HEDONIC PRICE INDEXES

With Automotive Examples

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Importance of Problem

Commodity price indexes are to be taken seriously. With farm policy tied to so-called "pre-war parity," and cost-of-living clauses included in wage contracts, measurement of price change has more than academic significance.

Commodity price indexes originally were based almost entirely on prices of standardized raw materials or semi-fabricated products whose specifications remained unchanged over long periods. The problems were mainly those of weights and the formula to be used.

Recently, however, articles fabricated from hundreds of separate parts, designed for complex functioning, and subject to rapid improvement in design and construction, have played an expanding role. Particular difficulties arise in constructing price indexes for these evolving products of twentieth century technology.

Automobiles constitute one of the most important of this new group of products. If better ways of measuring changes in their prices can be developed, the techniques may well be important for the general problem.

* The facts and opinions advanced in this analysis represent only the personal conclusions of the author and of no other. They are in no sense a statement of the point of view of the Automobile Manufacturers Association, his employers, or of any of its members. The author is indebted to the Automobile Manufacturers Association for clerical assistance and research facilities in preparing this study.

A double debt is owed Sidney W. Wilcox, Chief Statistician of the U. S. Bureau of Labor Statistics, for stimulating the train of investigation which led to the Hedonic suggestions and for patiently correcting several egregious errors of fact which appeared in early versions. Although Mr. Wilcox inspired and helped rectify the analysis, it cannot be considered, in any sense, a statement of his views.

Price Index Essentials

No valid price comparisons can be made without adequate commodity standards, i.e., definition of the articles priced in terms of their useful and desirable physical characteristics.

The importance of selecting realistically useful characteristics in establishing comparisons may be illustrated by cattle prices. Slaughter stock, being useful for their beef, are quoted and sold by weight and grade. Grade is largely determined by the estimated yield of beef of various qualities per hundred pounds of animal. Value is in terms of potential beef. In contrast, milk cows are quoted by the head and the price is a function of the animal's productivity, expected life and perhaps breeding value. Here, value is in terms of potential milk, butter fat and calves. To quote milk cattle on a poundage basis or beef cattle by the head without regard to weight, might well be misleading.

In the case of evolving, complex-functioned manufactured goods, like automobiles, the problem of choosing product standards for use in price comparisons is even more important and difficult. Serious errors have resulted from nominalistic identifications, *i.e.,* comparisons based on brand name or other completely inadequate standards.

A Few Errors

Until recently the U. S. Bureau of Labor Statistics *passenger car* price index was based almost entirely on such nominalistic identifications.[1]

In constructing this index, car prices were considered comparable so long as they referred to products of the same brand name, regardless of body type or size of vehicle represented. No distinction was made between standard, fully equipped cars and special, stripped, economy models offered without starter, battery, generator, speedometer, and other normal equipment.

The table on the following page compares 1935 models with 1925 by body types for a single leading make of car. The values of the recently discontinued B.L.S. index for the same make of car for the same periods are also shown.

Note that comparable body types were reduced in prices from 9 to 16 per cent. At the same time the size and capacity of the car improved immensely. Also the cost of extra equipment[2] and features included in the

(1) Much credit is due Commissioner Isador Lubin and his staff for disclosing this situation. He has enlisted the aid of the industry to collect the information necessary to the construction of a more realistic measure.

(2) In any realistic price comparison it is necessary, of course, to consider the amount of equipment included. For example, in January 1937 almost all advertised car prices increased although delivered prices remained unchanged. Automobile manufacturers had decided to include bumpers, spare tire and wheel, and similar basic equipment in the list price rather than as a standard accessory group. There was no actual price advance. Any satisfactory price comparison would have been forced to recognize that the advance in nominal prices was entirely the result of added equipment. This factor in the situation is so obvious that it will not be mentioned again, although, of necessity, it qualifies all price comparisons which may be made.

list price in 1935, but not in 1925, totaled more than $100, at 1925 catalogue prices.

In spite of the decline in actual prices of comparable body types, the tremendous increase in car size and quality, and the fact that more than a hundred dollars of additional equipment was thrown in "free," the B.L.S. price index for this make advanced 45 per cent from 1925 to 1935.

The specific errors which explain this departure from reality are too numerous to list here.[3] For example, at certain times basic equipment such as starter, generator, battery and balloon tires was included in the published prices, while at others they were treated as accessory equipment. As a result, the price index moved up or down ten or fifteen per cent whenever the form of the catalogue was changed, even though there was no significant change in actual prices of comparable cars.

