# *Principia* of Economic Growth
# Science from Ideas to GDP

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Technology Matters



# From Ideas to GDP

## How non-economist Economics Succeeds



Non-economist Economics succeeds by enumerating what everyone knows;
ideas – when developed – improve our lives and make us richer.

$$i \rightarrow \text{R\&D} \rightarrow \text{GDP}$$

Despite decades of effort – and the award of Economics Prizes for progress – economist Economics leaves gaps and questions in and around each arrow of the above sequence.

To fill these gaps and answer these questions reigning paradigms within economic discourse need new imagination. Among these are the Cournot determination of price, the Hedonic method of characterizing quality change and the Cobb-Douglas Production Function. Decades of trial and effort on these include those of Solow, Romer and Aghion & Howitt.

Non-economist Economics provides what these efforts have not. Its *Principia* do this by changing the emphasis in economic growth accounting from Capital and Labor to a novel and original mechanism of ideas that operate in markets and convert *i* to GDP.

These *Principia* are observed from

Pond Life in a Laboratory

Its Science is under the radar of academic economists despite its provenance from 1986 and the significant landmarks in 1993, 1997, 2008 and 2018 tabulated above. As a result National Accounting still **adds** R&D to GDP when iDe is known to **originate** it.

Insight on origination is essential for framing good policy and the economy of any country will be advantaged when its National Accounting accurately tabulates this and makes it public.

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## Pond Life in a Laboratory

Georgii F. Gause spent the summers of 1927 and 1928 in the North Caucasus studying grasshoppers across their natural habitats. When he returned to the University of Moscow so had his academic advisor, from a fellowship in the United States. Enthusiasm for the work of Raymond Pearl at Johns Hopkins now gave Gause a big idea.

Why not bring population studies out of the wild and into the laboratory?

But it went further than that, as Pearl himself articulated in 1928 *'When the biologist exercises something approaching the same precision and infinitely painstaking care, over all the most trivial details of a biological experiment that the physicist does over his, the results tend to take on a degree of precision and uniformity not so far short of that usual in the older science, as we are accustomed to expect'*, Gause (1964).

Gause exemplified that vision in his studies of two Paramecia species common in pond water.

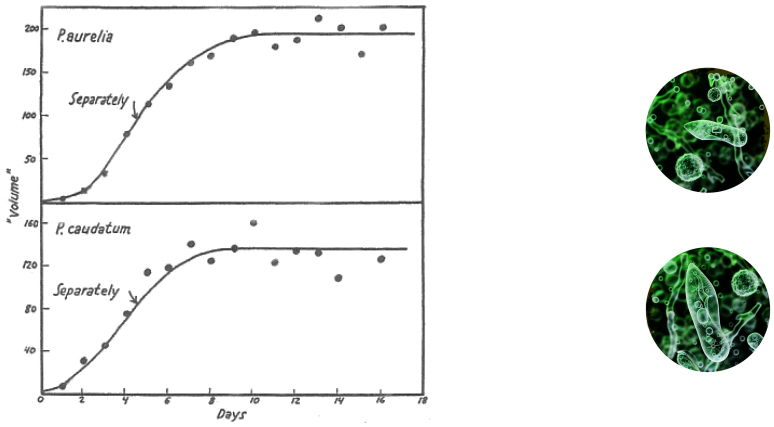
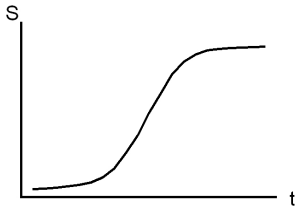



Figure 1 – The growth of two Paramecia (left) observed by microscopy (right).

Paramecium aurelia and Paramecium caudatum are slipper-like microorganisms exhibiting a twist through which they devour their bacterial food. Importantly for microscopy they are distinguishable by size; caudatum is the larger. Gause controlled their every aspect. He used a specially designed solution instead of pond water and a specially prepared monoculture of *Bacillus subtilis* as food. Grown alone they fitted the mathematics of Pearl.




$$S_t = \frac{S_\infty}{1+\exp(a-bt)}$$

or

$$S_{t+1} = \frac{\lambda S_t}{1+\alpha S_t + \nabla}$$

Figure 2 – The Pearl S-curve (left) with equations (right).

The curve promoted by Pearl is shaped like a laterally extended S. Its lower half is a modified exponential expansion that joins a modified exponential contraction halfway up. That is described

by the upper equation in figure 2, which is well adapted for calculators. The lower equation is adapted for spreadsheets. For a Pearl S-curve $\nabla = 0$ but in mixed populations it is not. And those populations are what Gause investigated next.

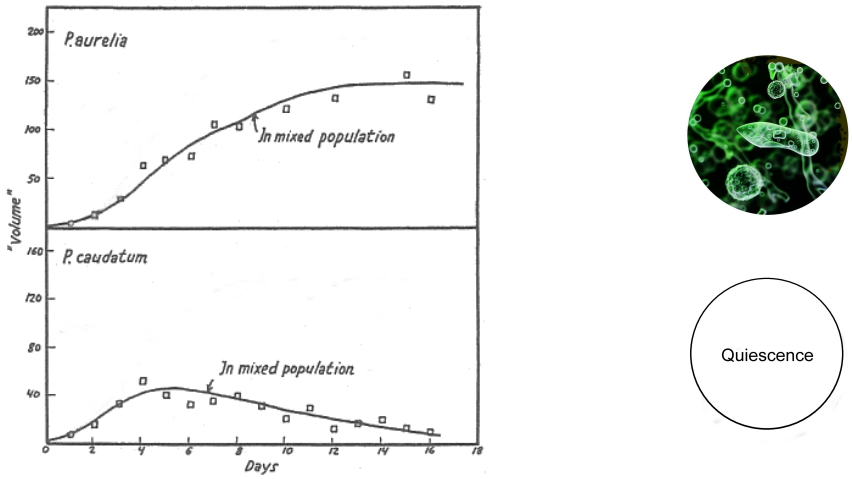



Figure 3 – P. aurelia grows along two connected S-curves to push P. caudatum out.

In this microscopic David & Goliath the smaller species vanquishes the larger one.

Gause explained this brilliantly using two equations. In each equation there is a term from the other represented by $\nabla$ in the spreadsheet formula. Because $\nabla$ appears in the denominator it can reduce $S_{t+1}$ from its previous value of $S_t$ at each step and that can send P. caudatum to actual, as well as mathematical, extinction.

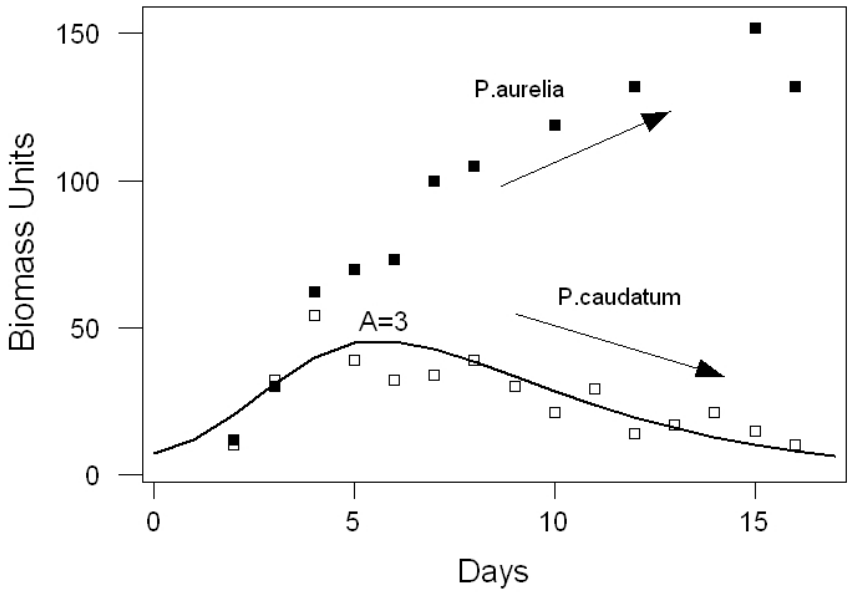



Figure 5 – P. caudatum's demise is captured using the parameter A=3 within $\nabla$ .

## Pond Life Elsewhere

In the early 1990s the same Lotka-Volterra methodology used by Gause was applied to explain the growth and extinction of everyday items, Farrell (1993); starting from audio players.

*'The wind-up gramophone of my grandparents' generation is extinct. In three human generations five sorts of listening hardware – Edison's cylinders, brittle 78 rpm records, vinyl LPs and singles, cassettes, CDs – have arrived and become pre-eminent; yet already two have gone. This list does not even include total failures. Eight-track tape and quadraphonic sound died out because they were ill-adapted to capture consumers' money'.*

Alison MacVicar's illustration accurately interprets this paragraph in the article, and in the context of Lotka-Volterra. The pond is now a pond of money. The latest gadgets are feeding from it. Turntables have already been turned away. His Master's Voice, once heard by an obedient dog from an acoustic horn, is so distant it's on the way to becoming a fossil.



Printed with permission from the artist Alison MacVicar

Figure 6 – A creative view of creative destruction for audio devices.

And when CD Players push out Cassette Tape Players an increase in A from 2 to 4 hastens the demise of the Cassette Player.

