PRODUCT EVOLUTION:
WHAT IT IS AND HOW IT CAN BE MEASURED

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INTRODUCTION

Few would dispute the dramatic changes that have taken place in human existence as a result of the invention and industrial development of new goods and services. Such change is not uniform, but varies greatly among products of different types [Chamberlin, (1953) 1957; Dosi, 1988; Griliches, 1971; Lewis, 1978; Payson, 1991; Steenkamp, 1989]. To understand certain aspects of this process of change, this paper presents an alternative approach to measuring quality enhancement. The unique features of this approach are that:

1. It is evolutionary [Nelson and Winter, 1982], examining product changes over extensive periods.
2. It utilizes broad definitions of product classes, based on the product functions rather than their physical characteristics.
3. It relies on the availability of prices and product descriptions in historical documents.
4. It applies a simple method of price-linking when such a method is justified given the available data.
5. Less rigorous than most other price-linking approaches, its usefulness is constrained to observing broad changes over long time spans, as opposed to one-year comparisons.
6. It may serve as a helpful device for understanding long-run trends in technological progress, but would not, in most cases, be appropriate for generating price indices.

A great deal of progress has already been made in the measurement of quality change through the use of hedonic price estimation, which associates prices with the physical characteristics of goods. Thus far, three products have dominated the hedonic price literature: automobiles, housing, and computers. Official federal estimates of the producer price index for computers and housing currently employ hedonic techniques [Siegel, 1994], while automobile studies accounted for many of the first, and most influential, papers on hedonic methods [Court, 1939; Griliches, 1961; Cagan, 1965; and Triplett, 1969]. Although largely used to analyze a few products, the number and variety of goods and services that have been examined with hedonic methods is remarkable, including, for example, refrigerators [Dhrymes, 1970], food items [Ladd and Suvannunt, 1976] and "the value of quiet" [McMillan et al., 1980].

Hedonic studies of quality change are preferable when physical characteristics of items can be measured across time, allowing for regression analyses of prices against characteristics.[1] Product characteristics, however, are not always easily measured, especially for a product defined by function only. For instance, for most practical purposes a vacuum cleaner is a "quality improvement" or "technological innovation" over a broom and dustpan. This kind of dramatic improvement, which we shall call *product evolution,* is rarely treated in the quality change literature. This paper will demonstrate how product evolution can be studied through the examination of historical documents. The historical document used in this particular case is the *Sears Catalog.*

Product evolution opens a new door for our understanding of evolutionary economic change. Consider, for example, the evolution over the past 50 years of four household products: footwear, vehicles, photographic equipment (from snap cameras to camcorders), and computing devices (from manually powered adding machines to modern-day computers). While all of these products have experienced considerable evolution, vehicles have evolved at a greater rate than footwear, photographic equipment at a greater rate than vehicles, and computing devices at a greater rate than photographic equipment, begging the question of why these rates differ.

Product evolution is often associated with phenomena that are not mentioned in economic literature, but lie within the realm of natural science. To a physicist there should be little mystery as to why computing devices have evolved at a much greater rate than vehicles. Vehicles are heavily constrained by physical laws of energy and inertia. The energy required to transport any cargo (or passenger) will always be at least as great as $\frac{1}{2}mv^2$ where m is mass and v velocity, even ignoring other factors like air resistance, friction, and directional acceleration. Thus, even if the mass of the vehicle itself were somehow made negligible in comparison to the mass of the cargo, the absolute minimum energy requirements associated with the mass of the cargo would remain unchanged. Transportation of a fixed mass can never be less costly than the cost of the minimum amount of energy required. In contrast, computing devices require the processing of information, where information, itself, has *no physical requirements* in terms of mass, except at an atomic level, and no speed restrictions except the speed of light. In the final analysis, the laws of nature best explain why computing capability evolves faster than transportation capability.

To a neuro-psychologist, or a psychologist specializing in human perception, the fact that cameras evolve at a greater rate than footwear should come at no surprise.[2] Although comfort in walking and running plays a definite role in sensory perception and cognitive processing, that role is minuscule in comparison to the role of visual input (and auditory input provided by a camcorder).[3]

Nevertheless, such heuristic arguments about product evolution will never be an adequate substitute for empirical methods of confirmation.[4] The product evolution concept would be much more useful if it could involve objective measurements of the rates of change among different types of goods. In this way, for example, one might demonstrate to even the most skeptical of audiences that cameras really do undergo more product evolution than footwear. Moreover, the concept itself would be more tangible if it could be defined empirically.

AN EMPIRICAL DEFINITION

In developing an empirical understanding of product evolution, goods and services must first be categorized in terms of their functions. Product evolution can then be defined as changes in the composition of these categories. The broader a category, the broader will be the interpretation of product evolution. For example, two broad categories of household goods examined in the present study are (1) window fans and window air conditioners, and (2) cameras, movie cameras, and camcorders. A window air conditioner is interpreted as an evolved window fan, and a camcorder an evolved snapshot camera.