1925 vs. 1935 MODELS

of a

LEADING MAKE OF PASSENGER CAR

Prices

*Body Type**	*List Price* 1925†	1935	*Per Cent Change*
Coupe	$545	$495	− 9%
Two door sedan	605	510	−16
Four door sedan	685	575	−16
B.L.S. Index‡ (1925 = 100) (recently discontinued)	100	145	+45

* Covers all comparable body types manufactured in both years. In addition to the body types shown, standard roadsters and touring models were offered in 1925 but not in 1935, while deluxe and trunk model sedans were important in 1935 but not available in 1925.

† Including low pressure cord tires which were optional in 1925 but have been standard equipment since 1928.

‡ The B.L.S. passenger car price indexes (though nominally wholesale) are based on factory list retail prices. If actual wholesale prices were compared with the index, the discrepancy in movements would have been even greater, for the dealer discount allowed by this manufacturer was larger in 1935 than in 1925.

[3] The automobile industry is to blame for not supplying adequate price quotations on a well-defined and uniform basis. It was not very cooperative at the time the index was revised in the mid-twenties and did not take the trouble even to check its movements until 1936.

Specifications

Description	*1925*	*1935*	*Per Cent Change*
Wheelbase, inches	100	112	+ 12%
Horsepower, Maximum Developed	20	90	+350
Weight (Two Door Sedan), pounds	1900	2700	+ 42
Piston Displacement, cu. in.	177	221	+ 25
Front Spring Frequencies, o.p.m.	160	85	− 47
Acceleration, Max., 10–25 m.p.h., f.p.s.^{2}	1.8	4.1	+128
Deceleration, Max., f.p.s.^{2}	12	21	+ 75
Speed, Maximum, m. p. h.	40	80	+100

Note:—These specifications are derived from a variety of unofficial sources. They are believed to be approximately correct.
o.p.m.—Oscillations per minute under normal load.
f.p.s.^{2}—Feet per second per second.
m.p.h.—Miles per hour.

Equipment

Included in the list price in 1935 but not in 1925, with 1925 catalogue prices:

Air Cleaner, Intake	$ 5.00	Pedal Pads (3)	$ 1.00
Anti-Rattle		Pants (4)	1.40
Steering (3)	.75	Pump, Water	2.15
Brake (2)	.50	Shock Absorbers, Hydraulic (4)	30.00
Door Windows (4)	1.40	Speedometer	15.00
Radius Rod (2)	.70	Stop-Light and Switch	1.28
Hood	.62	Thermometer, Dash	8.00
Braces		Throttle, Foot	1.00
Engine	3.00	Ventilator, Cowl	.98
Fender	1.00	Windshield Safety Glass, Exchange	15.00
Brake, Rear Wheel, Service	12.50	Windshield Wiper, Automatic	3.50
Crankshaft, Counterbalanced	19.00	Total	$142.68
Gas Gauge, Dash	3.50		
Light, Parking	1.40		
Lock, Steering	12.00		
Oil Retainers, Rear Axle (2)	2.00		

Probably this contradiction between actual price movements and the index number is unique. There is every evidence that the B.L.S. seeks carefully to establish price comparisons for products identified by their significant physical characteristics.

As tangible evidence of the acute difficulties which have beset the makers of passenger automobile price index numbers, note the fact that, *among all the commodity definitions used in compiling the B.L.S. wholesale price*

index, passenger car definitions alone do not include any physical specifications whatsoever. The passenger car definitions are in terms of brand name alone, although automobile trucks and farm tractors are both specified in terms of physical characteristics, as are all other products in the wholesale commodity price index.

In the case of passenger automobiles, the established techniques proved inadequate because of the complexity of the problem.

Establishing Price Comparisons

How can valid price[4] comparisons be made when the various products offered in any one year do not correspond exactly in specifications with those offered at any earlier period? No exact counterparts can be found today for the automobiles of the twenties.

There are three approaches to this problem:

1. Overlapping series.
2. Averages within broad definitions.
3. Price-specification comparisons.

Overlapping Series are widely used for evolving products in constructing the B.L.S. and other commodity price indexes. (See table on page 104.)

This is a valid approach when the new and old products are competitively priced.

