Economics Needs Science

to understand Innovation

Trouble Tickets are holding it back

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Manufacturers, or suppliers, of high-tech equipment or services, open Trouble Tickets for the purpose of de-bugging issues. This is symptomatic of fast moving technology advancement.

Economics has a long history of being far behind in understanding the economic impact of technology advancement and on the impact of its consequent innovations. The following open Trouble Tickets get to the heart of the problem in two ways that provide resolutions from a more scientific approach than Economics is currently capable of providing for itself.

First Trouble Ticket - Price Index Correction

Price Indexes have a long history. In 1707, William Fleetwood, Bishop of Ely, compared data he had collected on the price of corn, meat, drink and cloth between 1440 and 1460 and also between 1686 and 1706 to conjecture what could be bought for £5 in the first period would likely cost £28 or £30 by the second period; about a six-fold increase in about 250 years.

Fleetwood configured his selection of goods to represent what he called 'the necessities of life', what is referred to today as a 'market basket'.

For a far more extensive UK 'market basket' of business-to-business goods, 20th century prices showed a more than four-fold increase between 1975 and 2000. That price gain over 25 years comes close to the one observed over 250 years by Fleetwood.

Today's pace of technology and innovation growth is vastly greater than it was when Fleetwood was estimating. That provides a massive challenge for constructing price indexes today. How to account for the price change attributable to technology and innovation advancement has not been conquered by Economics and is known as its 'quality change problem'.

The most prominent attempt is the hedonic method.

In principle each commodity in a basket has a set of attributes a_1 a_2 … a_n that constitute its 'quality'. Since a given commodity also has a set of variants having different price points P_t in a given year the following equation can be set up for that year whose multipliers α, β … ω are determined by statistical regression of the attribute and price data for the variants

$$\log P_t = \alpha a_{1t} + \beta a_{2t} + ... \omega a_{nt}$$

A requirement for price indexes is identical market basket content and that requires forcing constant 'quality' on a basket's content over time.

Once the equations are established the price ratio between years for identical attributes can be determined. For example the attributes of new automobiles in a later year, such as 1983, are forced to the base year of 1967, as shown in figure 1.

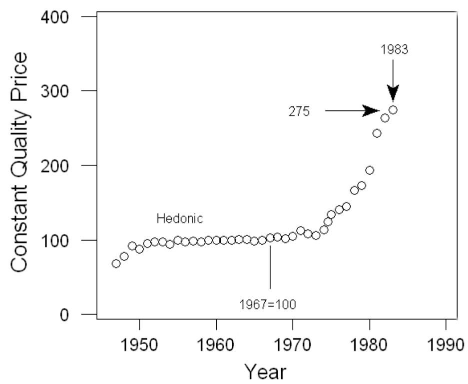


Figure 1 – Forced constant 'quality' prices for automobiles

For Bishop Fleetwood this would have meant that a payment of 100 required for a 'conveyance' in the earlier year would require an inflated amount of 275 in the later year, despite the 'conveyance' being identical, which identical attributes are weight, length, the number and type of horses (the horsepower and number of cylinders today) and the caliber of trim.

This hedonic correction of inflation has brought the Fleetwood method up to date for modern times.

Unfortunately it has also introduced new limitations, two of which are systemic,

1. Firstly it is clear that no one goes to an auto dealer to buy a length or a weight. These are weak proxies. It is the purchaser's attitudes to specifications that matter. These include how it may fit a perceived lifestyle, a truly intangible consideration.

2. Secondly the method cannot be reversed. Given a price for a single item with more than one attribute and the governing equation tells you what one attribute is only if you know the other(s).

'Quality change' cannot be determined from price.

Attribute methodology is troubled. It should not be used to determine 'Quality change'.

First Trouble Ticket – Resolved

The following law is in the public domain from 2018,

$$P_t = p_t / \Sigma Q_t \quad \text{or} \quad p_t = P_t \Sigma Q_t$$

and it overcomes **both** limitations.

p_t is the performance of the product or service intangibly perceived by the purchaser at the time of purchase.