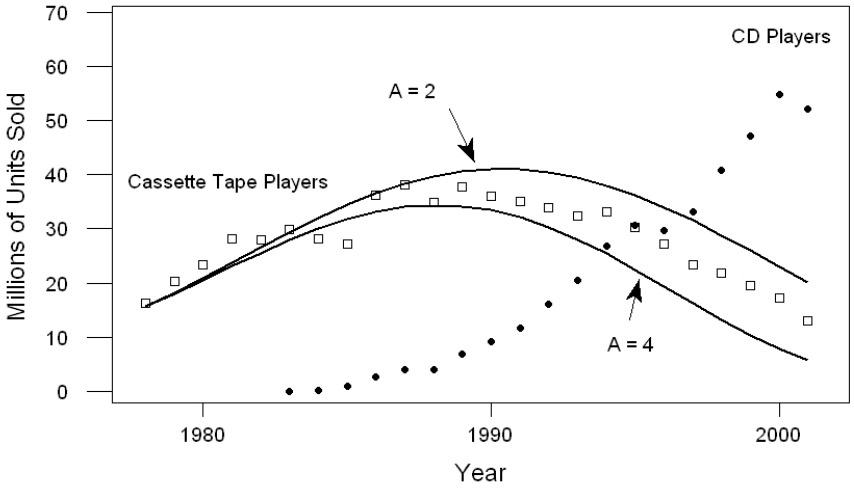



Figure 7- The rapidity of decline increases when A increases.

Leading to a vital question. What is A?

## Tire Cords

Motorists are generally unaware that the quality of their ride is highly dependent on reinforcements hidden in their vehicle's tires. Tire remnants shed by trucks are a common sight on the interstate highway system. Their carcasses have ribs sticking out. These are tire cords.

When McKinsey's Richard Foster was trying to understand how technologies overtake each other his clients had some very pertinent data. The Goodyear Tire & Rubber Company knew the engineering performance of these cords over four generations, cotton, rayon, nylon and polyester.

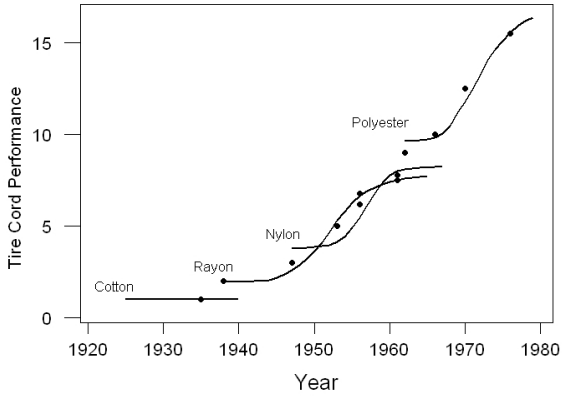



Figure 9 – S-curves capture a rising engineering performance for tire cords.

Richard Foster's answer was an Attacker's Advantage within engineering performance, an insight that provides an important clue for connecting economic life with pond life, Foster (1986).

## The Physics of Lotka-Volterra

Gause's equations originated from A.J.Lotka and V.Volterra who derived them by separate arguments. In particular the physicist Vito Volterra likened individual organisms to molecules governed by the kinetic theory of gases. This leads to a macro analogy in which the paramecia work together and exert a combined overall pressure on each other.

In a market this competitive pressure is the totality of competing entities, which is Sum: Q (in words or ΣQ in symbols). It is domestic consumption expressed in physical quantity instead of value and it is also the demand supplied to the market from production, inventory and imports. In other words it is supplied-demand.

## Leading to a New Equation

When other factors are fixed the price of a commodity, such as tire cord, should increase in direct proportion to its performance, p, so we can write

$$P \propto p$$

A second factor is competitive pressure. If performance remains fixed then price should decrease as competitive pressure increases, most simply expressed by,

$$P \propto 1 \Big/ \sum Q$$

Combining proportionalities we obtain,

$$P \propto p \Big/ \sum Q$$

or

$$p \propto P \sum Q$$

To make this proportionality into an equality requires at least a constant multiplier, perhaps A.

$$p = A\,P \sum Q$$

But it seems more likely, as Foster suggests, that p of the attacker provides enough force by itself, and this can be brought to bear in this equation by setting A equal to one by definition, so that

$$p = P\ \mathrm{Sum} : Q$$

where P is the real price paid and Q is the competitive pressure generated by the physical quantity that acts within the market. The shorthand for this equation is pPQ.

p is neither 'quality' nor 'utility' nor an 'hedonic' array of attributes. It deviates from these, and also from functional performance, by its integration of personal, psychological and sociological perceptions that influence the purchaser to buy at the moment of purchase[5].

In concordance with its simple algebra the pPQ equation generates a correspondingly simple geometry, which is shown in figure 10b. The top right-hand corner of the shaded rectangle - area p - traces each of a nested set of hyperbolae, one for each value of p, as needed.

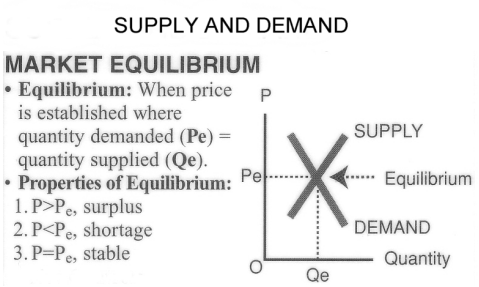



Figure 10a – The Classic Cournot Cross.

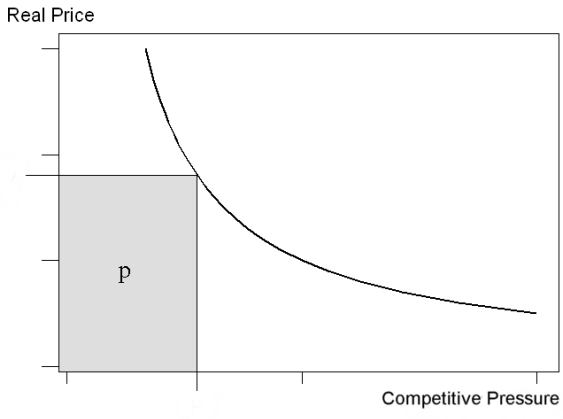



Figure 10b – The pPQ curve.

Figure 10a is a modern version of Augustin Cournot's original classic, Cournot (1836) shown in his Fig 6, and is taken from a recent student quick reference guide. Notice that the supply part of the cross is missing from the pPQ curve in Figure 10b because supply is combined with demand in competitive pressure, which is supplied-demand, on the horizontal axis.

This is not a trivial matter. The 'Market Equilibrium' in Figure 10a simply doesn't exist in any innovative economy. By its nature innovation perpetually disallows equilibrium.

In reality it is inventory that quickly absorbs or releases any disparity between supply and demand. If it does not, and a surfeit or scarcity in either supply or demand develops, purchasers will change their perception of that particular purchase and its perceived performance will move across to another hyperbola in the nest; and price will travel with it.

The absorption and release of inventory will bring an economy as close to price equilibrium as innovation will allow. Essentially there is no long run and in the short-run competitive pressure will determine the running.

The Holiday Celebration illuminates these statements.

[5] This is exhaustively established in Innovation in Economics: Missing Pieces.

## The Economics of the Holiday Celebration

When the demand for turkeys is high, as it is at Thanksgiving, their price is always low. This phenomenon is seen as contrary to the Cournot Cross price mechanism but is a natural consequence of pPQ[6].

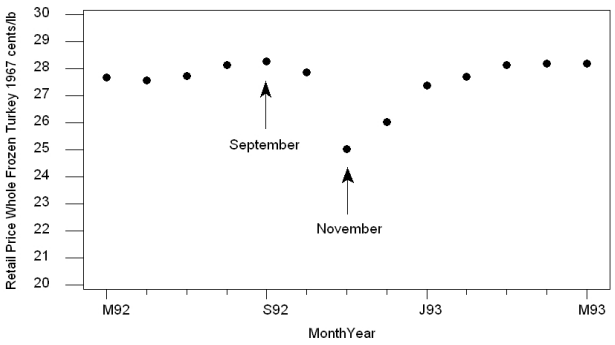



Figure 11 – The Monthly Price Trend in Whole Frozen Turkeys, May 1992 to May 1993.

No food is more imbued with American symbolism than the Thanksgiving Turkey.



Figure 12 – The Principal Depiction of the Thanksgiving Turkey in its Traditional Context.

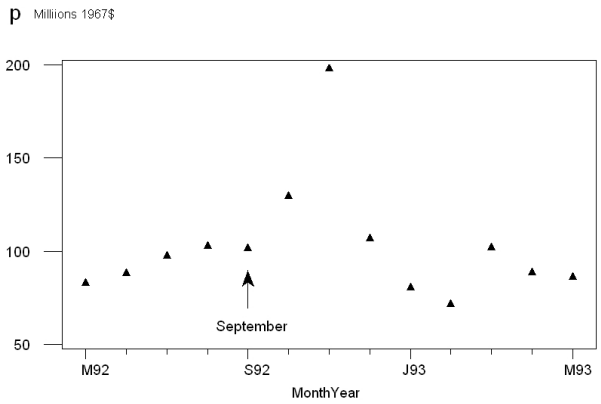



Figure 13 – The pPQ Performance of the Frozen Whole Turkey soars each November.

[6] The pPQ also dispels notions of counter-cyclical pricing.

The pPQ is bringing sociological psychological and personal intangibles into Economics[7].

Expressed graphically, between September and November the rectangular gray area representing the perceived performance of a whole frozen turkey enlarges while the rectangle's height – representing its price – contracts. This is the pPQ price mechanism at work, figure 14.

