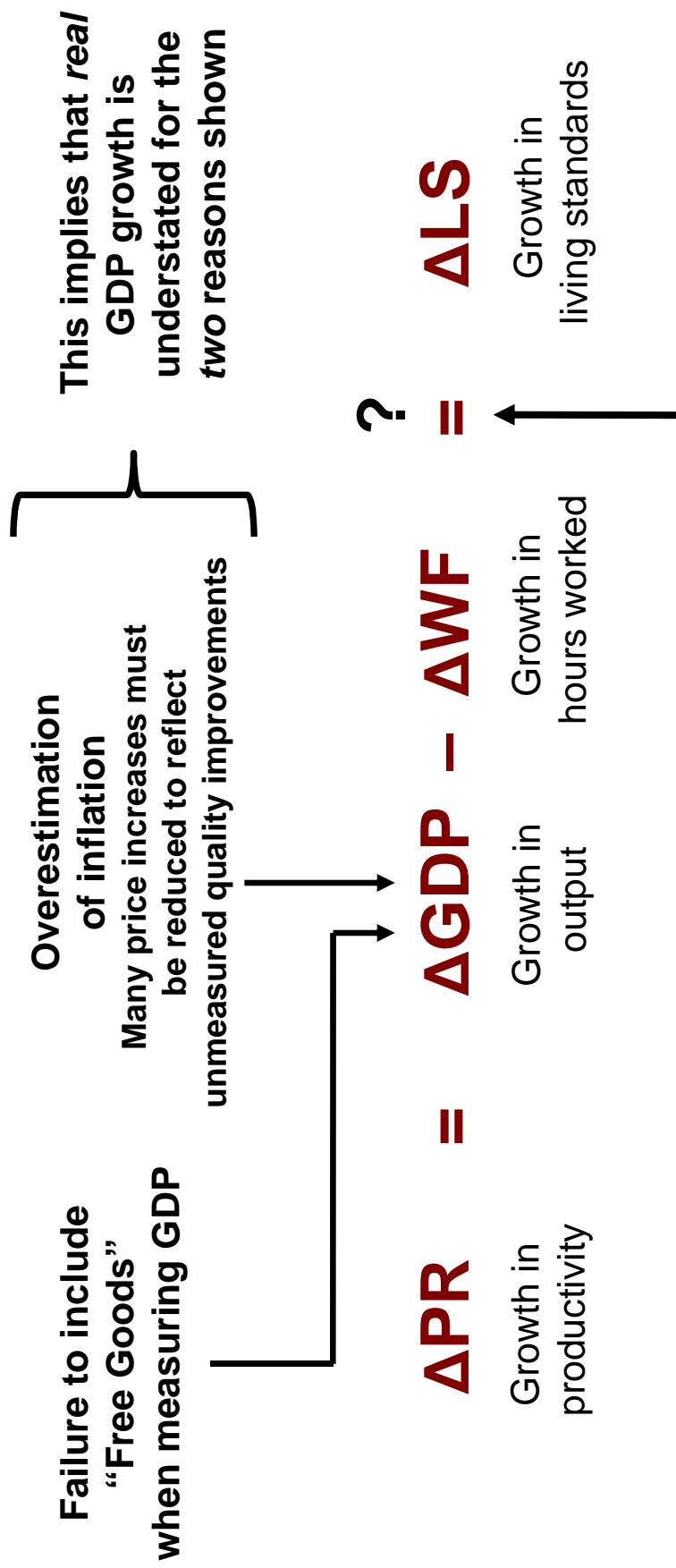
**August 2015**

## **Resolving the Productivity Paradox**

### **The Digital Revolution, Productivity Growth, and Living Standards**

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# Measurement Problems in the Official Data



The *true* rise in living standards is independent of official data on GDP and productivity. A *valid* measurement of LS (regardless of data) will signal the *correct* magnitude of the revisions in the GDP data that are needed. Only after such revisions are made will the equality above hold true — as economic theory requires.



## Resolving the Productivity Paradox

### The Digital Revolution, Productivity Growth, and Living Standards

Of all the gloomy economic news of the past eight years, perhaps none is more disturbing than the statistically documented decline of US productivity growth. Productivity growth is of course the source of most all economic progress (as defined below). Could the reported slowdown be incorrect due to mismeasurement errors? Many observers find it paradoxical that, in the midst of today's extraordinary digital revolution, productivity has been falling rather than rising.

This **PROFILE** will discuss the issue of productivity growth from first principles. What is it? Why does it matter? Is it mismeasured, and if so why? Ignoring issues of measurement, when will an **x%** increase in productivity growth actually imply an **x%** growth in real wages? And what about living standards? How *are* they measured (they are not), versus how *should* they be measured? And what are the true linkages between changes in living standards and changes in productivity growth and changes in real wage growth? This last question may be the most important one, and one that is rarely addressed. It is simply assumed that the growth rate of real wages (as measured in the data) *is* the growth rate in living standards. This is false.

The issues that arise here are contentious, with economists holding a wide range of views. We end up siding with those who argue that changes in the nature of GDP growth and in particular of the kinds of "products" that get measured in calculating GDP cause the traditional measurements of productivity growth to be downward-biased by over 1%. In addition to this finding about productivity, we believe that the actual US inflation rate has been at least 1% lower than officially calculated. [These two issues are different, and are not two sides of the same coin as is often supposed.]