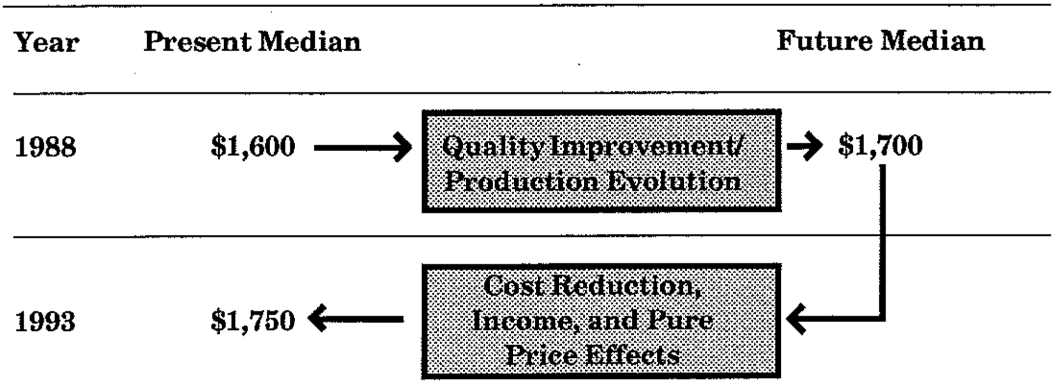
Once categories are established, the stage of evolution for any category and time period could be approximated by the observed quality of a specific good within the category and period, designated as the "representative good". This representative-good approach (RGA) to product evolution by design is *less rigorous* than the price-linking and hedonic methods of quality estimation. However, unlike these currently established methods, of quality measurement, the RGA has less tendency to drift away from an initially accurate measure of change as more periods are added because the process of identifying a representative good for a given period is independent of any results obtained from previous periods. By starting from scratch in each period, there is no systematic accumulation of bias from one period to the next.

The RGA makes the measurement of product evolution possible using data found in historical documents such as the *Sears Catalog* (in existence from 1893 to 1993), *Consumer Reports* (1936 to present) and the *New York Times* (1851 to present). What is necessary for the RGA is a consistent and logical means of designating a representative good (and its price) in one period, and an ability to find that same representative good (and its price) in an earlier period. A period can be long or short depending on the good's rate of product evolution. Personal computers, for instance, should have periods of less than one year, while goods that have not changed much over time, like items of jewelry, could have periods as long as a decade.

The representativeness of the "representative good" will always be one of the most important concerns. For instance, in the transition from one period to the next, if only a single, but markedly different new item is introduced to the category, it is hoped that this would lead to the identification of a new representative good to reflect the product evolution. In the present study the representative good is defined as the item with the median price among the items in the category (and the median quality to the extent that price reflects quality).

Once representative goods are identified, standard price-linking techniques can be used to measure rates of product evolution. For instance, consider sofas, one of the products examined in this study. Let A_{1988} denote the set of all sofas in 1988, and let the representative item be the sofa with the median price, p_{1988}. Using five-year

FIGURE 1
Use of Price Linking to Separate Product Evolution from Other Effects



intervals, and examining every fifth Spring/Summer issue of the *Sears Catalog*, in 1993 another representative item is observed, with price p_{1993}. Given this situation, any comparison of p_{1988} and p_{1993} would have little meaning in itself, because several factors besides quality change could have influenced them, since the two representative items exist at different points in time. On the other hand, one could ask the following question: Was the representative sofa in 1993 on the list of items available in 1988, and if so, what was its price in 1988? Assuming the 1993 median item was available in 1988, let us call that item the "1988 future median item", because the item itself will become the median item in the future, but its price is observed in 1988. To draw a clear distinction between designated items, let us call the median item of 1988, based on 1988 prices, the "1988 present median item" (see Figure 1).

The two main differences between the 1988 present median item and the 1988 future median item are characteristics and price.[5] Because both items exist at the same time, a cost reduction effect, a pure price effect, or an income effect on demand cannot account for any of the difference in their prices [Payson, 1994]. Their prices vary only because of their characteristics. Thus, the difference in their price reflects quality improvement, and defines product evolution, from 1988 to 1993. As for the 1988 future median and 1993 present median items, both are identical in characteristics, so quality is not a factor. Their price differences could have only resulted from a cost reduction effect, an income effect on demand, a pure price effect, or some combination thereof. This approach is no different from any other price-linking method, except for its identification and utilization of the "representative good" for each period.