ΣQ_t is the physical quantity sold within the market, which is also the market's competitive pressure.

P_t is the real price.

Because p_t captures the purchaser's attitude to the attributes, not the attributes themselves, this equation marks a major breakthrough that sits closer to 'quality' in economic parlance than it does to 'utility', but is uniquely neither.

The pPQ equation is derived from original sources. They arise from ecological experiments in a laboratory where microorganisms compete for food (money) in test tubes and where one microorganism pressures the other one out.

This science experiment and its scientific interpretation holds close analogy with commercial realities, which are characterized by an attacker's advantage, which turns out to be p_t.

p_t has been calculated for many commodities across the economy. A prime example is shown in figure 2.

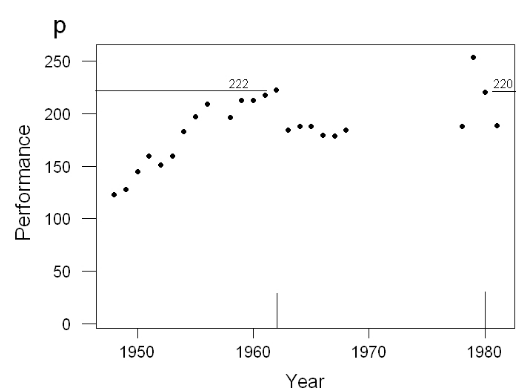


Figure 2 – p_t from the pPQ for inside frosted light bulbs

The performance for these Sears 100W incandescent light bulbs rises in a beautifully classic S-curve.

Observe that p_{1962} is close in value to p_{1980}. In 1962 the competitive pressure was 878 and P was 0.253. But by 1980 the competitive pressure ΣQ had increased to 1221 while P has reduced to 0.180. This dynamic interplay between the three variables p, P_t and ΣQ_t has profound consequences.

1. The pPQ equation solves the 'quality change problem' because it provides the direct single variable measure that hedonic methodology cannot.

2. The pPQ equation therefore empowers Economics to define and enumerate innovation using the following approach.

It starts from ideas that generate product concepts that enter an innovation funnel from which very few emerge as useful entities.

The funnel is driven by iDe (idea development expense) where it's iDe that turns a concept into a useful product whose innovation metric p/c has risen, figure 3, until it becomes a commercial success, or it doesn't.

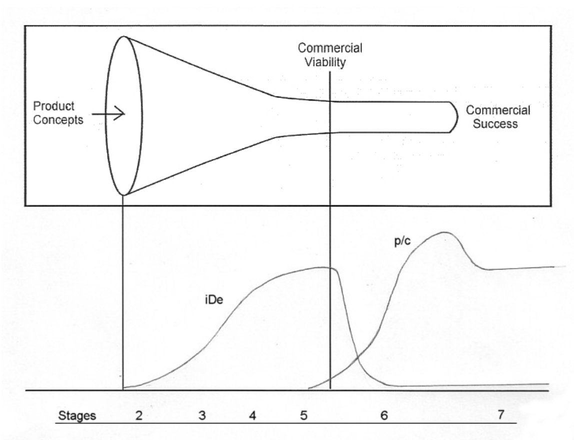


Figure 3 - The funnel admits ~300 'shaped ideas', or new product concepts, for every eventual commercial success. iDe raises p/c in stages as shown.

The pPQ equation provides the numerator of an innovation metric p/c while its denominator c is the unit cost of delivery. This ratio captures and enumerates innovation.

iDe is used because R&D is not economically significant unless it is parsed into elements. iDe adds 'applied research' and 'development' that is funded from company sources. It must be treated economically as expense and not as capital forming. R is 'basic research' that does form capital stock.

Its role in innovation is to sit outside the innovation funnel's mouth as a potential source of ideas, a force that exerts itself 'primarily' through academe.