Frequently it is impossible to use this method. The economics of mass-production, as in the case of automobiles, often makes it necessary to drop the manufacture of an old product as soon as a new design serving the same market goes into assembly. No overlap exists. The method, though sound, proves inadequate.

Broad Definitions provide another valid but limited approach to the problem of price comparisons. For example, the B.L.S. uses a specification range in connection with its auto truck price index which is described as "Trucks, weighted average 3½ Tons and Under of 3 Makes, Each, F.O.B. Factory."[5] The farm tractor price indexes are described as

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(4) The automobile prices used in this study are the advertised retail prices of passenger cars at the factory. In every case, allowance is made for the shift from so-called factory list to advertised delivered price basis in early 1937.

In practical application, automobile price quotations must be qualified by consideration of both freight charges and trade-in allowance. Since these are local, individual situations not reflected in any available figures, they are ignored in this analysis of the over-all trends of prices and values. They must be allowed for, however, in any realistic interpretation of the actual level of automobile prices to the final customer.

(5) From 1926 to 1933 the B.L.S. truck price index declined 32 per cent while their passenger car price index fell only 13 per cent. During the same period, actual prices of leading makes of passenger cars fell slightly more rapidly than did the actual prices of trucks of the same makes. Lacking any official explanation, it might be assumed that this disagreement between index number trends and actual price movements resulted from the use of specification ranges for trucks and nominalistic identification for passenger cars.

104 WHOLESALE PRICES, 1913 TO 1928

TABLE 9.—*Average wholesale prices of commodities, 1913 to 1928*—Continued

Year or month	Hides and leather products—Continued									
	(c) Boots and shoes—Continued									
	Shoes, pair, factory—Continued									
	Men's, work, medium grade		Women's							
			Black, kid, lace, Goodyear welt				McKay sewed			
	Average price	Relative price, 1926 equals 100	8½ inch boot, average price	7½ inch boot, average price	Dress oxford, average price	Relative price, 1926 equals 100	Gun metal, button, average price	Kid, lace, average price	Black kid, lace, oxford, average price	Relative price, 1926 equals 100
1913	.....	.....	$3.000	.....	.....	68.9	$1.659	.....	.....	41.4
1914	.....	.....	3.000	.....	.....	68.9	1.741	.....	.....	43.4
1915	.....	.....	3.000	.....	.....	68.9	1.850	.....	.....	46.1
1916	.....	.....	3.442	.....	.....	79.1	2.333	.....	.....	58.2
1917	.....	.....	4.496	.....	.....	103.3	3.250	.....	.....	81.0
1918	.....	.....	4.375	.....	.....	100.4	3.708	.....	.....	92.4
1919	.....	.....	6.596	.....	.....	151.3	5.029	$5.975	.....	125.4
1920	.....	.....	7.663	.....	.....	175.8	.....	7.086	.....	148.9
1921	.....	.....	5.063	.....	.....	116.1	.....	5.266	$3.979	110.5
1922	.....	.....	4.335	.....	.....	99.5	.....	.....	3.350	93.1
1923	.....	.....	4.250	$3.850	.....	97.5	.....	.....	3.476	96.6
1924	.....	.....	.....	3.854	.....	97.6	.....	.....	3.500	97.2
1925	.....	.....	.....	4.125	$4.000	101.3	.....	.....	3.599	100.0
1926	$2.050	100.0	.....	.....	4.074	100.0	.....	.....	3.600	100.0
1927	2.183	100.5	.....	.....	4.000	98.2	.....	.....	3.625	100.7
1928	2.521	123.0	.....	.....	4.140	101.6	.....	.....	3.729	103.6

Reproduced from B.L.S. Bulletin No. 493—"Wholesale Prices, 1913 to 1928."

"Tractor, 10-20 H.P., Each, Factory" and "Tractor, Farm, 15-30 H.P., Gear Drive with Friction Clutch Pulley and Steel Lugs, Each, Factory."

This procedure is a valid method for establishing price comparisons. In the case of trucks and farm tractors, a single specification is of sufficient importance. It is simple to apply.

By contrast, the uses of passenger cars are manifold. No single specification comes near to reflecting adequately their useful and desirable qualities. Where it is necessary to set the specification range in terms of more than one variable, it becomes difficult to find ranges which will provide reasonably close definition without eliminating so many quotations that the resulting averages become unstable.