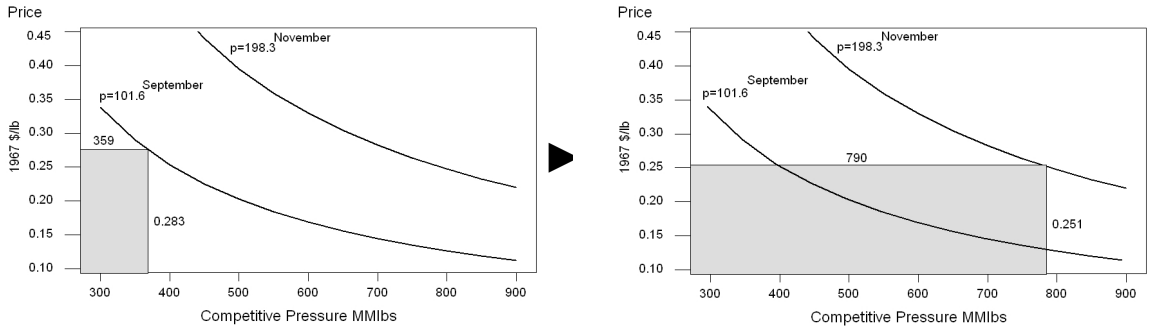



Figure 14 – The pPQ price mechanism in action on the Thanksgiving Turkey.

*Principia* **Number One is the 'Principle of Competitive Pressure'.**

Expressed by Q in the pPQ equation

$$p = P \text{ Sum} : Q$$

or more mathematically,

$$p_i = P_i \sum_{i=1}^{N} Q_i$$

for the ith entity in a market having a total of N entities.

Because competitive pressure equalizes throughout the market there is a second principle.

*Principia* **Number Two is the 'Principle of Co-Existence'.**

For every entity the ratio of performance to price is equal to the competitive pressure.

$$\frac{p_i}{P_i} = \frac{p_{i+1}}{P_{i+1}} \cdots = \frac{p_N}{P_N} = \sum_{i=1}^{N} Q_i$$

For inclusion in a market it's the ratio of performance to price that matters. Inferior products can succeed against superior ones if their price is lower. Purchasers will accept a necessary degree of aggravation for less outlay.

[7] There is no list of product attributes, no list of ingredients or nutritional values that can explain figure 13. Only the faces around Rockwell's table, or any table, can adequately do that. Such perceptions are extreme here but are also seen for otherwise ordinary products everyday. It is the role of advertising to create them.

## The Role of the Firm

The firm has no counterpart in the Gause experiments and no counterpart in Farrell's extensions. The reason is simple. The products firms produce from the technology they own have their own existences, just as paramecia do. The role of the firm is their stewardship and it doesn't matter which firm. The best evidence for this is well known. Trademarks – and the like - stay with their products through mergers and acquisitions, often for decades. A firm's products are more fundamental than their firm.

And it doesn't matter whether the operating market structure is oligopoly or monopoly competitive pressure is relentlessly experienced, as all pressure is[8]. It is neither perfect nor imperfect. Such distinctions do not fit the concept of pressure.

## Stewardship

If the products of a firm are firmly in charge of its destiny it is important to understand exactly what stewardship means. Fortunately there is a very simple definition. The firm must continuously increase the performance of its products and reduce their unit cost of delivery.

The ratio p/c defines this and becomes innovation, rigorously enumerated.

Stewardship means innovating.

The malted beverage market provides an excellent illustration of this as it segues to attract a new generation of beer drinkers from the 1960s to the 1980s.

Heileman and Falstaff were founded by, and had originally served beer to, German immigrants in Wisconsin and Missouri. By 1960 both had already enjoyed a long brewing history. The perceived market performance of their beers for the new period is shown in figure 15.

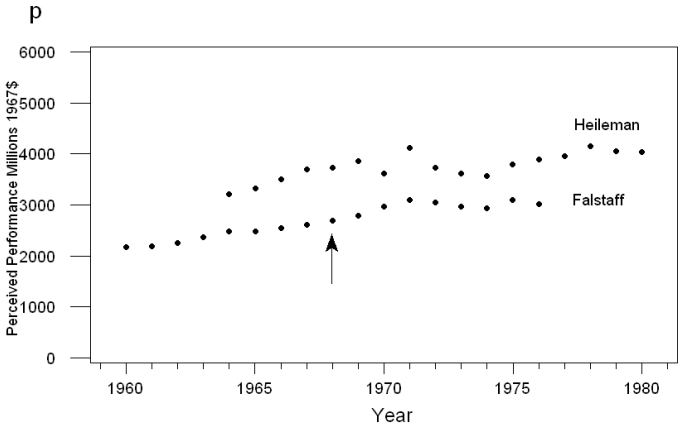



Figure 15 – The Performance of Two Beers as perceived by their drinkers, using the pPQ equation.

Both performances are rising with Heileman's significantly above Falstaff's. From the 'Principle of Co-existence' the performance to price ratio must be maintained and Falstaff's beers will have

[8] Monopolies also experience competitive pressure from their own products that they attempt to control. What is relentless for them is the 'Principle of Co-existence', which encourages alternatives and is backed by legislation.

a lower price, as they do. In 1968 (arrowed) Heileman's price is 33.5 $/barrel while Falstaff's is 24.2. That margin is approximately maintained from 1964 to 1976.

Occupying the bottom line of the innovation metric is the cost per barrel. It is falling for one brewer but rising for the other, figures 16 and 17. The cost per barrel for Falstaff peaks in 1972.

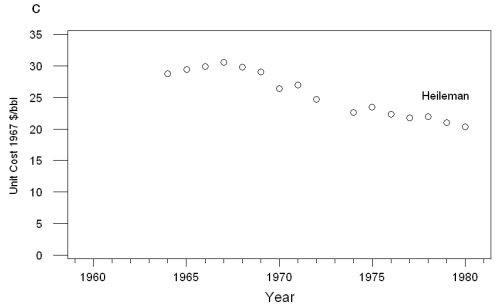



Figure 16 – Cost per barrel falls for Heileman.

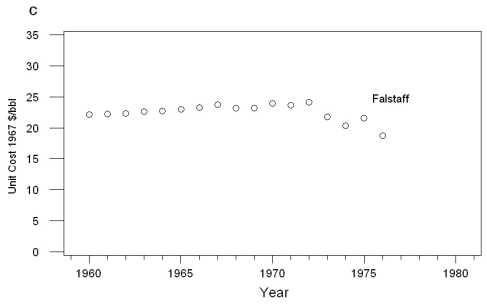



Figure 17 – Cost per barrel rises for Falstaff.

The innovation metric is found by dividing the perceived performance by the unit cost of delivering it. This is shown for both brewers in figure 18. Also shown in figure 18 is the innovation boundary IB, above which the innovation metric must stay.

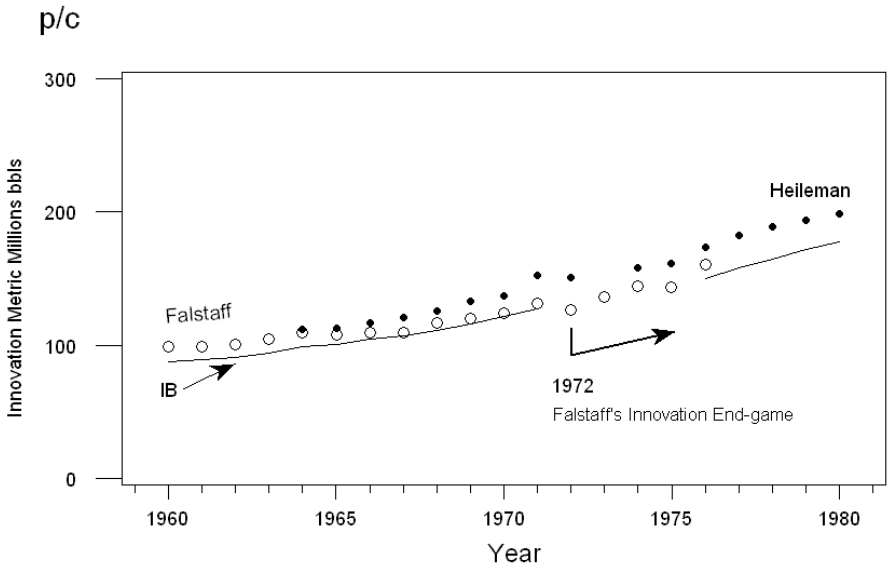



Figure 18 – Heileman's metric stays above the Innovation Boundary. Falstaff falls through it.

Heileman is clearly the more innovative brewer. Its innovation metric is everywhere above Falstaff's. Falstaff falls below the innovation boundary in 1972 and the Falstaff brand starts to disappear.

Annual Reports to shareholders convey this in terms of price and cost and not in terms of innovation. R&D is seen as white coats and clever instruments that have no innovation language to bring to the boardroom.

In innovation language Heileman were aggressively reducing c while Falstaff were struggling to increase p.

Heileman

1969 - New wells, boilers, bottling, and canning lines, electrical power installations, filters etc. have been and will be installed before long. All are of the most modern and efficient available. Our storage tanks for beer will look like a gigantic Six Pack.




Figure 19 – Storage tanks look like their beer can.

Falstaff

1971 - We announced we had changed our product to meet the changing tastes of the beer customer. We invited trial of our lighter, more delicious beer.




Figure 20 – Falstaff's old tankard remains.

Falstaff failed in the stewardship of its beer for want of clear messaging to younger drinkers, figure 20.