As a result, both real GDP growth and real wage growth have been significantly higher than reported during the past few decades. As for living standards, they have risen significantly when properly measured, regardless of what the official data say about "stagnant real wage growth since 1975." [Dissenting views are discussed in Section 8 below.]

*Is traditional economic theory wrong in claiming that living standards ought to rise with productivity, i.e., that “productivity growth is the source of all progress”? We argue that it is not wrong. Exactly how then might the government revise its statistics in such a way that the discrepancy between the actual rise in living standards and the story told by the data disappears? The highpoint of this **PROFILE** is to demonstrate how this can be achieved — to demonstrate via a worked numerical example how the growth rates of living standards, real wages, and productivity can all be aligned.*

Nothing about this subject is easy, and we have done our best to simplify matters to the extent possible. We know of no other essay attempting to address all these issues in a unified manner.

## **1. What is Productivity Growth?**

At an intuitive level, this concept describes the way in which the economy becomes more efficient over time. That is, the economy squeezes ever more juice from the lemon over time. Assuming that productivity growth does not raise unemployment (there is virtually no evidence that it does long-term), and assuming that *both* workers and the owners of capital benefit from it due to higher living standards and higher returns on capital respectively, then productivity growth is an unadulterated good for an economy.

At a quantitative level, this all-important concept of “greater efficiency” is defined as the difference between GDP growth and workforce growth. More specifically, it is the difference between the percentage growth in real output and the percentage growth in total hours worked. Thus, if real GDP growth is 5%, and total hours worked growth is 2%, productivity growth is defined as  $5\% - 2\% = 3\%$ . Because productivity growth so defined is a function of labor input, it is often described as *labor* productivity growth. There are other forms of productivity growth, but for our purposes in this essay, we can stick to this classical definition. We shall omit the word “labor” for simplicity.

## 2. Why Productivity Growth Matters – The Three Reasons

*First*, many equate declining productivity growth with a new era of “secular stagnation,” shorthand for reduced opportunities. This is because GDP growth is the sum of workforce growth and productivity growth, by definition. Therefore, if productivity growth slows from a long-run average of 2.3% to 1.1%, as many believe it has, then GDP growth will necessarily slow by 1.2%. When compounded over several decades, such a reduction in growth is hugely significant for many obvious reasons, in particular for the growth of debt.

*Second*, productivity growth over the long run should be equal to the growth rate in living standards. In today’s materialistic and non-God-fearing world, no threat to democracy is greater than that of living standards which decline rather than increase. In this regard, many on today’s Left argue that living standards of average people have stagnated or even declined for thirty years — and that this is the fault of “capitalism.” It is often forgotten that democratic capitalism’s greatest success has not been the benefits bestowed upon billionaires, but rather the staggering 25-fold rise in average living standards during the past three centuries. This contrasts with the pre-capitalism failure of living standards (and life expectancy) to rise *at all* during the previous 2000 years. The threat today is that, when average people believe their economic life will be worse in the future than in the past, democratic capitalism can readily morph into various forms of populism offering bogus remedies to all problems.

*Third*, reduced productivity growth matters very much to central banks, and to the monetary policies they pursue. To understand why, suppose that Fed Board members believe official statistics suggesting that productivity growth is trending downward by 1.2%. Then they will reduce their “full employment non-inflationary GDP growth target” from  $x\%$  to  $x - 1.2\%$ . For the lower productivity growth is, the less the economy can grow *without putting pressure on unit labor costs* and thus on the PPI. Now if the official statistics are biased as many believe, and true productivity growth has not in fact declined, the Fed should and probably would raise its non-inflationary GDP growth target back up by 1.2%. It will fear inflation less, and will raise interest rates more gingerly than it otherwise would. The lower interest rates will in turn boost growth.

### 3. What is the Link between Productivity Growth and Living Standards?

Many economists take it as gospel that the rate of increase in living standards is and must be equal to the rise in productivity over time. Economic theory says this must be true. To be sure, no one would claim outright equality here in the short run, as the times series data for these two variables diverge considerably due to technology shocks and business cycles. But even in the long run, equality is not assured. Historical data do reveal a strong correlation between productivity growth and real wage growth — at least until recently. If and only if real wage growth is a valid proxy for living standards growth, then the data do indeed imply a strong correlation between productivity growth and living standards growth.

In the past three decades, however, problems with data mismeasurement have been causing these fundamental linkages to weaken. This is particularly true in the case of linkages to “living standards,” a variable that is rarely defined much less measured.

Subsequent sections of this essay explain the true problems here, as well as how to adjust the official statistics so as to eliminate troubling discrepancies between economic theory and the official data — discrepancies which in principle ought not to exist. However, we cannot deal with this complex discrepancy issue *without first explaining what economic theory predicts when there are no data problems at all*. In this vein, we now construct a simplified numerical example of when and why productivity growth will translate into and indeed equal living standards growth.