REPRESENTATIVE GOOD APPROACH VERSUS CONVENTIONAL PRICE LINKING

Figure 2 illustrates another example of quality change among items in consecutive periods. Period 0, the base period, contains five models, A-E, with corresponding prices $a_0 = 1, b_0 = 2$, etc. In period 1, model A drops out; model F is added; and the prices of models B-E are reduced by one unit. (If these are computers, the prices shown could be thought of as being in thousands of dollars.) Prices in period 1 are $b_1 = 1, c_1 = 2$, etc.

For simplicity, assume that the quantity sold is divided equally among the five models in each period. Let Q_0 and Q_1 be scalars that serve as index numbers of the quality of all items in periods 0 and 1. Under these conditions, qualities in period 1, measured by conventional price-linking (CPL), would be proportional to values in period 1 at base-period prices. The only item that does not exist in the base period is model F. However, under a price-linking approach, the hypothetical value of F in period 0 could be estimated as

(1) $$\tilde{f}_0 = f_1(e_0/e_1)\,.$$

Thus, one has

(2) $$Q_0 = a_0 + b_0 + c_0 + d_0 + e_0$$

$$Q_1 = b_0 + c_0 + d_0 + e_0 + f_1(e_0/e_1).$$

The proportional change in quality, based on CPL, is then given by

(3) $$[(Q_1 - Q_0)/Q_0]_{\text{CPL}} = [f_1(e_0/e_1) - a_0]/(a_0 + b_0 + c_0 + d_0 + e_0).$$

Under the RGA, the proportional change in product evolution would be based exclusively on the representative good in each period. Because model C is the present median good and model D is the future median good, one has

(4) $$[(Q_1 - Q_0)/Q_0]_{\text{RGA}} \equiv (d_0 - c_1)/c_0.$$

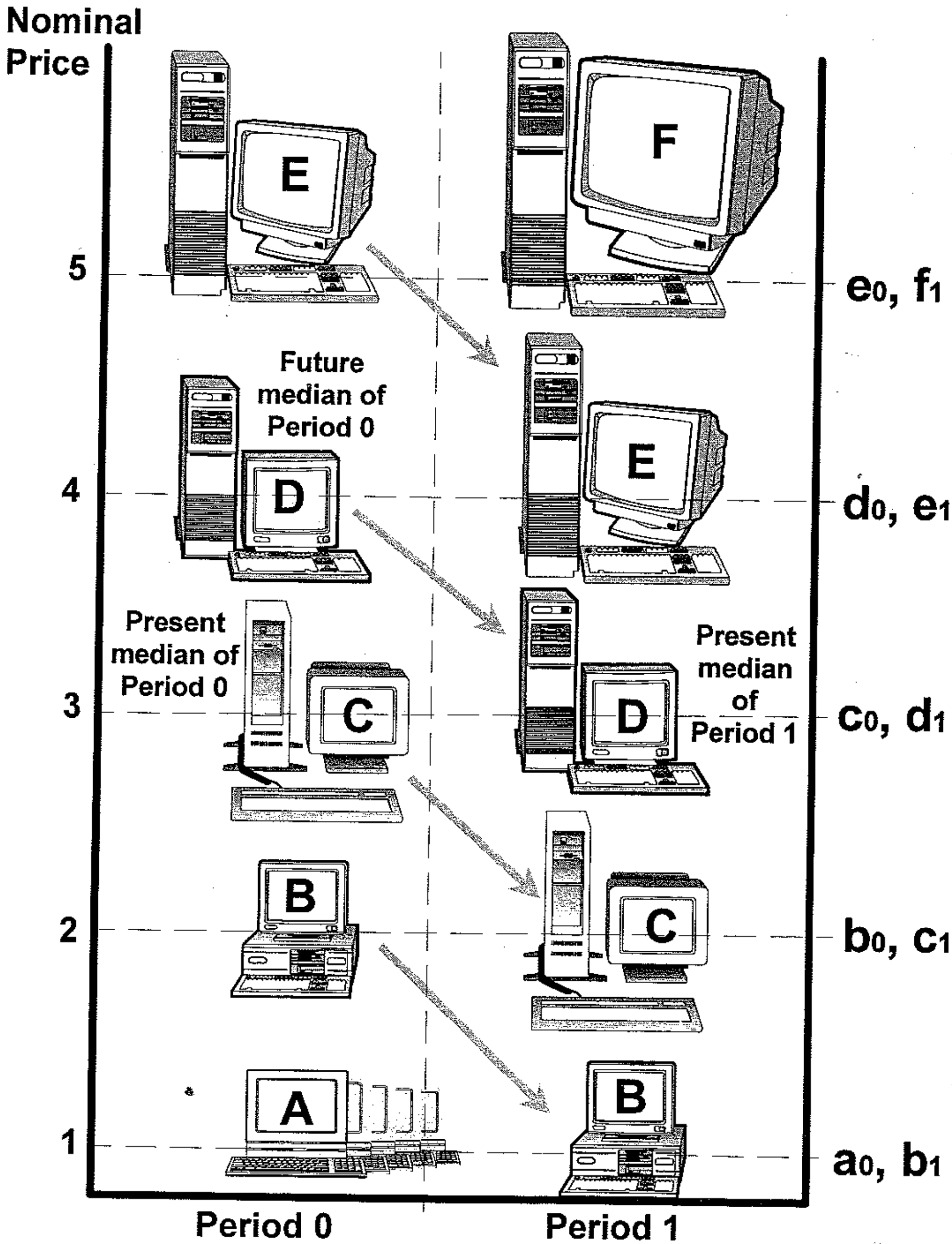
With the numbers provided in Figure 2, we find:

(5) $$[(Q_1 - Q_0)/Q_0]_{\text{CPL}} = 21/60$$

$$[(Q_1 - Q_0)/Q_0]_{\text{RGA}} = 20/60.$$

In this example, the RGA serves as a close approximation to the conventional price-linking approach.

FIGURE 2
Illustration of Quality Change Among Items in Two Periods



In actual practice, however, it is quite possible that the uniqueness of model F may not be discovered and/or accounted for in period 1. Suppose, for example, that model F is treated as equivalent to model E, even though its price is higher in period 1. This could occur quite easily if the higher price of F is simply attributed to a pure price effect, because the unique features of F that distinguish it from E are not recognized by individuals collecting or analyzing the data.

If F is not recognized as distinct from E, then its estimated base-period price, $\tilde{f}_0$, could be taken as e_0, implying:

$$(6) \qquad (Q_1 - Q_0)/Q_0]_{CPL} = (e_0 - a_0)/(a_0 + b_0 + c_0 + d_0 + e_0).$$

Using the hypothetical values in Figure 2, the estimated proportional change in quality would be 26.67 percent, in comparison to 35 percent if F were recognized as a unique model. Yet, such an error would not alter the estimated proportional change under the RGA, 33.33 percent, because model D would still be regarded as the representative good in period 1.

The more subtle the changes in quality between periods, the greater the tendency for conventional price-linking to underestimate quality change. Of course, over long periods, any small but systematic underestimation of quality change between consecutive periods could lead to a dramatic underestimation of quality change for an entire time span. For instance, suppose the true quality change were, in fact, 35 percent in every five-year interval. Suppose the RGA consistently measured 33.33 percent instead, while the CPL approach went back and forth between the underestimate of 26.67 percent and the correct estimate of 35.00 percent. Let the initial quality index in period 0 be 100. After 100 years (or 20 five-year periods), the true quality index would be 29,946; the RGA product evolution index would be 23,650 (79 percent of the true index); and the CPL quality index would be 15,835 (53 percent of the true index).

One could argue that the mix-up between model F and model E in this example would not create a problem for the RGA in period 1, but would lead to its underestimation of quality change in periods 2 or 3, when E and F are being considered as potential representative goods. However, such a mix-up between E and F is much less likely to occur, because under the RGA all of the focus and attention is placed on the analysis of representative goods. Consequently, the characteristics of potential representative items would be studied much more thoroughly than in the conventional approach. This additional attention would be feasible, because rather than having to rate all items in relation to each other, we would only need to determine how other items fare in relation to the representative item.

Depending on the type of good being investigated, the time span considered, and the rigor with which comparisons are made, the RGA and product evolution framework could have certain advantages over conventional methods of quality adjustment. The RGA allows for easier recognition of new items, even uniquely different items, that appear first at the top of the quality spectrum. In conventional methods of quality measurement, when a good that is unique first appears on the market, it is often not accounted for until much later. For example, Gordon [1990, 426] finds that the room air conditioner had appeared in the *Sears Catalog* and in *Consumer Reports* for 11 years before it became incorporated into the consumer price index. Furthermore, conventional and hedonic methods often have a bias toward the under-reporting of minor and subtle quality improvements [Cagan, 1965; Siegel, 1994]. The RGA is less likely to display this bias in the comparison of representative goods, although it could create a less precise estimator for certain pairs of consecutive periods, due to imprecision in the initial identification of representative goods.

Over long time spans, e.g., 100 years, the higher period-to-period fluctuations in the RGA due to inefficiencies in the identification of the representative good would be of minor importance. In contrast, a continual and cumulative drift away from accurate quality assessment (due to a systematic bias in measurement) in a conventional or hedonic approach to quality adjustment could be an important source of error.

It should also be noted that the concept of a representative good has a great deal of precedence in economic thought. The consumer price index is based on a bundle of representative goods, which are occasionally changed to reflect quality improvements over generations. The representative good approach, if applied to several different categories of goods, could provide a more accurate representative bundle for each period.