*Principia* **Number Three is the 'Principle of non-Existence'.**

The 'Principle of non-Existence' turns 'creative destruction' into algebra.

Competitive pressure will force an entity to leave a market when its,

$$\frac{p}{c} \langle IB$$

where

$$IB = \sum_{i=1}^{N} Q_i$$

**The Innovation Profession**

Today a whole set of professional activity is dedicated to raising (p/c). The Product Development and Management Association is its vibrant and central repository. It holds tacit knowledge either unknown to, or unappreciated by, economists; the knowledge behind this book.




Everything the PDMA promotes, and everything the Innovation Profession does, aims to reverse the algebra of the third principle viz.

$$\frac{p}{c} \rangle\ IB$$

## The Idea of ideas

The Idea of ideas – a potentially infinite resource – was noted as early as 1945 in the title of a government report written by Vannevar Bush, Bush (1945). In proclaiming 'Science The Endless Frontier' he may have instinctively realized scientific truth is a truth 'not yet untrue' before Karl Popper articulated the same, Popper (1956). This 'not yet untrue' mantra propels the scientific method under its own scrutiny to create the most profound source of knowledge human endeavor has ever conceived. When further translated, as shown in figure 21, it leads to economic prosperity.

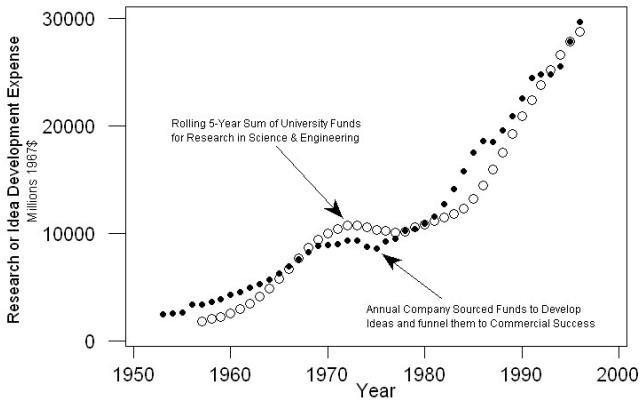



Figure 21 – It takes 5 years of academic effort to deliver a STEM-capable idea[8]

Ideas arising from University Science and Engineering have two advantages. They are advanced and they are STEM-capable, by definition. That significantly raises their chances of contributing to economic growth from a new market or from an existing one.

All ideas must also survive a path of extreme attrition that is quantified in stepped ratios assessed by Stevens & Burley (1997). Whether, or where, Artificial Intelligence may step-in remains to be seen; the steps, however, will remain, though perhaps the ratios between them may improve.

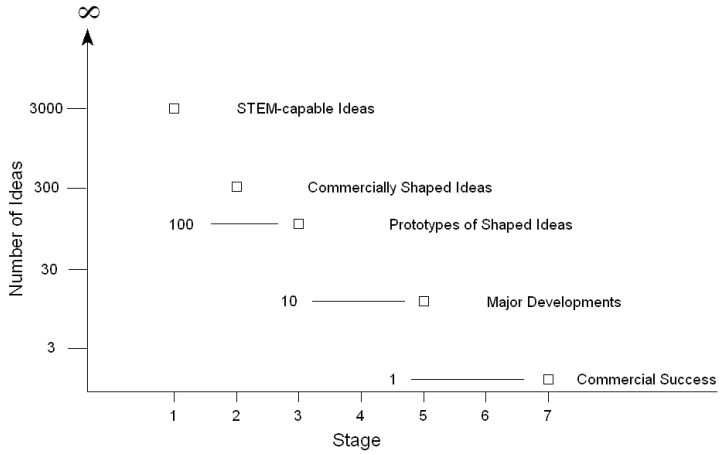



Figure 22 – STEM-capable ideas are eliminated by factors of ten on the way to one Commercial Success.

[8] From 50 to 70% of this spending is funded by taxpayers who benefit directly and ultimately when the p (=PQ) of new products available to, and purchased by, them lifts their standard of living. Taxpayers also contribute to spending on government research that's otherwise uninteresting to business and which, when later funneled back into commerce, can keep a nation ahead, Mazzucato (2013).

To wrest a Commercial Success from a STEM-capable idea is very expensive proposition, on average about 4 to 5 times more expensive than its STEM-capable starting point. Figure 23 shows idea development expense iDe[9] pushing concepts through a discriminatory funnel that leads to commercial success for one of them when its p/c rises above a market's innovation boundary.

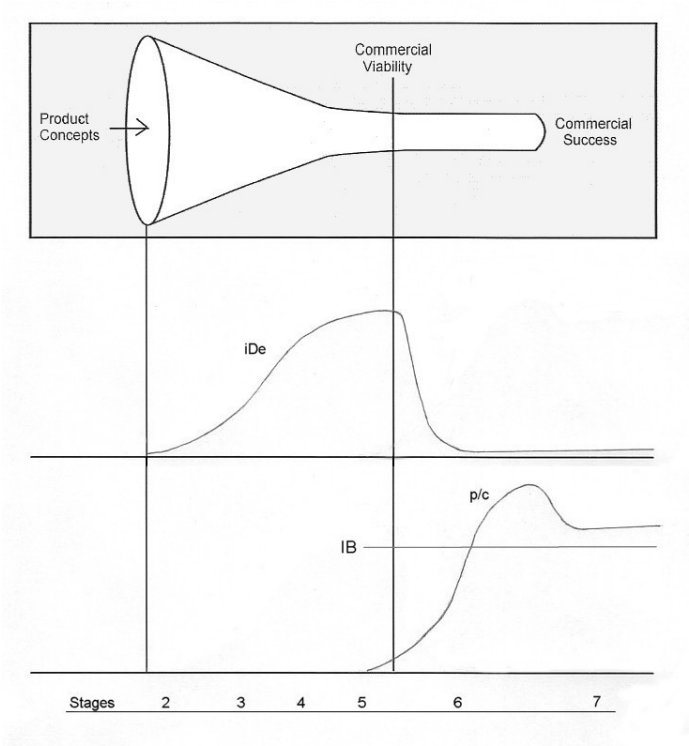



Figure 23 – iDe enables the embodiment of an idea to perform above its market's innovation boundary.

In the mid 1970s the American Can Company became aware that a plastics technology it was already using to make a single-layer juice can, and another one it was using to make a double layer plastic oil can, might be developed to produce a third one capable of rivaling its core business.

The company feared that if they thought this, then one of the very large and very profitable plastic producers of the day might have the same idea. Faced with this threat of creative destruction to its steel can American decided - if anyone was going to develop a plastic one – American would.

The project followed figure 23. By 1979 Stage 3 had been reached. A series of small projects, mainly involving machine development, were meeting their milestones. To show the size of the challenges subsequently met; thirty utility patents protecting American's technology were issued while parallel steel food-can development was boosted by anticipation of its continuing success[10].

At an iDe peak of 3 million dollars in 1992 the plastic can prototype was ready for transfer to a purpose adapted manufacturing facility where p/c began to rise until it exceeded the innovation boundary for the then-novel microwaveable convenience market. More than 8 billion of these plastic containers were profitably made and sold and its ∑ iDe was recovered two-fold. The feared competitor didn't emerge and the steel food-can survives today.

[9] iDe is a sub-set of R&D containing Applied Research and Development funds that are company sourced.
[10] Including a patent attorney hired to stimulate and catalog inventions. This disaffirms the Aghion & Hewitt model, in which R&D in a first period is negatively affected by anticipation of rent loss in a second period.

*Principia* **Number Four is the 'Principle of New Existence'.**

In this Principle any individual entity's $\frac{p}{c}(t)$ must start from zero at a particular t and then rise above $IB$ for its market lifetime, where

$$\frac{p}{c}(t) = \Gamma\left(iDe(t-\partial)\right)$$

in which $\Gamma$ is a deliberately unspecified shape for the growth curve of p/c, which varies by entity. The term $(t-\partial)$ in $iDe(t-\partial)$ describes a latency period δ before the effect of iDe becomes apparent in p/c, as seen for American in figure 23.

## Aggregating Innovation from all Durable Goods Markets[11]

In 1992 the economy had 459 Manufacturing Industries at the 4-digit SIC level, within which there were 1462 Product Classes at the 5-digit SIC level. Each Product Class had many sub-classes at the 7-digit SIC level. Competitive pressure requires the economy to be divided by market. In each market several 7-digit entities usually compete.

This division by market was achieved using surrogates scaled to represent the many by the few[12]. For Durable Goods each of eight such markets had a known innovation metric. Total Durable Goods innovation was found by aggregating them, figure 24 (upper data) shown with iDe (lower data).