#### – A Simple Model where the Growth in Living Standards *is* Growth in Productivity –

Suppose that we live in a simplified textbook economy with a \$1 trillion level of GDP. Suppose also that the measurement of productivity growth poses virtually no problems in this simplified economy. To wit, assume that this economy produces only steel and grain where it is easy to measure output (e.g., tons and bushels produced). Thus there is no ambiguity about the concept of “quantity” of goods produced. Suppose also that the quality of steel and of grain does not change, and that consumers’ tastes for finished steel products and grain foodstuffs do not change, reflecting what economists call “constant marginal utility.”

Suppose also that the “prices” of the two goods are unambiguous, e.g., dollars per ton or per bushel. *Calculating GDP requires unambiguous quantity and price measures for each component product*. [In today’s world, measuring the price and quantity of ever-evolving software programs or of streamed music files is highly problematic — if not impossible.] Also



assume that there is no inflation in this economy (neither wage nor price inflation) — so nominal and real prices are the same. This will further simplify the analysis.

Suppose next that this \$1 trillion economy has steady GDP growth of 3%, with 1% of growth coming from annual workforce growth, and 2% from productivity growth due to new and improved capital stock and to new skills learned on the job. Thus if the level of the economy in year  $t$  is \$1 trillion, it will be 3% greater or \$1,030,000,000,000 in year  $t+1$ , and so forth over time. Note importantly that, in this very simple example, the “true” growth in output (GDP) is unambiguous since those prices and quantities needed to correctly calculate GDP in both years are crystal clear. Let’s go a bit deeper.

The 2% increase in productivity will also be unambiguous since the 1% increase in hours worked is unambiguous, as is the 3% increase in output (GDP), and productivity growth is simply the arithmetic difference between these two numbers. In the simplified case we are discussing, productivity growth is equal not only to the difference between these two numbers, but also to the increase in *physical* output of the economy (the increase in tonnage produced). This follows from our assumption that prices and wages do not change, so that the calculation of GDP growth (changes in the total dollar value of GDP) reduces to changes in quantities alone. In this example, the measurement of GDP growth is a piece of cake. No measurement problems arise, not even as regards productivity growth.

**Living Standards:** What does all this tell us about changes in living standards in our idealized economy? Here matters become a bit more complex. Recall that we can describe economic output in two equivalent but different statistical ways: Output can be measured **(i)** as GDP, the dollar value of goods and services produced; and **(ii)** as National Income — the sum of all checks written to workers and to the owners of capital. Assuming that all income is reported, the two numbers will be the same.<sup>1</sup> They represent the two sides of the output coin. Thus, if GDP increases by 3% as it does in our model, then so will national income increase by 3%. Assume now that the *share of increased national income going to labor versus capital is fixed every year* at the conventional 35%/65% split (the capital/output ratio). Then workers will receive total wage increases of \$19,500,000,000 which is 65% of the \$30 billion increase in national income in our simple example. Owners of capital will receive the remaining 35%.

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<sup>1</sup> We are omitting here the discrepancy between GDP and National Income due to the depreciation of capital stock. It is irrelevant to our example.

Note that these wage increases are nearly identical to the 2% rise in productivity growth that was unambiguously measured just above. Workers will then be free to spend their higher wages to buy *more* foodstuffs and finished steel products than they did the year before. There are no new products to tempt them. Furthermore, by our assumption of constant and unchanging tastes for steel products and foodstuffs (constant marginal utility), they will always desire to consume more of these products. *Thus their living standards rise because of productivity growth, and at the rate of productivity growth.* So much for a simple textbook model.

**Real World Messiness:** Suppose we now relax the rigid assumptions of the above model, and for example permit the prices, the quality and the variety of products produced in the economy to change. Suppose in particular that wholly new products are regularly introduced via ongoing innovation. Suppose additionally that wholly new products and services arise that are “free” — i.e., customers are not charged for using UBER and GPS apps. In this context, while it may still be straightforward to measure increases in total hours worked, it will be very challenging to measure GDP correctly. *For both price and quantity measures become ambiguous.* But if we cannot measure output correctly, what hope is there for measuring productivity growth, even if we know workforce growth?

#### 4. Has Productivity Growth Actually Slowed Down?

**The Data:** The official data tell two different stories about productivity. First, it has slowed appreciably during the past six decades. Productivity growth was CAGR 2.25% between 1950 and 1980. It declined thereafter to 1.95% between 1981 and 2014. Between 2005 and 2014, it slowed even more to 1.28%. The only bright spot were the years between 1995 and 2004 when it surged to 3.09%, supposedly because of the internet boom. Second, the *share* of the gains from productivity growth going to labor rather than to capital has fallen. Some four developments caused the traditional 65%/35% allocation of national income gains going to labor versus capital to drop to 58%/42%. [The two shares must sum to unity.] This is why we read that capital has bested labor for several decades. And this is true.

In an earlier **PROFILE**, we identified the four developments underlying this reality, and argued that the recent trend favoring capital will reverse over the next few decades. This will be largely due to mean reversion in three of these four drivers, e.g., interest rates will rise, not fall. So we shall not discuss this issue herein except to point out that this development — *one having nothing to do with productivity* — helps explain the failure of real wages to rise at the rate of productivity growth since the owners of capital ate workers’ lunch.