THE POTENTIAL FOR EXPLOITING RICH SOURCES OF HISTORICAL DATA

One of the most advantageous features of the representative good approach is that it allows for the empirical investigation of product evolution through the examination of historical documents. In the present study, five groups of household goods are examined: men's shoes; sofas and love seats; gas ranges; window fans and air conditioners; and cameras, movie cameras and camcorders. The prices and the descriptions (in terms of characteristics) of individual items are obtained from Spring/Summer editions of the *Sears Catalog* for every five years from 1928 to 1993. Each item is weighted equally, which could be a potential source of bias in the data. On the other hand, even if expenditures are skewed to one side of the distribution of items (e.g., greater expenditure on less expensive items) the main findings, which are based only on the *differences* across periods, could still be accurate under certain circumstances.

The median of the sample of items is chosen as the representative item because the mean and median prices, based on equal weight per item, are very similar throughout the time span, as are the ratios of minimum/median and median/maximum.[6] For shoes, sofas, and gas ranges, the median tends to be midway between the minimum and maximum on a logarithmic scale. For cameras and fans, the median is closer to the maximum, but is still reasonably distant from it. Except for fans, the ratio of the minimum price to the maximum price remains fairly constant throughout the time span, suggesting that the diversity in quality among items does not increase over time, contrary to what some researchers might expect. More precisely, new, high-quality items tend to enter the market no more or less rapidly than old, low-quality items leave it. For fans old models do appear to linger on while new models are introduced.

TABLE 1

Creation of Product Evolution Index from Prices of Representative Goods

	1928	1933	1938	1943	1948	1953	1958	1963	1968	1973	1978	1983	1988	1993
Men's shoes														
Present median	4.48	2.00	2.95	3.98	7.65	7.90	8.97	9.97	13.43	17.99	26.99	44.99	44.99	63.00
Future median	3.79	3.98	2.98	5.00	7.95	8.85	9.90	10.97	13.97	25.70	31.99	34.99	69.99	NA
Index	100.00	84.60	168.35	170.06	213.65	222.02	248.72	274.51	302.04	314.31	449.01	532.19	413.90	643.89
Sofas and love seats														
Present median	79.50	32.95	47.95	38.90	126.98	117.00	132.45	162.48	119.95	202.45	179.95	359.99	269.98	449.00
Future median	86.85	30.95	47.95	69.75	129.95	164.50	169.95	69.95	179.95	209.95	279.95	299.99	399.00	NA
Index	100.00	109.25	102.61	102.61	183.99	188.30	264.75	339.71	146.26	219.41	227.54	353.99	294.99	435.96
Gas ranges														
Present median	48.50	25.85	39.95	39.95	39.95	134.95	154.95	169.95	199.00	274.95	399.95	434.99	529.99	599.99
Future median	48.50	25.85	39.95	39.95	69.95	169.95	209.95	189.95	189.95	316.95	419.95	549.99	399.99	NA
Index	100.00	100.00	100.00	100.00	100.00	175.09	220.51	298.77	333.93	318.75	367.44	385.81	487.81	368.16
Window fans and air conditioners														
Present median	7.40	7.85	6.35	6.35	33.23	59.95	194.95	229.95	239.95	256.95	294.48	384.95	399.99	499.99
Future median	26.45	6.35	6.35	14.75	47.50	314.50	249.95	299.95	269.95	256.95	309.95	339.95	399.99	NA
Index	100.00	357.43	289.13	289.13	671.61	960.16	5037.05	6458.12	8424.07	9477.29	9477.29	9975.34	8809.24	8809.24
Cameras, movie cameras and camcorders														
Present median	8.95	9.90	17.65	29.17	76.11	29.50	67.80	67.06	78.50	106.75	59.50	264.99	429.99	339.99
Future median	8.25	14.95	17.65	69.50	87.54	150.95	58.20	127.50	179.00	68.25	189.50	319.99	339.95	NA
Index	100.00	92.18	139.20	139.20	331.71	381.55	1952.38	1675.94	3186.30	7265.87	4645.39	14794.98	17865.76	14124.66