This is evidenced - in figure 4 - by the high correlation coefficient between the cumulative sum of 'University Spending on Science and Engineering' and iDe (= 0.979) when the period of accumulation is five years. This rolling sum shows a remarkable correspondence to post-graduate movement into post-academic commercial technical employment.

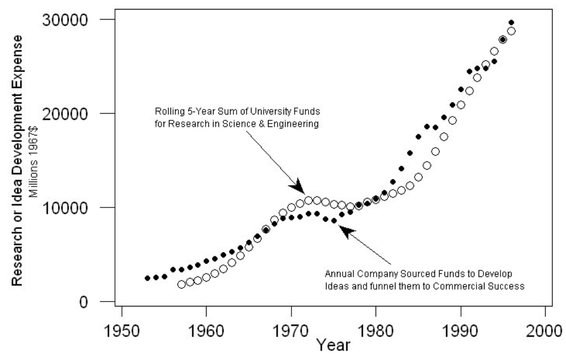


Figure 4 – Ideas from academe merit commercial development

This strongly supports the long-held but unproven contention that a stock of ideas generated from basic research in Universities generates a small flux of ideas meriting commercial exploration through iDe.

To accurately capture which R&D becomes,

R-iDe.

Second Trouble Ticket - Productivity

The macro-economic treatment of economic growth rests on two primary variables. They are capital K and labor L. Their conjectured (Cobb-Douglas) relationship is

$$GDP = K^{\alpha}.L^{\beta}$$

Convention has it that α and β are constants and that α = 0.3 and β = 0.7.

There is an immediate problem with the 'total' presumption in this equation. Capital is measured in \$s but labor is measured in hours. Dimensional analysis across the equation means a factor with the dimensions $\sim hrs^{-1}$ is missing from the right side. This anticipates a third factor and the equation should be

$$GDP = K^{\alpha}.L^{\beta}.r$$

Convention also requires that factors be indexed to a base year where they are all set equal to 100. Now there is another problem with

$$GDP = K^{0.3}.L^{0.7}.r$$

because in the base year the left hand side of the equation is 100 but the right hand side is 10,000. The requirement of *'constant returns to scale ‡'* to satisfy which $\alpha + \beta$ was made equal to one in the first place is now violated unless r is raised to the power 0. That means r is a constant equal to one in the base year **and** every other year, but r is **known** to be a variable.

Setting a condition and then violating it does not seem to concern economists but is a red flag to scientists.

Economists claim that the residual third factor r = GDP/ $K^{\alpha}.L^{\beta}$ (euphemistically renamed from residual to Total Factor Productivity) is a technology or innovation factor, or could be something else.

Armed with the ability to independently measure innovation, this assertion on innovation can be tested.

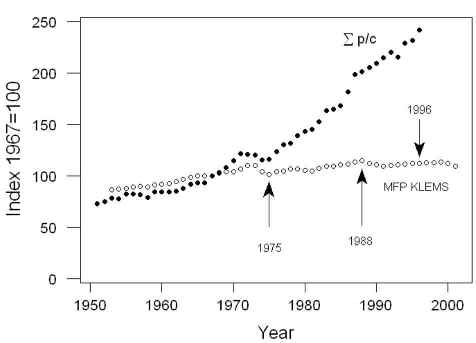


Figure 5 – Σp/c follows iDe expense. MFP KLEMS does not

Figure 5 shows two graphs. The one that's labeled Σp/c is the innovation metric for non-durable goods growing over five decades. The one that's labeled MFP (Multifactor Productivity) KLEMS shows a variant on TFP that factors energy E, materials M and services S alongside capital K and labor L in an expanded Cobb-Douglas equation.

Between 1975 and 1988 MFP KLEMS rises slightly but between 1988 and 1996 it is essentially quiescent. There are two reasons why MFP KLEMS is **not** measuring innovation.

1. MFP KLEMS does not even get close to matching the actual growth of Σp/c (figure 5)

2. iDe for non-durable goods soars from 2.1 billion dollars in 1975 to 6.9 dollars in 1996. This effects Σp/c but there is no response to it from MFP KLEMS.