In this **PROFILE**, we focus on the well-documented slowdown in productivity growth itself, and why the data tell us the counter-intuitive story that they do. Economists including Lawrence Summers, Robert Gordon, and Edmund Phelps predict that productivity growth will continue to be stagnant during the next few decades of “secular stagnation.” [Some reasons for their pessimism are critically reviewed in Section 8 at the end of this essay.] People in this camp make productivity growth predictions in the range of 1.2% – 1.5% for the future. The fact that officially measured growth was recently negative for two consecutive quarters has won converts to their views, and has elevated the entire problem of productivity to the fore.

The paradox here is that society is witnessing a blizzard of technological advances as the digital revolution continues to unfold. This innovation bonanza seems completely at odds with data stating that productivity has been trending downward. We now demonstrate why it is.

## 5. Truth of the Mismeasurement Allegation

If we stick to our definition of productivity growth as the change in real output net of the change in total hours worked, what does it mean to claim that we are “mismeasuring” productivity growth”? This allegation must imply that we are mismeasuring the growth in real GDP, as just stated above. For given a reliable measurement of workforce growth — and we have one — the problem *must* lie in our measurement of changes in output.

Suppose we are mismeasuring and indeed understating the growth of real GDP. How might this happen? What could cause it? There are two possible explanations.

*First*, we could be understating the quantity of goods and services being produced in the economy, and/or their true nominal price. In this regard, recall that GDP growth represents the increase in the arithmetic product of Prices and Quantities across all markets. If quantities and/or prices are measured too low, or are treated as non-existent (in the case of free goods), nominal GDP growth will itself be understated by that amount.

*Second*, we could be using an upwardly-biased measure of inflation. The latter will cause real GDP growth to be lower than it truly is.

Let us now discuss why US data suffer from both these kinds of mismeasurements.

### **Bias #1: Output/Price Mismeasurement**

One of the champions of the view that we are underestimating output growth by virtue of omitting many goods and services from the official data is Hal Varian, formerly Professor of Economics at UC Berkeley, and now Director of Economic Research at Google. His main concern is that more and more of the goods and services being produced are “free.” He cites a wide variety of goods and services including Google, UBER, and GPS, that in his view definitely increase labor productivity, but do not enter the calculation of US output. One reason is that they are *free* and thus have no listed price. What about their quantity? When a new digital app is introduced by Apple, or when a new song is produced, then both are emailed free to millions of users, and “quantity of goods sold” becomes a concept with no meaning.

Since the increase in GDP is calculated from the arithmetic product of Price times Quantity summed over *all* goods, the increase due to the production and proliferation of *new* products will usually not be included. GDP as measured will therefore have a downward bias.

To complete our logic, this underestimation of GDP growth translates into a downward mismeasurement of productivity, since the latter is measured as the difference between the (biased) increase in the value of output and the (unbiased) growth of total hours worked. *But the resulting distortion in productivity growth is even worse than this.* For the working hours of the new and highly paid technology workers who create these new digital products *are* included in the “total hours worked” term of the productivity growth equation, whereas the output of their labors is *not* included. This reality constitutes a double downward bias for measured productivity growth.

Contrast a modern economy of this kind with a classical economy producing pizza pies and automobiles. Technological changes lead to new and better pizzas that stay hot longer, taste better, that have new toppings, and are delivered faster. Customers are willing to pay for these improvements, implying that the *price* of pizzas increases. The same has been true in the case of automobiles as cars became equipped with air conditioning and customers paid extra for it. Moreover, the *quantity* of pizzas or autos sold by firms is measured and known, and this quantity rises over time. So all in all, prices and quantities both rise, and thus so does revenue — which is nothing but Price times Quantity. GDP, which measures total revenue, will rise correspondingly.

Varian sees an ever greater share of the economy shifting away from classical to new-type products. We have only skimmed the surface in discussing this particular bias in productivity growth measurement. There are many related issues such as the *rate of penetration* of new “free” goods and services into more established product lines — lines where customers *do* pay an unambiguous price for a meaningful product. The more this happens, i.e., the more the digital revolution becomes “embedded” in the larger economy, then the faster measured GDP per capita will rise, and so therefore will productivity.

**Can This Bias in the Official Statistics be Remedied?** Can anything be done statistically to correct for the “free goods” problem? We have seen no compelling answer to this question. One approach would be to create in the GDP accounts a new *abstract product* possessing price and quantity indices. We could then add to traditional GDP the “revenue” (Price times Quantity) generated by this currently unreported abstract good.

More specifically, the government could determine the dollar amount customers would pay if faced with a choice to either give up access to all such services as Google, or else to pay for all such services on a monthly basis. [We are measuring what economists call “consumer surplus” here.] With appropriate mathematical adjustments that take account of the various elasticities of supply and demand, this measure could generate a proxy of “price” for our new abstract product. Additionally, statisticians would be monitoring changes in “quantity” (output) by developing measures that capture the rate of propagation of such services throughout society. [Clicking on Google in year  $t$  might occur 100 million times a year, and rise to 10 trillion by year  $t+n$ .] In this way, the Price times Quantity “revenue” associated with free goods could be computed and added to the GDP numbers. As the revenue from such sources would rise rapidly over time, the growth rate of measured GDP and hence productivity would also rise. In our view, this adjustment would add at least 1% to GDP.