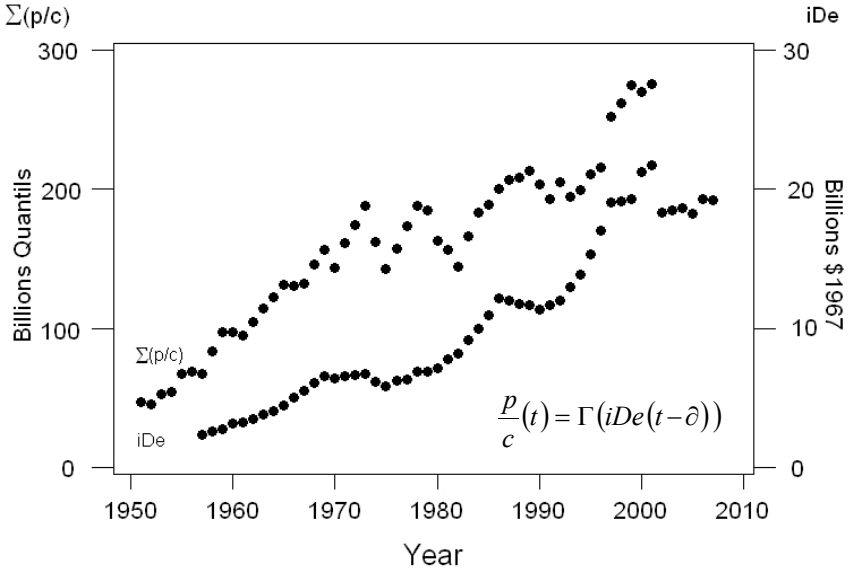



Figure 24 – The Fourth Principle's Equation for a single entity. The growth of aggregate data.

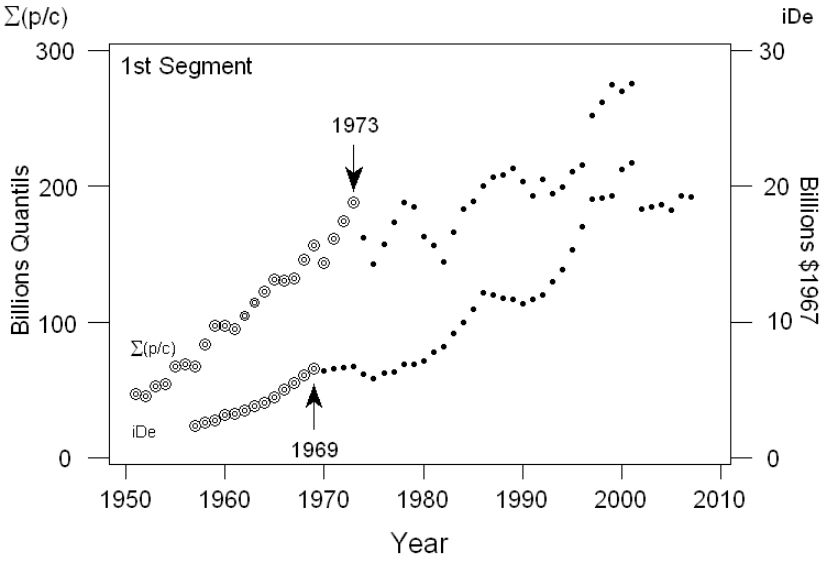
[11] Durable Goods are chosen because they equip us to do, or have done by someone else, whatever we want to do, or have done. Non-Durable Goods and Services are treated in Innovation in Economics: Missing Pieces where the Service Sector – including the digital economy – still suffers from the absence of pertinent data due to a massive 'data hole', Federal Register, 72, No 71, Friday April 13th, Notices, 18627 – 18628.

[12] Full details of this novel methodology are in Appendix A of Innovation in Economics: Missing Pieces.

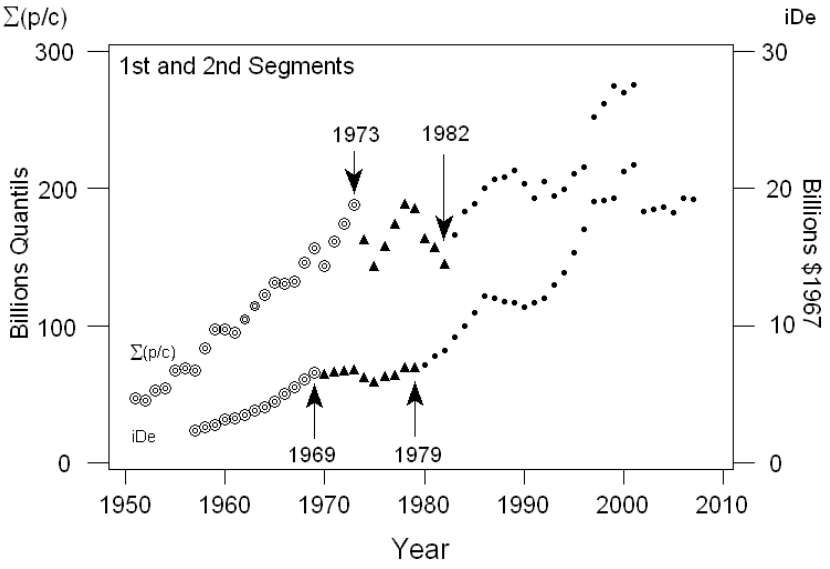
The aggregate growth in figure 24 exhibits two very distinct sequences of sudden growth rate changes as each of p/c and iDe progress upwards. Their hinge points are markers that create four segments. Importantly these hinge points do not occur in any same year.

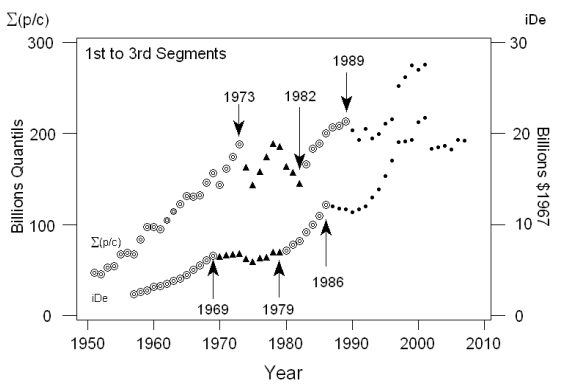
1st Segment - The 1950s and 1960s were decades when life was made easier by affordable appliances. The advent of television symbolized this more than any other, not just in home entertainment but also because of the popular awe it inspired. The pPQ treatment of television sets shows two peaks, one each for B&W and color, similar to the one in figure 13 (see[5] page 8).

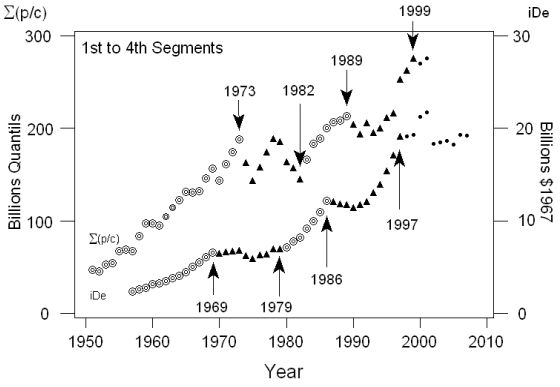
All idea development in this period was influenced by the space race. When Apollo 11 landed men on the moon and returned them safely to earth, iDe leveled off.




1st and 2nd Segments - The perceived performance of terrestrial appliances – boosted by space ones seen on TV – soared until 1973 and then collapsed and bounced. It didn't recover from the oil crisis, and its aftermaths, until 1983.






This sequence of four segments has a shrinking latent period δ from iDe to Σp/c.

| | iDe | **Σ(p/c)** | Latent Period δ |
|---|---|---|---|
| 1st Segment | 1969 | 1973 | 4 |
| 2nd Segment | 1979 | 1982 | 3 |
| 3rd Segment | 1986 | 1989 | 3 |
| 4th Segment | 1997 | 1999 | 2 |

Clear linkages, like these between iDe and p/c, open the innovative path to GDP.

*Principia* **Number Five is the 'Principle of Origination'.**

Idea Development Expense originates GDP by opening innovation's numerical pathway from ideas → to their embodiment → to GDP.

## Gross Domestic Product

Gross Domestic Product is the total output of goods and services produced by labor and property located in the United States, valued at market prices.

Since the pPQ acts in markets, contains market prices, and uses output to create competitive pressure, there is an algebraic pathway from innovation to GDP as follows.

The contribution to GDP from N markets in each sector of the economy will be,

$$GDP = \sum_{i=1}^{N} P_S^i Q_S^i$$

where for the ith market,

$$P_S^i Q_S^i = P_U^i Q_U^i + P_E^i Q_E^i$$

where S signifies shipments from US manufacturers, U signifies shipments from US manufacturers into US markets, E signifies export shipments from US manufacturers, and I will signify imports,

$$GDP = \sum_{i=1}^{N} P_U^i Q_U^i + \sum_{i=1}^{N} P_E^i Q_E^i$$

or

$$GDP = \sum_{i=1}^{N} P_U^i Q_U^i + V_E$$

Where $V_E$ is the totality of exports from N markets and where the performance of these products will be determined in the economy of destination.

For the US economy and from the pPQ equation, where competitive pressure is $\left(Q_U^i + Q_I^i\right)$

$$P_U^i = \frac{p_U^i}{\left(Q_U^i + Q_I^i\right)}$$

so that

$$GDP = \sum_{i=1}^{N} p_U^i \left( \frac{Q_U^i}{\left(Q_U^i + Q_I^i\right)} \right) + V_E$$

This equation brings long sought illumination to the consumption side of the National Income and Product Accounts[13].

[13] Federal Register, 72, No 71, Friday April 13th, Notices, 18627 – 18628. To adjust NIPA's consumption account to GDP, export value is added and import value is subtracted. An innovation account adds export value but does not subtract import value because imports $Q_I$ have a more complex downward adjustment; and there is no separate upward adjustment from iDe to GDP because iDe has already **originated** GDP.

In the absence of foreign trade the situation becomes very clear indeed.

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

> *Principia* **Number Six is the 'Principle of Conveyance'.**
>
> The numerator of innovation conveys the embodiments of ideas to GDP.