As an example, the passenger car specification range[6] 2400-3200 pounds dry weight, 106-120 inches wheelbase, 60-100 developed horsepower was chosen. This range was broad enough to include over ninety per cent of all production in 1935, yet not a single car came within it before 1925, and the number of cars qualifying before 1930 was inadequate for a significant average. In order to establish price comparisons back to 1920, it was necessary to select three sets of car weight, wheelbase, horsepower ranges covering the periods 1920-25, 1925-30, 1930-39. The averages based on each of these ranges were linked together on the overlapping years to form the continuous index, shown on Chart 2, page 112.

Although fundamentally valid, the specification range approach is unsatisfactory in several respects. The range chosen is necessarily arbitrary and products may fall into or out of it as a result of inconsequential changes in specifications. The effects are likely to be distorted movements of the average. Although this method can yield a satisfactory approximation of broad price trends, it lacks any delicacy and may be positively misleading in the short term.

Product analogies provide another approach to the price comparison problem within the *broad definition* framework. The table which follows compares a popular current series of each manufacturing group with the car *most nearly* analogous in terms of car weight, wheelbase, and horsepower in 1920. Note that in seven of the eight manufacturing groups where analogous cars could be found in 1920 and 1939, the name was different. In seven cases out of eight, nominalistic price comparisons on the basis of brand name would have been misleading. The difficulties lie in finding adequate analogies, *e.g.*, in earlier years no cars had the horsepower of recent models. The index based on the analogies tabulated is plotted on Chart 2 below in comparison with the specification range index. If really significant specifications had been used as criteria, the problem of finding analogies would have been even more difficult. Specifically, nothing approaching the comfort and performance of the cheapest 1939 models was available in 1920, at any price. When an exact analogy can not be found, a subjective element is necessarily injected into the analysis.

In addition to the overlap and broad definition procedures described above, there remains the technique of establishing price comparisons in terms of specification units. This approach includes established methods and the Hedonic suggestions.

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(6) For illustrative purposes, it has been assumed that passenger car usefulness is reflected by, and can be measured in terms of, the three specifications, dry weight, wheelbase, and advertised horsepower. These specifications have the advantage of being available for all makes over a long period of time from published sources. They do not really begin to reflect the useful and desirable characteristics of passenger cars. Since, however, *this is a discussion of possible methods* rather than a definitive analysis of price trends, they will serve.

ANALOGOUS CAR SEQUENCES
based on
CERTAIN SPECIFICATIONS

Make and Series	*Year*	*Weight Lbs.*	*Wheel-base Inches*	*Brake Horse-power*	*Factory Delivered Price*	*Per Cent of 1920 Price*
		CHRYSLER				
Plymouth Roadking..	1939	2824	114	82	$ 685	21.6%
Chalmers 35C.....	1920	3100	117	45	3170	100.0
		GENERAL MOTORS				
Chevrolet Master....	1939	2820	112	85	648	26.6
Oldsmobile 37B.....	1920	2739	112	44	2435	100.0
		GRAHAM-PAIGE				
Graham Standard....	1939	3250	120	90	940	28.8
Paige 6-42.....	1920	3150	119	43	3260	100.0
		HUDSON				
Hudson 112.....	1939	2634	112	86	775	25.7
Essex A.....	1920	2955	109	55	3010	100.0
		HUPP				
Hupmobile Std. 6....	1939	3280	122	101	995	29.3
Chandler NS.....	1920	3400	123	45	3400	100.0
		NASH-KELVINATOR				
Nash-Lafayette Mstr.	1939	3200	117	99	810	24.7
Nash 685.....	1920	3455	121	35	3285	100.0
		STUDEBAKER				
Studebaker Comm. 6.	1939	3160	116	90	955	34.4
Studebaker Light 6...	1920	2900	112	45	2780	100.0
		WILLYS-OVERLAND				
Willys 4.....	1939	2300	100	48	555	33.1
Overland 4-90.....	1920	2152	100	35	1675	100.0
		AVERAGES				
	1939	2934	114	85	795	27.6
	1935	2933	114	83	806	28.0
	1930	2930	113	64	1118	38.9
	1925	2875	113	50	1387	48.2
	1920	2981	114	43	2877	100.0

Notes:
No satisfactory comparison is possible for Ford and Packard.
All prices refer to cheapest 4 passenger closed car in series. Delivered prices at main factory city are estimated by adding 13½ per cent to f.o.b. list. This has not always been exactly applicable to all makes, but the error involved is negligible for the purposes of this presentation.
The averages are unweighted and are based on the most nearly analogous products of each of the eight manufacturers listed.