### **Bias #2: Inflation Mismeasurement**

The second way in which the official statistics cause GDP and productivity growth to be understated comes from an overestimation of inflation as currently measured. The root problem here is well known and has been addressed by government statisticians for decades: this is the improvement-in-quality-over-time issue that has given rise to “hedonic” adjustments to the price levels. The problem here is simple: suppose you compute the inflation rate by comparing the market cost of an ear of corn today with that of yesteryear. No measurement problem occurs here.

However, suppose you compute the inflation rate of the cost of a lightbulb over time. The problem here is that the putatively “same” lightbulb of 1960 produced much less light than an LED bulb can produce today, utilized five times the amount of electricity (wattage), and lasted one twentieth as long. To compute the true inflation rate, it is insufficient to know that the shelf-price of a lightbulb has *inflated* from \$1.20 in 1960 dollars to \$13 in today’s money. For the old and new bulbs cannot meaningfully be compared due to myriad technological changes.

In reality, we should be measuring the changes in the total cost of generating an equivalent amount of light, measured in lumens. When we do so, we find that the cost of the light bulb viewed as a source of lumens has *deflated* hugely. William Nordhaus of Yale University has shown that, over the past three centuries, the cost of a lumen has fallen to 1/10,000 of what it was in 1700.

The same is true of computers, memory chips, automobiles, and a host of other products. The real cost of computing power today is virtually free compared to what it was in the recent past. Cars are much more stable, more comfortable, and safer (airbags and seatbelts alone quadrupled safety). Once again, comparing the shelf-price of a computer or car today compared to the shelf-price “back then” yields a massive overestimation of true inflation.

To be sure, government statisticians (at least in the US) have been well aware of the need for “hedonic” price adjustments to the inflation rate. These have been introduced over several decades, especially in the case of computers. The problem is that officials may have only scratched the surface of what needs to be done to incorporate quality improvements. Economists have published studies showing that we have overestimated inflation by between 1% and 2% during the past two or three decades. Others disagree.

In our view, the preponderance of evidence suggests that government statisticians are way behind in making all the hedonic price adjustments they should have made. Additionally, they do not deal at all with the disinflationary effects of ever more “free” goods and services discussed above. This is a logically different matter involving *new* products and therefore not centered on the price of software “back then” with “today.” There is no hedonic issue here.

Taking both these sources of inflation mismeasurement into account, we believe that the official inflation rate is and has been at least 1% higher than the true rate. Of course, this is simply a crude estimate. *Recall why this matters.* It is the growth in *real* output per worker that defines productivity growth given an unambiguous estimate of workforce growth. Overestimating inflation clearly depresses measured real growth since the official price deflator

used to deflate nominal GDP growth is too high. And it thus depresses the growth rate of productivity by definition. If our quantitative estimates are approximately true, then the slowdown both in GDP and productivity growth during the past two decades may have been entirely illusory.

## 6. Implications for Increases in Living Standards

In the final section of this **PROFILE**, we address what is perhaps the most difficult and important dimension of the entire productivity debate: Are Americans truly living no better than they were forty years ago, as is suggested by the failure of real wages to rise over past decades according to the nation's official statistics? Or could it be that living standards have in fact risen appreciably, thus throwing into question the validity of the nation's entire economic data base?

In this section, we first attempt to establish that living standards have risen appreciably over the past three or four decades. We then attempt to demonstrate *why* it is that official statistics show real wage growth to have been way below the true growth in living standards. Persuasive economic theory implies that these two variables should move in tandem. What is the true source of this discrepancy between the two growth rates?

Intuitively, the two developments we have discussed above can largely explain away this problem. *First*, the government has underestimated real GDP growth by failing to include the revenues generated by the production and consumption of new goods. *Second*, inflation has been significantly lower than measured due to the failure to incorporate as many hedonic price adjustments as were required. There exist adjustments to the official data series on real output and on inflation that generate higher real wage growth than the current data reveal.

*But how much higher should this revised estimate of real wage growth be for it to equal (as it should) the "true" increase in living standards? This all-important question could be answered if we were to possess a valid estimate of living standards growth that is independent of the data on wages, productivity, output, and inflation. If we possessed this, and it revealed a 30% true rise in living standards since 1975 — regardless of any data — we could then have a better understanding of the magnitude of adjustment needed in the official statistics so that the revised statistics imply a growth rate in real wages equal to the true, independently given rise in living standards. The truth about living standards must be the horse driving the cart (the data).*

The point here is extremely subtle. Please reread the previous paragraph. We take the view that what ultimately matters are the true changes in the standard of living, and that government statistics *if they are to be valid* must imply a real wage growth estimate that equals this change — an equality required by sound economic theory. To look at this manner in reverse, what validity would official statistics have if they implied a growth in real wages *not* equal to an independently measured (and correct) rise in living standards?

**The Two Challenges:** We must first introduce a way to measure increases in living standards that is independent of official data. Next, we must show how to adjust official data in such a way that they imply an increase in real wages equal to this independent measure of living standard growth.