## Innovation Productivity

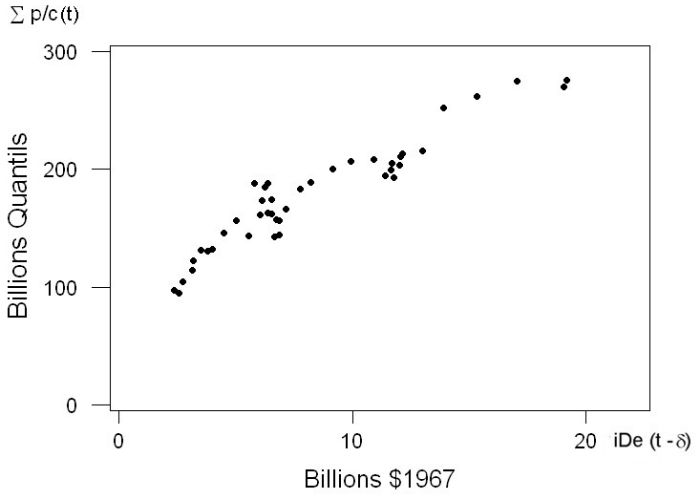



Figure 25 – Innovation Productivity is the tangent from 0,0 to any point.

The Fourth Principle's equation for a single entity is,

$$\frac{p}{c}(t) = \Gamma\left(iDe(t - \partial)\right)$$

and for aggregated entities the equation becomes,

$$\sum \frac{p}{c}(t) \approx \sqrt{iDe(t - \partial)} \times 60$$

which is the simplest fit to the data presented in figure 25.

Its parabolic form – specifically its square root - implies that Vannevar Bush's 'Endless Frontier' is indeed endless from a 20th Century perspective. However, because innovation productivity is decreasing, that will be tempered by whatever iDe spending can be afforded. The Idea of ideas will face a practical constraint.

The Principles of *Principia* are

1. The Principle of Competitive Pressure.
2. The Principle of Co-Existence.
3. The Principle of Non-Existence.
4. The Principle of New Existence.
5. The Principle of Origination.
6. The Principle of Conveyance.

Ralph A. Gomory - from IBM - instituted Industry Studies at the Sloan Foundation. He created an observational science and invented a device for penetrating its economic details, Gomory (2008).

Images from a microscope begin this book. An image from a Macroscope bookends it, figure 26.

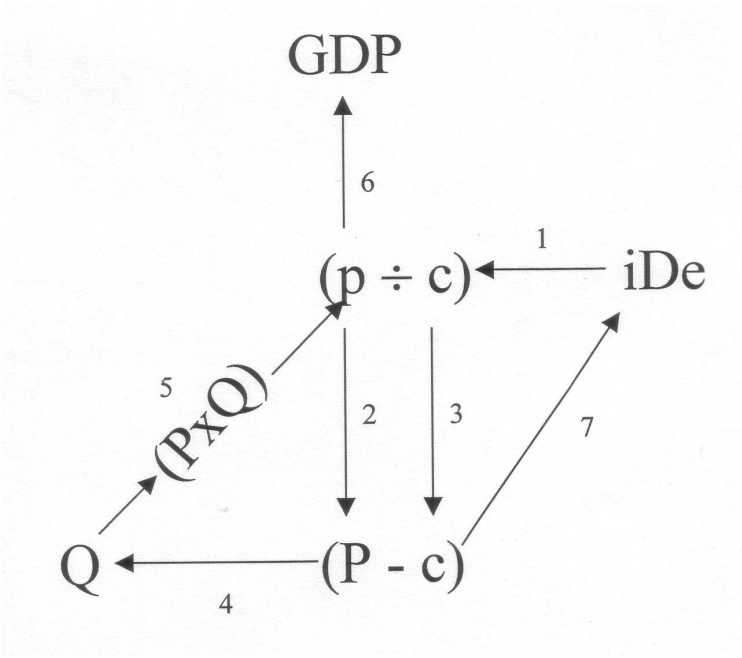



Figure 26 – The Innovation Parallelogram.

This Macroscope sees the detailed consequences of the unseen *Principia* in 1. to 7.

1. spending on iDe raises an entity's innovation metric (**p/c**); by
2. increasing the numerator p through product development, for which a higher price can be asked,
3. and/or by reducing the unit cost denominator c through technology development.
4. profit (P-c) is invested in more production to reach a higher Q (more entities),
5. pPQ multiplies Q by P to give p to a new entity,
6. conveyed to GDP,
7. profit (P-c) is spent on iDe to complete the parallelogram.

Capital invests in units of Q while Labor is divided between iDe and c.

## Important Miscellaneous Considerations

## 1. The Sears Catalog 1967 Base Year



To make choosing the right tire easier, Sears grades tires by the type of driving they handle best

***This is the tire for average driving***

If one or more of these descriptions fits you, you do average driving . . and this tire's the kind you need

**YOU DRIVE BETWEEN 6,000 AND 12,000 MILES PER YEAR**—You may not set mileage records, but you do need long wear for your on-the-go driving. This tire gives it. The Guardsman outwears our Tire for Moderate Driving by at least 40%—severe wear tests prove it.

**20% to 50% OF YOUR DRIVING IS ON HIGHWAYS OR EXPRESSWAYS**—This tire's built with an extra-strong 4-ply body . . stronger than with our Tire for Moderate Driving. And added strength means added wear . . longer wear than you'll find on most new-car tires. Contour safety shoulders help smooth out ruts and lane-expansion joints . . make handling easier.

**MUCH OF YOUR HIGHWAY DRIVING IS WITH A HEAVY LOAD**—A heavy load is equal to 4 or more passengers—the kind of load you might have on your vacation or week-end family driving. This tire gives you more load-carrying strength and safety than our Tire for Moderate Driving . . and that means more protection against damage from the heat build-up heavy-load driving causes.

**The ALLSTATE Guardsman**

Guaranteed to wear 30 months . . see page 602

The Guardsman with 4-ply nylon cord body

6.50-13 Tubeless Blackwall **$13.99** plus $1.83 Manufacturer's Excise Tax

6.50-13 Tubeless Whitewall **$16.99** plus $1.83 Manufacturer's Excise Tax

You can get a set of 4 for only $7 to $10 monthly on Sears Easy Terms

...tur best-selling tire. Wears extra long because the tread contains more Dynatrel rubber than our Hi-Way Special. Great for rainy-day driving . . traction slots sponge up water. And you get full braking power because spacer bars keep tread ribs open.

4-ply Nylon Cord Tires. Cash Prices
Prices Include Manufacturer's Excise Tax

| New Size* | Old Size* | Catalog Number | Shpg. wt. | Each | Catalog Number | Shpg. wt. | Each |
|---|---|---|---|---|---|---|---|
| Tubeless Blackwalls | | | | | Tubeless Narrow Whitewalls | | |
| ..... | 6.50-13 | 95 B 31213C | 17 lbs. | $15.82 | 95 B 81213C | 18 lbs. | $18.82 |
| ..... | 7.00-13 | 95 B 31243C | 19 lbs. | 18.95 | 95 B 81243C | 20 lbs. | 21.95 |
| 6.45-146.00-14 | | 95 B 31103C | 17 lbs. | 17.95 | 95 B 81103C | 18 lbs. | 20.95 |
| 6.95-146.50-14 | | 95 B 31133C | 19 lbs. | 18.45 | 95 B 81133C | 19 lbs. | 21.45 |
| 7.35-147.00-14 | | 95 B 31113K | 21 lbs. | 19.95 | 95 B 81113K | 21 lbs. | 22.95 |
| 7.75-147.50-14 | | 95 B 31163K | 22 lbs. | 21.45 | 95 B 81163K | 23 lbs. | 24.45 |
| 8.25-148.00-14 | | 95 B 31143K | 24 lbs. | 23.95 | 95 B 81143K | 25 lbs. | 26.95 |
| 8.85-148.50-14 | | 95 B 31123K | 26 lbs. | 26.45 | 95 B 81123K | 26 lbs. | 29.45 |
| 8.85-149.00-14 | | ..... | ..... | ..... | 95 B 81193K | 28 lbs. | 31.95 |
| ..... | 5.60-15 | 95 B 31083C | 17 lbs. | 17.45 | 95 B 81083C | 18 lbs. | 20.45 |
| 6.85-156.00-15 | | 95 B 31033C | 18 lbs. | 18.95 | 95 B 81033C | 19 lbs. | 21.95 |
| 7.35-156.50-15 | | 95 B 31013C | 20 lbs. | 19.95 | 95 B 81013K | 21 lbs. | 22.95 |
| 7.75-156.70-15 | | 95 B 31063K | 22 lbs. | 21.45 | 95 B 81063K | 23 lbs. | 24.45 |
| 8.15-157.10-15 | | 95 B 31043K | 23 lbs. | 23.95 | 95 B 81043K | 24 lbs. | 26.95 |
| 8.45-157.60-15 | | 95 B 31023K | 25 lbs. | 26.45 | 95 B 81023K | 26 lbs. | 29.45 |
| 8.85-158.00-15 | | ..... | ..... | ..... | 95 B 81093K | 27 lbs. | 31.95 |

NOTE: Replace 6.40-13 with 6.50-13; 5.90-15 with 6.00-15; 6.40-15 with 6.50-15, for Mercedes Benz we recommend 6.50-15.

*Two size markings show pre-'65 as well as present industry size markings.