FIGURE 3
Product Evolution in the Five Goods

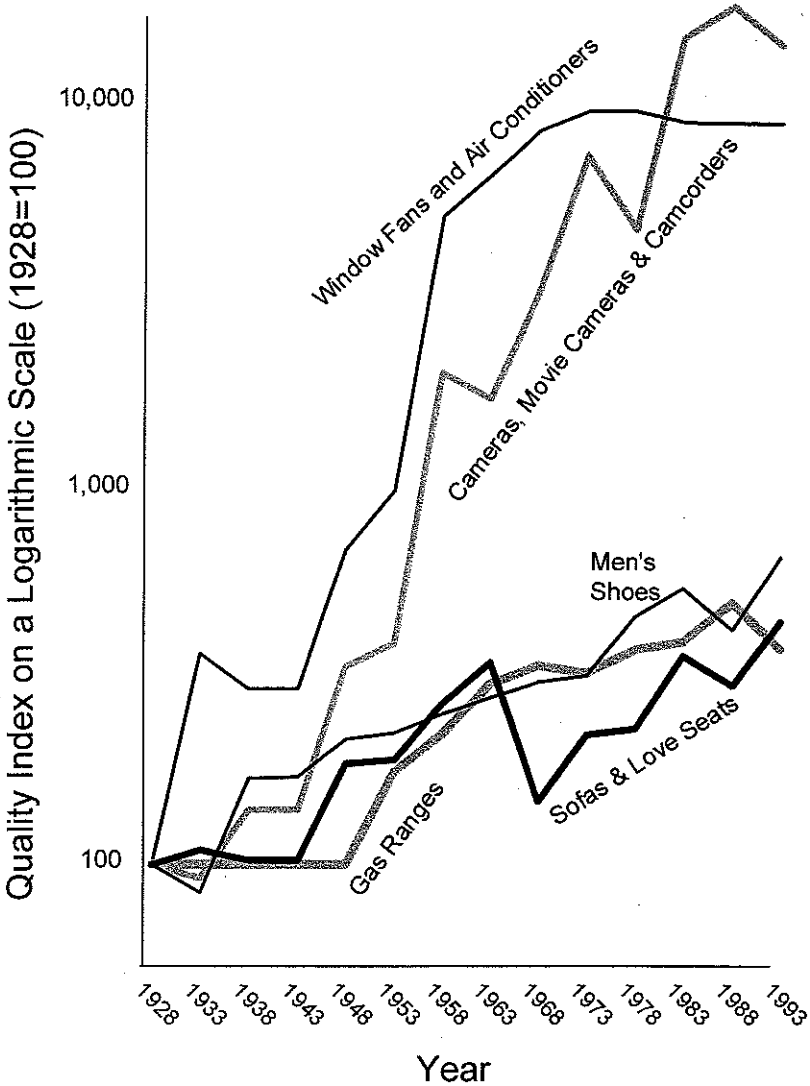


TABLE 2
Summary of Regression Results

Type of good	Product-Evolution Coefficient		Durbin Watson statistic	Adjusted R^2
	Rate of increase	t-statistic		
Men's shoes	2.716%	12.57	2.31	0.924
Sofas and love seats	2.073	5.83	1.88	0.717
Gas ranges	2.799	9.82	0.94	0.880
Window fans and air conditioners	7.462	8.28	0.70	0.839
Cameras, movie cameras, & camcorders	9.252	15.84	1.96	0.951

Nevertheless, in terms of rates of change, the minimum, mean, median, and maximum prices grow at roughly the same rate [Payson, 1994].

Taken together, these observations provide substantial evidence that from 1928 to 1993 the basic structure and distribution of items within the categories of goods have remained fairly constant. This implies that, in each category, product evolution in the representative item reflects overall quality improvement for the group.

An index with the value of 100 in the year 1928 was established for each good, which would increase or decrease in proportion to changes in the quality of the representative item. These indices are derived in Table 1 and illustrated in Figure 3. The rates of product evolution for window fans and air conditioners and for cameras, movie cameras and camcorders dramatically exceed the rates for the other three goods. These findings constitute strong evidence that certain types of goods undergo, in a consistent fashion, much greater rates of product evolution than others. In fact, the magnitude of the estimated rate for cameras, 14,000 percent over 65 years, could represent a notable discovery in itself. By performing an ordinary least-squares regression of the log of the quality index for each good against time, estimates were made of the rates of product evolution; they are summarized in Table 2.[7]

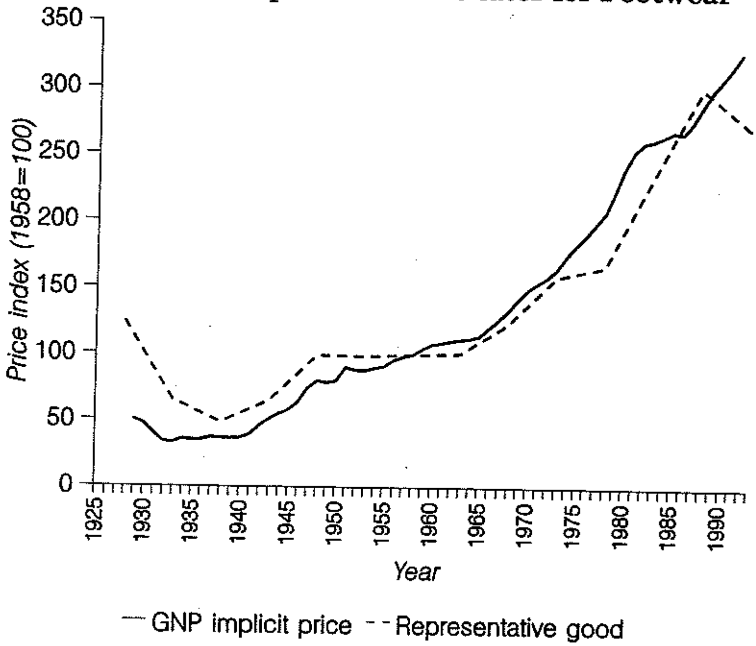
PRODUCT EVOLUTION IN RELATION TO OTHER MEASURES