#### – A Theoretically Correct Way of Measuring Living Standard Increases –

We owe the following observations to a discussion several years ago with Stanford University economist Kenneth Arrow. Suppose there is a population of one million people. Then by asking each citizen to answer one and only one question, and by averaging the answers, we can arrive at a correct answer to the question: What was the average rise in living standards in the population? The analysis may seem quite “subjective” to some readers, but as we now learn in Decision Theory 101, subjective questions and answers are logically required when investigating such subjective issues as human preferences, levels of happiness, and living standards. In particular, subjective methods are required to make possible a comparison of new versus old “consumption bundles.”

**The Question for Each Citizen:** Consider the period of the past thirty years. How much of your current 2015 income would you forfeit to be indifferent between **(i)** your pleasure from the reduced consumption bundle you would acquire with your reduced income today, and **(ii)** your pleasure from your consumption bundle of thirty years ago. Suppose a citizen replies: “I will accept no reduction in my income today to be indifferent between the two. The pleasure I receive from my consumption bundle today spending my full income is equal to that of my bundle thirty years ago, even though what I now consume is very different from before.” *Only if this is his/her reply will that citizen be said to have had no change in living standards over the past thirty years.*



During the past decade since our discussion with Arrow, we have posed this question to some two hundred people. The average answer (once the respondent understands the question) is in the range of 30%, not the 0% implied by the official data on real wage growth. More specifically, the average respondent is saying that he is indifferent between the consumption bundle he *would* enjoy with 70% of his current income, and the consumption bundle he *did* enjoy thirty years ago. Equivalently, he is saying that he enjoyed a 30% rise in living standards.

To restate this, “I would give up 30% of my current consumption NOT to be stuck with autos that are many times more dangerous than today’s cars — which are equipped with seat belts and airbags, not to be deprived of mobile phones and, of their apps (no apps), of statin drugs that keep me alive three years longer, and of cancer treatments tripling my chances of surviving a lymphoma.”

Note that the use of an “indifference calculus” here abstracts away all difficulties of measuring the true price and quantity of new goods and services, of measuring quality improvements, of quantifying the value of intangibles such as “more safety” or “improved ease of use,” etc. The process of stating indifferences also permits consumers to compare and to rank wholly different consumption bundles — *and to do so quantitatively*.<sup>2</sup>

We now come to our second fundamental question, the answer to which draws upon the previous sections of this essay.

#### **– How to Reconcile Official Data with “True” Increases in Living Standards –**

Suppose that people believe their living standards to have risen a cumulative 20% over the past decade, or a bit less than 2% a year. Suppose that officially-measured nominal GDP growth has risen at 3%. Suppose inflation has been officially measured at 2% per year so that real GDP growth has averaged 1%. Finally suppose that workforce growth grew by 1% per year. Then productivity growth will have stagnated (1% real GDP growth minus 1% workforce growth = 0%), and living standards will also have stagnated *if these are equated with productivity growth* as officially measured. But citizens claim that their living standards have risen by 2% a year, not by 0%. The discrepancy here is between living standards and productivity growth.

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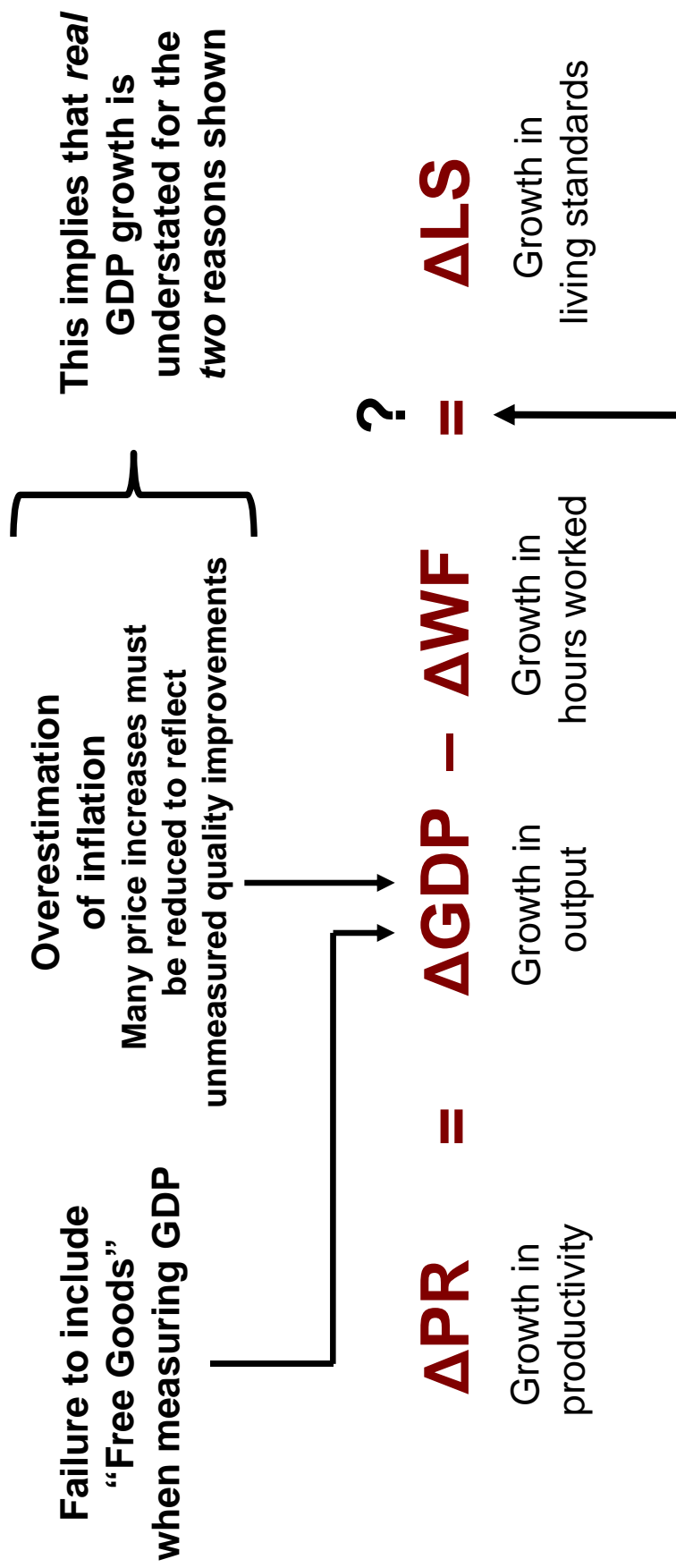
<sup>2</sup> This technique of utilizing “indifferences” was first introduced in the development of modern utility theory by the mathematician John von Neumann in his effort to show how properly to measure human preferences (cardinal utilities) by assessing indifferences among lotteries. Scholars such as L. J. Savage, R. Anscombe and R. J. Aumann would later use similar methods to permit the quantification of “subjective probabilities” along with preferences when no data are available.