95 B 25—**Tubeless Tire Valve.** Shipping weight 3 ounces. ..... Each 50c

The Guardsman with 4-ply rayon cord body

6.50-13 Tubeless Blackwall **$12.49** plus $1.83 Manufacturer's Excise Tax

6.50-13 Tubeless Whitewall **$15.49** plus $1.83 Manufacturer's Excise Tax

$76.95 cash
$5 monthly

7 $64.95 cash
$5 monthly

8

**7 Cartridge-type, battery-operated Tape Recorder.** Just drop in *reusable* cartridge and press buttons . . records, plays 1 hr. Big monaural sound from 2½-in. speaker. Private earphone. Slips easily into briefcase. Weighs a mere 4 lbs. . . just 2¼x5x9 in. Plastic case. Grey color. With 5 "C" batteries. Japan.

**Recorder and reusable Cartridge.**
57 B 7241—Shpg. wt. 5 lbs. ..... $64.95

**Extra Reusable Tape Cartridge.**
57 B 9955—Shpg. wt. 8 oz. ..... $2.75

**AC Adapter.** Lets you run recorder on house electricity to save batteries.
57 B 9978—Shipping wt. 2 lbs. ..... $7.75

**8 Monaural Recorder with 2 speeds, 5-inch reel** (can use 7-in. reels) and compact size—just 6 in. high, 10 in. deep, 13 in. wide. Makes big clear monaural recordings at 7½ or 3¾ in. speeds. Runs on regular house electricity. Single-lever control, meter to show correct volume settings.
Big 5-inch speaker. Plastic case. From Japan.
57 B 7230C—Shpg. wt. 20 lbs. ..... $76.95

8 9 10 11 12 13

**Single-play Phonographs with built-in speakers**

**8 Two side-mounted speakers.** Fully transistorized . . plays instantly . . no warmup is required. Plays standard or stereo records monaurally. Padded metal turntable. Plastic-coated covering; aqua, white case. About 14 x 10 x 6½ in. high. Shipping weight 12 lbs.
57 B 7254. . . $23.95

**( 9 and 10 )** Play all 4 speeds, standard or stereo records . . monaurally; can't harm stereo records. Metal turntables. Synthetic sapphire needles. Plastic-coated coverings. Four-inch speakers.

**9 Transistorized.** Tone control for finer tone than before. Blue. About 12x10x7 inches.
57 B 7252—Shipping weight 11 pounds. . $18.95

**10 Tube-type.** Red and white. About 12x11x5 in.
57 B 7250—Shipping weight 9 lbs. . . . $14.40

Note. All electrical items on both pages UL listed for 110-120-volt, 60-cycle AC.

***Movable* Speaker**

**11 Our best single-play Phonograph.** Distinctive look of 2 components—professional-like turntable with transistorized amplifier, movable speaker on 3-ft. cord. Big 5¾-in. speaker. Walnut grain plastic-coated covering, black-white trim. About 18x11 x8 in. Wt. 12 lbs.
57 B 7256. . . . $28.50

**Play up to 8 records automatically**

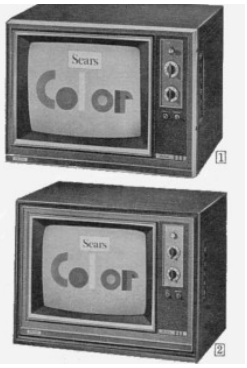
**( 12 and 13 )** Even shuts off automatically after the last record. Both play standard or stereo records monaurally. Both have big-sounding 5¾-in. speaker, room-size monaural sound. Plastic-coated coverings.

**12 Luggage-look case;** blue-black. About 19x15x8 in.
57 B 7260L—Shipping wt. 23 lbs. Cash $37.95

**13 "Pedestal" cabinet, lift-out changer.** Muted green, orange, black. About 16x13x10 inches.
57 B 7262L—Shipping wt. 20 lbs. . . . Cash $47.95

SPIEGEL Sears 851

COLOR TV with 18-inch diagonal measure picture and built-in Color Purifier so you can move either set from room to room . . colors *stay* vivid






**( 1 and 2 )** Four screw-on legs included so you can convert set from table model to trim consolette. And you get: brightness of 21,000 volts for true-to-life colors, tinted glass, automatic picture steadier for extra-stable images. Big 5-inch speaker. From Japan. See screen size note, bottom of page.

Metal cabinet **$329.95** cash **$13.50** monthly

**1** Walnut finished metal cabinet 26 in. wide, 18⅝ in. high, 19½ in. deep. Japan. Wt. 112 lbs.
57 B 7165N. . . . $329.95

Veneer cabinet **$349.95** cash **$14** monthly

**2** Walnut-grained wood cabinet 26¾ in. wide, 19⅝ in. high, 19⅝ in. deep. Japan. Wt. 116 lbs.
57 B 7166N. . . . $349.95

1967 prices used in this volume buy the performance these items offered in that year's Sears Catalog.

## 2. Total Factor Productivity

Robert J. Gordon illustrates his economic history 'The Rise and Fall of American Growth', Gordon (2016) with many metrics, including TFP, about which he says *'This measure is the best proxy available for the underlying effect of innovation and technological change on economic growth'*.

He is referring to the standard treatment that relies on a production function in which GDP is output and Capital K and Labor L are input factors raised to powers and multiplied together.

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

But data for GDP, K and L do not fit this equation. The equation needed is

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

r is a factor of production in the second equation only when $\alpha + \beta + \gamma = 1$. Gordon uses $\alpha = .3$ and $\beta = .7$ from the first equation and $\gamma = 1$ so $\alpha + \beta + \gamma = 2$ in the second equation and TFP = r is worked out using non-factor math.

The determination of TFP does not match the innovation growth rate, figure 27[14].

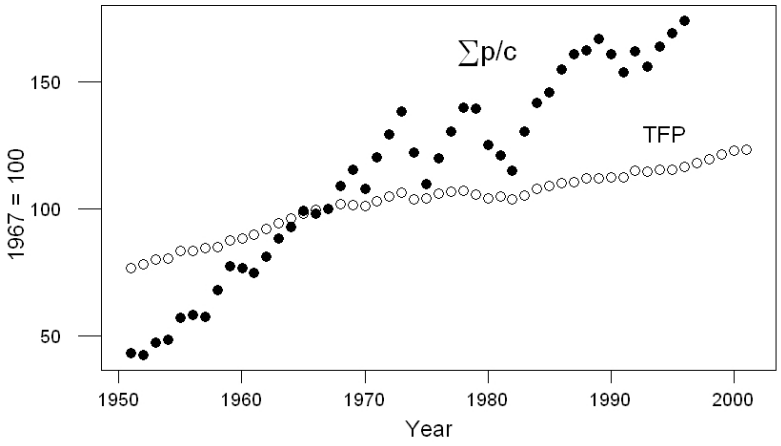



Figure 27 – The TFP proxy (for the whole economy) and Σ(p/c) (for manufactured goods).

It was true in 2016 that TFP is *'the best proxy available for the underlying effect of innovation and technological change on economic growth'*.

Today there is a direct and cardinal measure of innovation all the way to GDP.

[14] Neither does multifactor productivity even with the addition of Energy, Materials and Services, KLEMS. The alternative to Factor Productivity is throughout this volume and on page 23.

## 3. **Attributes in Hedonic Analysis**

There is another economic analysis that uses proxies and that is the hedonic correction of price indexes for 'quality change'. The equation used is

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

$P_t$ is the price of an entity that has n quality attributes $a_{1t}$ to $a_{nt}$. In a given year entity variants will have other prices and other attributes. The multipliers α, β … ω are determined by regression of these prices against their attribute values. Once the equation is established the attributes can be reverted to a base year to find a price differential not due to quality change, which is what is needed.

The problem is that consumers don't purchase $a_1, a_2 \ldots a_n$ they buy on perception that may diverge from what $a_1, a_2 \ldots a_n$ is capable of specifying. The pPQ equation can solve this for consumer goods using $P = CPI / \sum Q$ where the CPI is the CPI-U and where ΣQ is the competitive pressure exerted in the entity's home market.

For Smartphones, Aizcorbe et al. (2019) and for IBM PCs, Nelson, Tanguay & Patterson (1994) constant quality prices diverge according to the methodology used, figure 28.

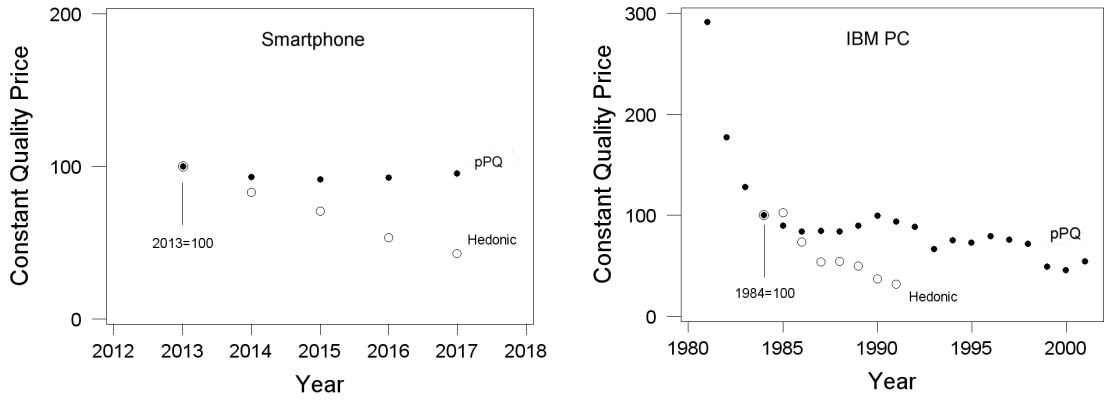



Figure 28 – Quality corrected Smartphone and IBM PC prices.