Prices in Terms of Specifications reflecting usefulness has long been recognized as a valid basis of price comparison. In the early days of index number construction, bread was quoted by the loaf although it was known that the weight of the loaf typically varied inversely with the price of flour. In fact, the average weight of the loaves quoted was published along with the average price.[7]

After a period, the basis of pricing was shifted from the loaf to the pound, giving public recognition to the importance of relating price to those physical specifications which measure product usefulness (where it is impossible to get quotations on comparable articles from period to period).

Price per unit is a satisfactory procedure where the useful and desirable qualities of an article can be roughly summarized in terms of a single specification. Passenger cars serve so many diverse purposes that such a single, most important specification can not be found (like rated tonnage in the case of trucks). The simple method is inapplicable, but why not combine several specifications to form a single composite measure?

The Hedonic[8] suggestions are addressed to this problem of establishing an objective composite measure of usefulness and desirability in terms of which prices of products of complex function can be compared. In the case of passenger cars, if the relative importance to the customer of horsepower, braking capacity, window area, seat width, tire size, etc., could be established, the data reflecting these characteristics could be combined into an index of usefulness and desirability. Prices per vehicle divided by this index of Hedonic content would yield valid comparisons in the face of changing specifications.

It has been proposed that the specification weights (coefficients of relative importance) be based upon a survey of the opinions of owners, or of professional consumer groups. This has much to commend it. Unfortunately, it is expensive and not applicable to the historical problem.

Probably the persons most familiar with the desires and needs of automobile users are the designers and engineers who lay out the cars, and the sales managers with whom they work. Their judgment as to the balance between customer preference and cost of manufacture is reflected in the prices and specifications of the products which they offer. With higher

(7) Some students of the problem have contended that it is best in cases like this to continue to compute and tabulate a price index per loaf and a changing average weight per loaf, since this gives the maximum detail of information.

(8) Webster's New International says "Utilitarianism, seeking the good in the greatest happiness of the community as a whole, is the chief hedonistic doctrine." Thus, Hedonic price comparisons are those which recognize the potential contribution of any commodity, a motor car in this instance, to the welfare and happiness of its purchasers and the community.

Alexander Sachs suggested this use of *HEDONIC*.

priced cars, there is more margin available with which to cater to the less important desires. The automobile buyer has a good deal to say about these decisions, for it is only in so far as he is pleased at a price that the engineers continue their work.

Actual prices and specifications for the various makes and series of automobiles offered each year reflect the relative importance of each specification for car buyers. For example, if two series of a certain make of car are identical, except for the motor and the price, which show an inter-series differential of say 20 horsepower and 30 dollars, it is possible to say that, as far as these two cars are concerned, each additional horsepower costs the customer, and is presumably worth to him, an average of $1.50.

The existence at any one time of quite a number of cars of different makes and series selling for a wide variety of prices, and having different specifications, provides a guide. A multiple regression analysis[9] covering all the various cars offered during the index base period, and using the prices of individual makes and series as the dependent observations, and relevant specifications as the independents, will give those weights best assigned various specifications in explaining prices existing at that time.

Solution of the normal equations gives the coefficients of net regression, the "b's," of price on the various specifications. These "b's," used as weights, are multiplied by the specifications to which they apply. The resulting products are added to yield a composite measure of Hedonic content[10] for cars in periods preceding or following the base period.

The relation between prices and Hedonic content of all cars offered at any period of time provides a Hedonic Price Index. The ratio is always 1.00 for the base period.

The weights assigned to the various specifications in estimating the Hedonic content of any car or group of cars are based on relationships between prices and specifications during the base period chosen.[11] The prob-

(9) This approach of letting the actual price and specifications of the various cars offered in any year determine the relative importance of each specification was first suggested by Sidney W. Wilcox, Chief Statistician of the U. S. Bureau of Labor Statistics.

(10) The deviation between actual price and Hedonic content for individual cars should reflect over-pricing and under-pricing, in so far as the analysis is realistic and complete. This deviation might reasonably be expected to correlate with sales trends of individual cars, although there are so many other factors in sales that the possibilities of any useful analysis along these lines are nebulous.