A second and related discrepancy is lurking here. It can be derived by looking at things from the standpoint of national income as opposed to GDP (remember these are equivalent). Suppose that nominal wages have risen by 2% a year. This would be typical given our assumption of a 3% increase in nominal GDP, and given that 2/3 of increased national income goes to labor. Then given the official inflation rate of 2%, real wages will have stagnated, since a 2% increase in nominal wages minus a 2% inflation rate implies a zero growth rate in real wages. Living standards will also have stagnated *if these are equated with real wage growth*. This second discrepancy is between living standards and real wages.

**Reconciliation:** If we assume citizens are correct in determining that they live 20% better now than a decade ago, then *either or both of the following two measurement errors must be reflected in the official data*. First, nominal GDP growth could have been higher than measured, namely 4% rather than 3%, once today's bias in measuring "output" is remedied. Second, inflation could have been lower than measured by the official data, say 1% versus the official 2%, once appropriate hedonic quality improvements are taken into account. In this case, *real* GDP growth would have been 3% (4% nominal growth minus 1% inflation). Real wage growth would have been 2% (this is equal to 2/3 the 3% increase in real national income — workers' share). Then assuming as above a total-hours-worked increase of 1% per year, productivity growth would have been 2% (a 3% real output growth minus 1% workforce growth), not 1% as shown in the official data. Then this 2% annual rise in productivity and in real wages would equal the 2% rise in annual living standards that citizens claim they have enjoyed.

*Given these adjustments, economic theory would be fully vindicated. The independent measure of increasing living standards we have proposed is logically required for government to know by how much to revise the statistics on inflation and output. This measure will help statisticians know how much consumers value free goods and quality improvements — subjective issues that cannot be avoided. The goal will be to end up with statistics that mathematically imply a "true" increase in living standards that is equal to the increases in productivity and real wages — an equality implied by fundamental economic theory.*

# Measurement Problems in the Official Data



The *true* rise in living standards is independent of official data on GDP and productivity. A *valid* measurement of LS (regardless of data) will signal the *correct* magnitude of the revisions in the GDP data that are needed. Only after such revisions are made will the equality above hold true — as economic theory requires.

## 7. Policy Implications of Our Analysis

The thrust of this **PROFILE** has been that, were real GDP growth properly measured, the data would show that US citizens have enjoyed substantial gains in living standards during past decades. Via the logic of economic theory, this implies that productivity growth and real wage growth have risen commensurately. If this is true, then the “secular stagnation” hypothesis of Lawrence Summers and others must be modified — but not abandoned — since certain points of this hypothesis are valid. Our analysis also implies that the Fed should revise its “non-inflationary” growth target upward, and worry a lot less than it has about inflation. Finally, there are implications for reducing cost of living benefit increases in entitlement programs.

**The “Are we better off?” Debate:** What does our analysis imply for today’s heated political debate as to whether living standards have remained stagnant for thirty years? It says a great deal. We have sketched a completely new way to define and measure “changes in living standards” based upon modern utility theory. Drawing upon this, we have suggested that average living standards have risen approximately 30%, not 0%, during the past thirty years. Our analysis here had nothing to do with official data and its mismeasurement.

Separately, we examined the official data. We concluded that **(i)** *nominal* GDP growth has been understated by about 1% due to government’s failure to account for “free goods” in calculating GDP, and in addition that **(ii)** *real* GDP growth has been about 1% higher than measured due to statisticians’ failure to make as many “hedonic” price reductions as are needed to account for quality improvements in many goods and services.