Of the five types of goods considered in this study, men's shoes is the only one for which there exist comparable price indices in the GNP Implicit Price Deflator series, which is derived from the Consumer Price Index (CPI) and Producer Price Index (PPI). For the other four goods, there are discontinuities in the government statistics regarding the definition of categories from 1929 to 1993, making it impossible to identify a single, continuous trend. For men's shoes, the comparable index for 1929-1993 is the GNP Implicit Price Deflator for "shoes and other footwear" (which includes both men's and women's footwear).[8]

Figure 4 provides a comparison of the derived price deflator for footwear, and the median cost per quality unit of men's shoes in the *Sears Catalog*.[9] To facilitate the comparison, the measures were normalized to 100 in 1958, the year closest to the center of the time span. As the figure demonstrates, the two indicators are very similar across the time interval 1938 to 1988. Even though the measures are different in the first ten years, and in the last five years, the graph does provide evidence that, in certain cases, the RGA index could be a valid substitute for the GNP implicit price deflator.

Although the comparison between the government price deflators and RGA could be interesting for a variety of reasons, it should be obvious that the usefulness of such a comparison is limited. In constructing the RGA, for example, one could consider an air conditioner as a quality improvement over a fan, or a camcorder as a quality improvement over a camera. This interpretation of quality improvement as product evolution is much broader than the interpretation used in the construction of the price deflators. Hence, a comparison between the results under the two methods would often be inappropriate in view of the large difference in their underlying perspectives.

FIGURE 4
Representative Good Index for Men's Shoes Versus GNP Implicit Price Deflator for Footwear



Furthermore, the key purpose of deflators is not to measure product evolution, but to enable cost-of-living adjustments in wages, benefits, rents, etc. In this regard, the economic impact of the CPI is enormous. Juran [1992, 468] notes that for every 1.0 percent increase in the CPI in 1986, Federal outlays, in nominal terms, were increased by $2.8 billion, and personal income tax receipts were reduced by $1.8 billion (from what they would have otherwise been) due to a redefinition of tax brackets. Surely, it would be absurd for the *Sears Catalog*, or any other historical document, to be used in this role. Hence, those who use the RGA to measure product evolution must acknowledge that the RGA can never be a *replacement* for the consumer price index or any other deflator. Conversely, those who construct and/or advocate the methodology for constructing price deflators should not be opposed to other measurement techniques that are designed to answer entirely different questions.

DISTINGUISHING CARTS FROM HORSES

Three areas of concern have surfaced regarding the product evolution/RGA framework: (1) ambiguity in defining the product group and the representative good within it, (2) inaccuracy of price data, and (3) disinterest among researchers due to the simplicity of the approach. *The question that must be asked with regard to each of these concerns is whether a problem exists with the framework itself, or with the environment surrounding the framework*. The first concern regarding ambiguity will always exist, because the researchers will always have the option of defining a product group to fit their own research interests. The definition of a product group and representative good within it merely forces researchers to do the analytical homework that they would need to do in order to ensure meaningful and definitive conclusions. Any methodological alternative, e.g., the use of SIC code categories taken at face value simply because data are available in that form, may relieve researchers of that task, but at the cost of rendering little useful information about the underlying reality of product evolution.

Price data will always be suspect. For example, an anonymous referee noted,

> The fact that the representative good is being replaced by an improved good in period 2, suggests that the representative good is overpriced in period 2 and thus the quality change taking place is understated. The assumption that relative prices at a given moment of time reflect true valuations does not allow for the fact that different consumers have different information and ability to judge different products. At any one time, some products are overpriced and other products are underpriced. The overpriced products may be in excess supply, and there may be a shortage of underpriced products. This will result in gradual correction of the situation, but in the short run such price disparities will exist and will affect price measurement.