(11) The multiple regression analysis suggested above neglects the factor of different levels of sales of different makes and series. A car selling in large volume is more certainly attuned to consumer needs and desires than one selling in much smaller volume. There is no question about the significance of any of the mass-production cars for this analysis, but should the V-16s be included at all? If so, their prices and specifications are certainly much less important.

This difference in importance can be nicely allowed for by setting up the multiple regression equation not with one set of observations for each make or series, but rather one set for each car sold. This sounds complicated, but really it is not much more difficult to compute cross products for 100,000 Buicks, 10,000 Cadillacs, and 1,000,000 Chevrolets than it is to compute them for one car of each make.

The problem is that the great relative weight given the leading makes is equivalent to cutting down the number of observations. Perhaps, the weighting might better be based on the logarithm of the sales total rather than the actual volume.

lems of choosing and shifting bases are similar to those in any normal price index computation.

Hedonic suggestion number two is really a variant of the first proposal. It consists of setting up the multiple regression equation, including various makes, series, and body types using price as the dependent observation and specifications as the independent observations. Instead of limiting the equation to the base period, as in the first suggestion, the variant proposal includes in one multiple regression equation observations from two or more periods the price levels of which it is desired to relate. An additional factor, time, is included in the analysis. The equations are solved, and the net regression of price on time, holding specifications constant (the "b" of the trend factor), is a direct generalized approximation of the change in price for a car of constant specifications between the periods included in the equation.

If the net price change between two periods only is to be computed, one trend series will be sufficient.

If more than two periods are to be included in one equation, however, it will be necessary to use additional trend series to the number of one less than the number of periods to be considered. Since the purpose of the analysis is to determine the net regression of price on time, the time factors chosen must not prejudge the nature of the result. If five different periods of time were to be included in a single equation, four trends must be used.

Applied to three periods in time and using the three specifications chosen for illustrative purposes, the trend factors would be designated t_1 and t_2; where p = price, w = car weight, f = wheelbase, and h = horsepower, the equation would be:

$$p = k + b_{pw \cdot fht_1t_2} w + b_{pf \cdot wht_1t_2} f + b_{ph \cdot wft_1t_2} h + b_{pt_1 \cdot whft_2} t_1 + b_{pt_2 \cdot whft_1} t_2$$

An *oversimplified* picture of this second procedure is presented by Chart 1. Using car weight as the only specification, taking the cheapest series in each make for the years 1925 and 1935, and using the logarithm of car prices, it appears that each 1,000 pounds increase in car weight has been associated with a doubling of price. Moreover, it appears that during this ten-year period, the price of a car of a given weight has come down about 45 per cent. This represents the net price change during the period, holding specifications (car weight only in this case) constant.

In practical application, using many specifications, the net price change during a period would be the distance between two parallel multi-dimensional surfaces reflecting the effect of all the various specifications used on price.

To explore the Hedonic proposals, computations were made following the second suggestion using a pair of years in each equation: 1920-1925, 1925-1930, 1930-1935, 1935-1937 f.o.b., 1937-1939 advertised delivered price. These periods overlapped so that the net price change could be