*If both parts of our analysis are correct, then the revised GDP and productivity data we are calling for will imply the (separately measured) rise in living standards that we have identified. This increase in living standards will in turn be equal to the new and revised estimate of growth in real wages, just as economic theory says it should be. In short, we have sketched how quantitatively to vindicate the equation shown in the accompanying graph. If we are correct in all this, then today’s celebrated “productivity paradox” will have been fully resolved. For there never was a paradox.*

**Criticism:** We know of no other attempt to resolve the productivity paradox along the lines proposed above. In some fifteen pages, all we have been able to do is to sketch the logic required to do so. Much future research will be needed to properly assess the average rise in

living standards, to assess the distribution in increases in living standards, and to compute the data revisions needed to address the free goods and hedonic issues.

## 8. Dissenting Views

We have not had the space to address the concerns of those who take the other side of the productivity paradox debate. Here are some of their views.

(i) “The importance of the digital revolution to the economy *should* not be expected to transform productivity the way the advent of the steam engine and electric power did 150 years ago — and the data confirm that it *did not* do so, with the exception of the ‘internet explosion’ period of 1996–2004 when productivity growth exploded.” Robert Gordon of Northwestern University champions this view, arguing that today’s innovations are quite trivial compared to such “General Purpose Technologies” as steam engines and electric power that powered productivity boosts long ago. Many other economists consider his view far off the mark. They argue that Moore’s Law along with the digital revolution may be the greatest productivity enhancer in centuries, notwithstanding our difficulties in measuring its true impact on real GDP and productivity growth. We find Gordon’s view unconvincing.

(ii) “The fact that productivity growth has fallen, and (worse) that the rate of real-wage growth has fallen well below productivity growth make clear that the digital revolution is not bestowing benefits upon the general public.” There are two problems here. *First*, with the share of increased national income going to labor having fallen from 65% to 58%, real wages were hit by developments having little to do with Digital Era productivity growth. *Second*, there are the various mismeasurement problems that we have discussed.

(iii) “Businesses have significantly reduced their capital spending while increasing their rate of share repurchases. This strategy for artificially boosting earnings while reducing investment is one good reason why productivity growth *should* have fallen.” We believe that today’s reduced level of business investment is a *shorter-term* issue reflecting the collapse of optimism about the future due to the Global Financial Crisis. Many economists agree with us on this point. Going deeper, far fewer investment dollars (the proxy for “investment” that is measured in the official statistics) are *needed* to get the same productivity boost from cheap new digital products than were required in the past. One would then expect a slowdown in the magnitude of *dollar* investment spending, just as we have witnessed. But this does not equate to a slowdown in investment when measured by the superior efficiency gains of Digital Era technologies (many of which are not measured).

Regarding this last point, Brent Neiman of the University of Chicago has measured the marginal efficiency of “new” capital stock, and found that a dollar spent on capital goods today has a much greater impact on output than such an investment did in the past. This has led to an increased substitution of capital for labor, and is one reason for the decline of labor’s share of national income.

In a different direction, the Federal Reserve Board itself has drawn attention to the radical changes taking place in “business investment.” First, their economists claim that official data understate investment growth because price trends in IT equipment and software have increasingly failed to take into account (hedonic) quality gains. More broadly, they believe that the official data fail to capture the increased expenditures on *intangible* (and thus non-measured) assets such as research, skills, and patents. The *Wall Street Journal* ran a full page story on this issue on Monday, August 17, 2015, page A2.

(iv) The Nobel Laureate Edmund Phelps recently published an article in the eminent *New York Review of Books* (August 16, 2015, pp. 54-56) entitled “What is Wrong with the West’s Economies?” Phelps explains the great slowdown in growth as due to a dramatic reduction in productivity growth during the 20<sup>th</sup> century. This reflected ever-shrinking interest in “innovation.” This in turn was due to an ever-increasing lack of “fulfilling” work. Notwithstanding our admiration for Phelps, a brilliant economist, we find his views highly perplexing. He makes no references to the measurement issues that we (and many others) have addressed herein, and he accepts government data as gospel.

He dismisses Silicon Valley’s contribution (“It only accounts for 3% of GDP and even less of employment”) as not very important. While it may be true that Silicon Valley proper is quite small, what matters is the astonishing impact that its products have had in boosting efficiency throughout the broader economy. The invention of e-mail alone has apparently impacted over 95% of the economy. Phelps also writes as if there are fewer innovative young people than in the past. We find no evidence to support this lack-of-creativity thesis. Indeed it is preposterous given the myriad innovations of people under twenty-five that have recently transformed the world as we know it.

Even after taking into account these four explanations for today’s putative productivity slowdown, we conclude that productivity growth has been at least 1% higher than is measured, that inflation is 1% lower than measured, and that real GDP growth is correspondingly higher than measured by about 1.75%. [The figure is 1.75% not  $1\% + 1\% = 2\%$  since there are certain

overlaps and redundancies between the “missing goods” problem and the “quality improvement” problem.]

We hope the arguments advanced in this **PROFILE** will help clients to better navigate the great productivity debate.