Factor Productivity is a troubled measurement.

Second Trouble Ticket – Resolved

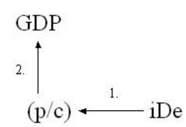
Growth does **not** originate from a multiplication of Capital and Labor raised to powers that add to one.

It arises from two connections,

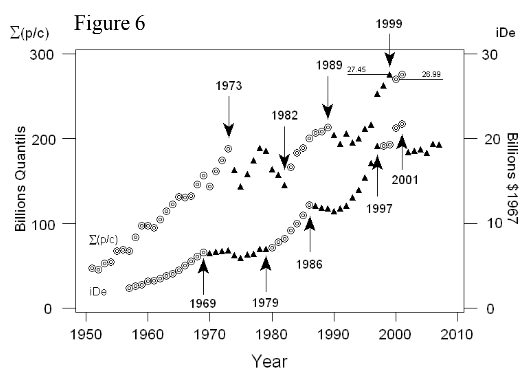
1. iDe connects to (p/c)

then

2. the p of p/c connects to GDP



1. is established graphically for durable goods from two sets of data displayed in figure 6. The lower set has annual values of iDe from 1957 to 2006 while the upper set has annual values of Σp/c from 1951 to 2002.



The iDe data set offers a sequence of distinct shapes while the Σp/c data set shows the same sequence of distinct shapes especially when fluctuations due to the perception affect within p are ironed out between

‡ The requirement *'constant returns to scale'* is a convention that constrains a % rise in output to equal the same % rise in each factor input. When K and L increase by 10% (to 110 from the base year) then GDP must also increase to 110 from the base year, which $\alpha = 0.3$ and $\beta = 0.7$ assures. But when a third factor r is added the condition must be extended to include r or the requirement is violated.

1973 and 1982.

Guided by triangles or circles that mark the shaped segments an anticipated latency period from iDe to $\Sigma p/c$ is clearly apparent.

2. is established by algebra. Because GDP is the total adjusted final value created by an economy and because a single value is a price times a quantity there is a natural fit between GDP and the pPQ equation.

Because p and ΣQ are determined in markets and because exports act in foreign markets the explanation applies only to GDP-V_E

Imports from foreign markets increase the competitive pressure in the domestic markets they penetrate and ΣQ needs to incorporate that.

These subtleties are accounted for in the full algebra.

However, when there is no foreign trade the algebra reduces to the powerful result,

$$GDP = \sum_{i=1}^{N} p_U^i$$

where the U in p_U signifies that U (the USA) is consuming all and only what it produces. Then the sum of p_U for N markets goes straight to GDP.

Concluding Remarks

Growth Economics finds itself in two dead ends, which are

1. its inability to bring its primary method for eliminating 'quality change' in price indexes to work for measuring 'quality change'. The embedded economic concepts of 'quality' or 'utility' impedes Economics from discovering an alternative that is neither 'quality' nor 'utility'. That alternative is 'perceived performance' determined from the pPQ equation.

2. its persistence in trying to divide GDP between macroeconomic factors despite overwhelming evidence that it does not work. The solution is to start from innovation measurement and work up to GDP.

Growth Economics can come alive again if outdated paradigms are retired in favor of this

Numerical Sequence,

$$\Sigma R \rightarrow iDe \rightarrow \Sigma(p/c) \rightarrow GDP$$

in which three fundamental variables ΣR, iDe, and Σ(p/c) lead inexorably to GDP if the unique

productivities $\alpha_1 = iDe/\Sigma R$, $\alpha_2 = \Sigma(p/c)/iDe$ and $\omega = GDP/ iDe$ are deliberately enhanced through policy.

This powerful outcome arises from the pPQ equation whose variables implicitly capture all factors previously thought to be responsible for growth.

References

The volume 'Innovation in Economics: Missing Pieces' provides detailed supporting evidence with references to the appropriate literature. A compendium of its parts (there are two) is available from the Technology Matters homepage together with Q&A on its content from leading Economists.

www.techmatt.com
June 2024