This behavior is almost predictable from Moore's Law. While computer components advance at an astonishing rate consumers are more interested in the outside of these gadgets than on what is going on inside[15]. The current hedonic method applied from their insides is not appropriate.

Hedonism cannot be captured by specifications. The pPQ methodology is far better suited to adjusting consumer prices than any current hedonic one.

[15] Moore's Law is an empirical rule on the density of transistors doubling every two years. The Smartphone and PC hedonic attributes are their component attributes.

## 4. Stock Market Response.

Figure 29 shows the familiar rise in stock value, before 1965 and especially after 1982, indicated by the Dow Jones Industrial Average, while between those dates it stays relatively flat.

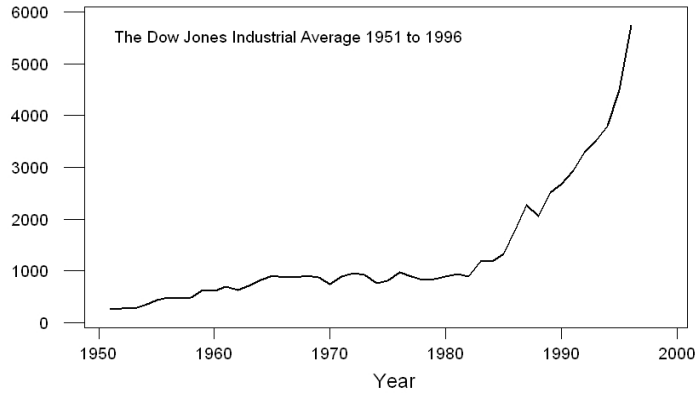



Figure 29 – The Dow Jones Industrial Average (included the American Can Company for 36 of these years).

The three periods really stand out when the DJIA is expressed in constant dollars, figure 30.

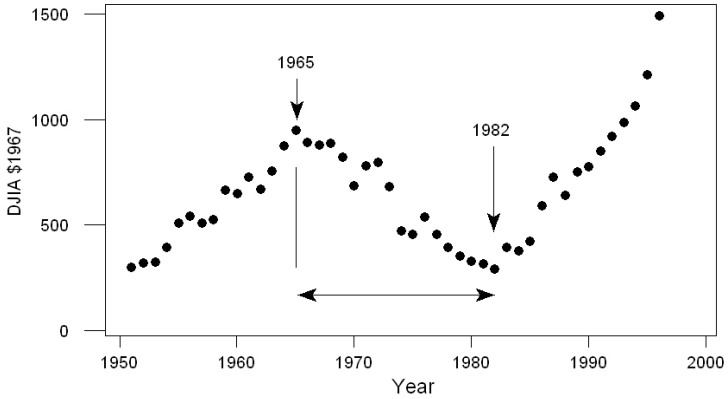



Figure 30 – The Macroeconomic Period known as The Great Inflation lasted from 1965 to 1982.

In 1965 the US Economy entered a period called The Great Inflation, which has been explained in Federal Reserve History as a loss of control over macroeconomic factors, Bryan (2013). It lasted until 1982 when inflation came under that control. This leaves open the possibility of a non-policy explanation for two growth periods – one to 1965 – and one from 1983, figure 31.

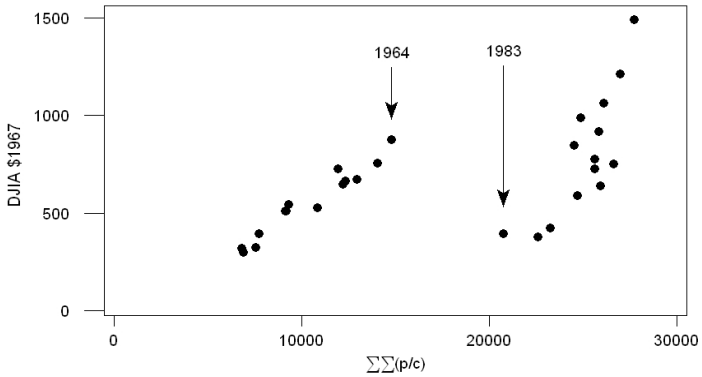



Figure 31 – The DJIA responds to Innovation before and after The Great Inflation.

The stocks of firms stewarding durable and non-durable entities dominated the DJIA. *Principa* enables enumeration of their innovation metric in figure 31. The linear connection between the DJIA and this metric is striking for both periods. But the 1983 to 1996 period shows a higher impact from innovation than is seen between 1951 and 1965; the later period is the age of computers, while the earlier one is the age of appliances.

Far from looking to productivity for the economic effect of computers it seems more likely, from figure 32, that personal experience with the power of personal computing transferred itself to investment in the stock market, an observation that deserves further investigation.

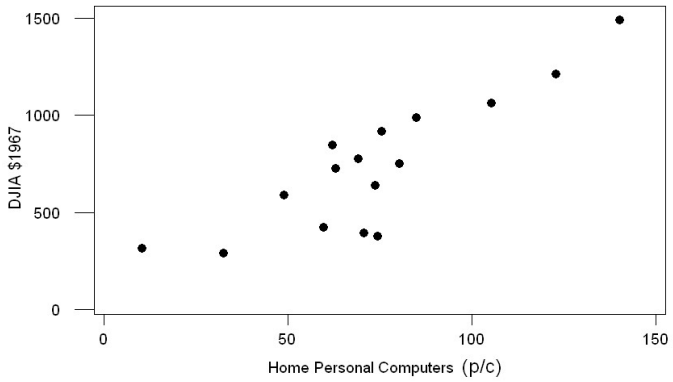



Figure 32 – The DJIA responds to Innovation in Home-Use Personal Computers (1981-1996).

**References**

Farrell (2018), Innovation in Economics: Missing Pieces, First Edition 90 pages.
Farrell (2025), Innovation in Economics: Missing Pieces, Latest Edition 100 pages.

**Additional References** (not in Innovation in Economics: Missing Pieces)

Aghion & Hewitt (1992), A Model of Growth Through Creative Destruction, Econometrica, 60, No.2., noting *Principia* evidence does not affirm its guiding mechanism, see page 16 reference[10].
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Cournot (1836), Recherches sur les Principes Mathématiques de la Théorie des Richesses, Fig 6 appears on its page 222.
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**Acknowledgements**

To Professor Jim Poterba, President of the National Bureau of Economic Research, who suggested condensing 'Innovation in Economic Pieces: Missing Pieces' into about 30 pages.

To Professor Robert J. Gordon of Northwestern University for sharing the spreadsheet he used to calculate Total Factor Productivity. Our mutual interest in using price data from the Sears Catalog began in the 1990s (some selections are on page 24).

## 5. What Comes Next? Removing Bias from Price Indexes

Because the pPQ provides a method for calculating quality change it follows that bias arising from quality change in price indexes can be eliminated. This has presented a major challenge to conventional economic thinking for decades. The new methodology to achieve it is highly advanced and may become a seventh Principle of *Principia*.

The result is demonstrated in Figure 33 for almost five decades of the Producer Price Index, noting that the same method can be applied to the Consumer Price Index, or to any price index.

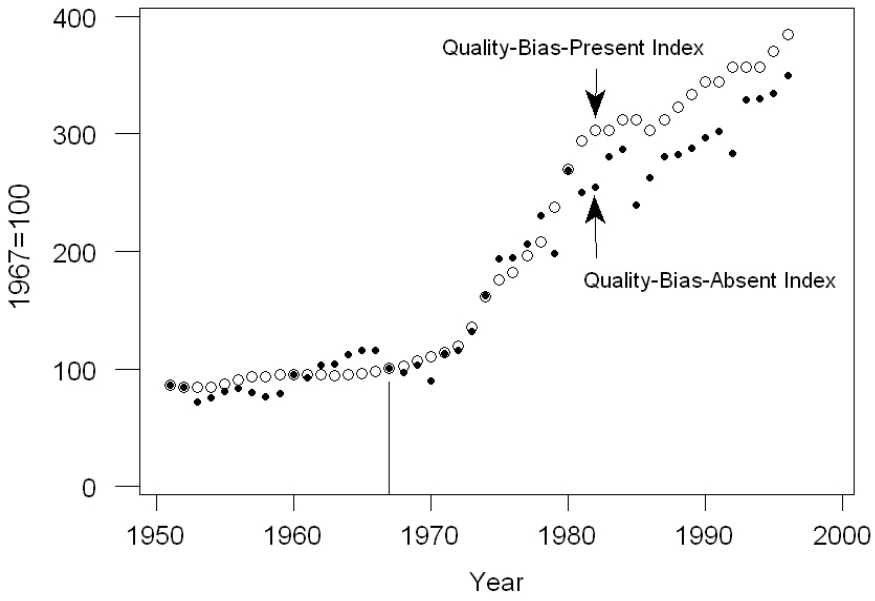



Figure 33 – The Bias-Present (current) PPI index is upwardly biased compared to the Bias-Absent one.

The upward bias in the PPI by this method is ~ 0.6%/year from 1980. The Boskin Commission bias estimate for the CPI was ~ 1% in 1996 downgraded to ~ 0.8% in 2001.

Eliminating this bias has profound consequences for all Economics.

### Further Reference

Lebow & Rudd (2001), Measurement Error in the Consumer Price Index: Where Do We Stand? Board of Governors of the Federal Reserve System.

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