The mechanics of price adjustment, however, are highly dependent on the product and time interval. For example, in some markets a new, superior product may have an exclusively high price that exceeds marginal cost. Initial overpricing could serve a dual purpose to the supplying firm: exaggerating a good's relative quality for the sake of winning more customers after a planned price reduction, and/or providing a means of price discrimination where certain households, early on, would gladly pay a premium to be the "first on the block" to own the new item. Overpricing of future median goods (as described above) would lead to overestimates, not underestimates of product evolution; hence, the overestimation or underestimation of quality is highly dependent on the particular market situation. Ultimately, the scrutiny of a price datum should depend as much on market share as on a discrepancy between supply and demand. For instance, if only three units of an item exist, and four people would each be willing to buy one unit at the current price, then the novelty aspect of the item, or Veblen effect, could cause it to be "overpriced" in a broader sense of the term, in spite of demand exceeding supply. Of course, these limitations in the use of price data apply equally well for the representative good approach as for conventional price linking and hedonic methods. The CPI, PPI and GNP implicit price deflator, etc. are inherently limited. As demonstrated in this study, observed differences in the rates of evolution across different products can be quite substantial, thereby overshadowing the inaccuracies inherent in the use of price data.

Disinterest in the approach because of its simplicity may be the greatest constraint that it faces. The application of the approach is not meant to be an intellectual end-in-itself. The intellectual reward lies in the findings that the approach can generate. Why, we may ask, do cameras evolve faster than furniture? Though this is an interdisciplinary question, it is one that could be useful for economists to answer [Payson ,1994]. However, without some feasible and affordable means of measuring product evolution, economists would not even be able to ask these questions.

CONCLUSION

The basic concept of the representative good approach is analogous to the concept of the "center of gravity" in physics. That is, the motion of an object in space can be described by first observing the motions of various parts of that object, and then finding some aggregate measure that averages these motions. Alternatively, one could characterize the motion of the entire object as a whole as the motion of a point located in that object's center of gravity.

With the RGA, there may be little guarantee that the designated representative good is, in fact, the item that best characterizes the group. Moreover, it is quite possible that no such item exists, because there is a dichotomy among the items in the group, or because it is unclear which items belong to the group. Surely, the RGA is only useful in certain well-defined and well-behaved contexts. Its usefulness depends on how well the representative item captures the quality changes experienced by the group as a whole. This "representativeness" of the representative item would need to be tested before any conclusions could be drawn from an RGA experiment.

As argued above, the RGA for the study of product evolution must be recognized as being relatively accurate only over long periods of time, while having the potential to be *inaccurate* on a period-to-period basis. In contrast, government deflators are accurate between consecutive periods, but could be inaccurate in the long run due to systematic drifts resulting from small but consistent biases. Therefore, in addition to shedding light on evolutionary patterns of change, the RGA could also be used as a check against the results obtained by other methods of quality estimation. It can provide a check not only on other methods, but on the databases those methods employ, since the RGA can provide quality-change estimates using data from alternative, historical sources.

As already suggested, perhaps the most subtle advantage of the product evolution/RGA framework is that it will always force the researcher to have a concrete, and fairly specific, understanding of the particular product being studied. The representative good approach could be more helpful than other quality measurement approaches in its tendency to simplify, clarify and pinpoint what is actually meant by "product evolution" and what has actually happened over time to the good or service in question. Most* importantly, it allows for feasible and useful, quantitative comparisons of the rates of product evolution, through the use of inexpensive historical documents.

NOTES

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1. Nominal price changes in this case are often easily identified as the price changes over time holding characteristics constant.
2. For background on the relationship between quality and human perception, see Scitovsky [1976] and Steenkamp [1989].
3. In fact, even for footwear one observes that some of the more elaborate models of children's athletic shoes now feature flashing lights that respond to motion. Such visual showiness, in place of marginal improvements in comfort and wear (that might otherwise be achieved with the same price markup) attests to the greater overall importance of visual input to human perception. A notable exception, however, to the relative stagnation of quality in footwear is the top-of-the-line athletic shoe. Here, physical endurance is the relevant variable, which is dependent upon interdisciplinary breakthroughs involving physics (shock effects), chemistry (shoe materials), athletics (patterns of movement), and medicine (orthopedics).
4. For background on the importance of empirical confirmation of intuitive ideas in economics, see Blaug [1992].
5. For background on the economic meaning of characteristics, see Lancaster [1971; 1991].
6. The only exception would be the minimum/median ratio for window fans and air conditioners, due to large fluctuations in the minimum.
7. For the small sample sizes of 14 observations, the Durbin-Watson statistics are not significant, although there is some suggestion that autocorrelation could be present for gas ranges and for fans and air conditioners.
8. A disaggregation into shoes only or men's footwear only was not possible because of discontinuities in the CPI data.
9. The median price shown for 1929 is based on the linear interpolation between the 1928 and 1933 prices, i.e., it is the 1928 price, plus 0.2 x (1933 price minus 1928 price).

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