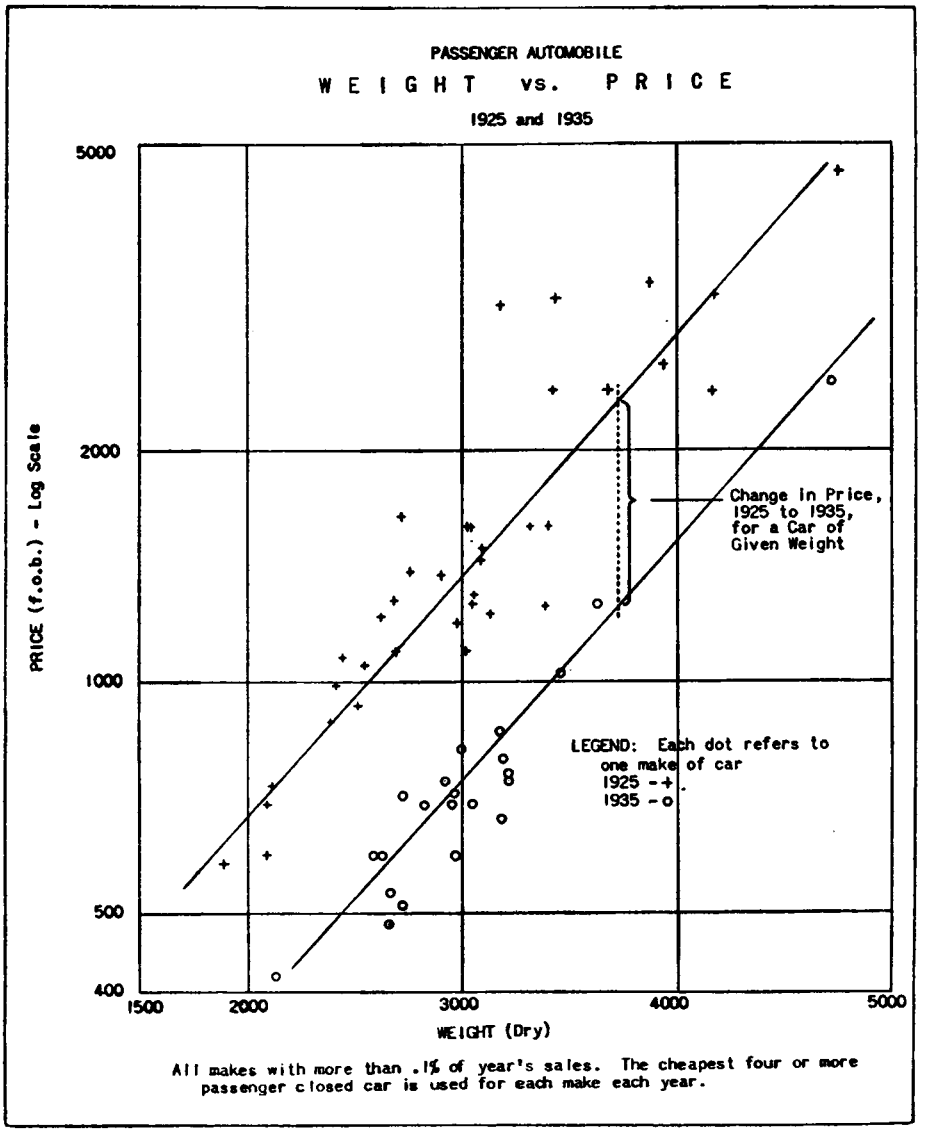

Chart 1

linked to form a continuous index for the period. Prices and specifications for the years listed were used in five multiple regression equations as described above, including a trend in each equation. Prices were included in the form of their logarithms, since preliminary analysis indicated that this gave more nearly linear and higher simple correlations.

The specifications used were car weight, wheelbase, and horsepower,[12] since the purpose was to explore methods, and not to measure actual net price movements.

The net regression of price on each of the specifications and on time, and the "R" for each period are shown below:

NET REGRESSION OF PRICE ON SPECIFICATIONS AND TIME

	Per Cent Change in Price				*Coefficient of Multiple Correlation*
Period	*Per Inch*	*Per Cwt.*	*Per Horsepower*	*Per Year*	*(R)*
1920-1925	2.01%	2.35%	.80%	−12.4%	.96
1925-1930	1.82	4.02	.30	− 7.1	.96
1930-1935	.31	5.66	.55	− 7.4	.95
1935-1937	.01	5.76	.53	− 2.5	.97
1937-1939	.15	2.95	.71	+ 2.5	.93

The net regressions on time shown above are in effect price link relatives for cars of constant specifications. By joining these together, a continuous index is secured. Chart 2 compares the Hedonic price index with the specification range and analogous car averages described above.

The parallelism between the trends shown is rather good, indicating that the various types of analyses do measure the same thing. The Hedonic suggestion yields results in general agreement with the commonly accepted method of specification range averages and the common sense, analogous car approach.

The Hedonic method has several advantages over either of the other methods:

1. The various specifications can be assigned weights on an objective basis.
2. It is feasible to use in weighted form all the observations (cars offered) each year.
3. Determination of short-term and long-term fluctuations is of equal validity. The method does not inject any artificial instability into the results.
4. A comparatively large number of specifications can be handled by the Hedonic technique with a given number of observations.

A question arises. In the event of engineering advances making any particular specification less important for car value, how would the Hedonic suggestion meet the situation? One of the three specifications chosen for this analysis provides an example.

The net regression of price on wheelbase has been decreasing since 1930, and the gross correlation coefficient is smaller for the 1937-39 period than

[12] See footnote 6, p. 105.

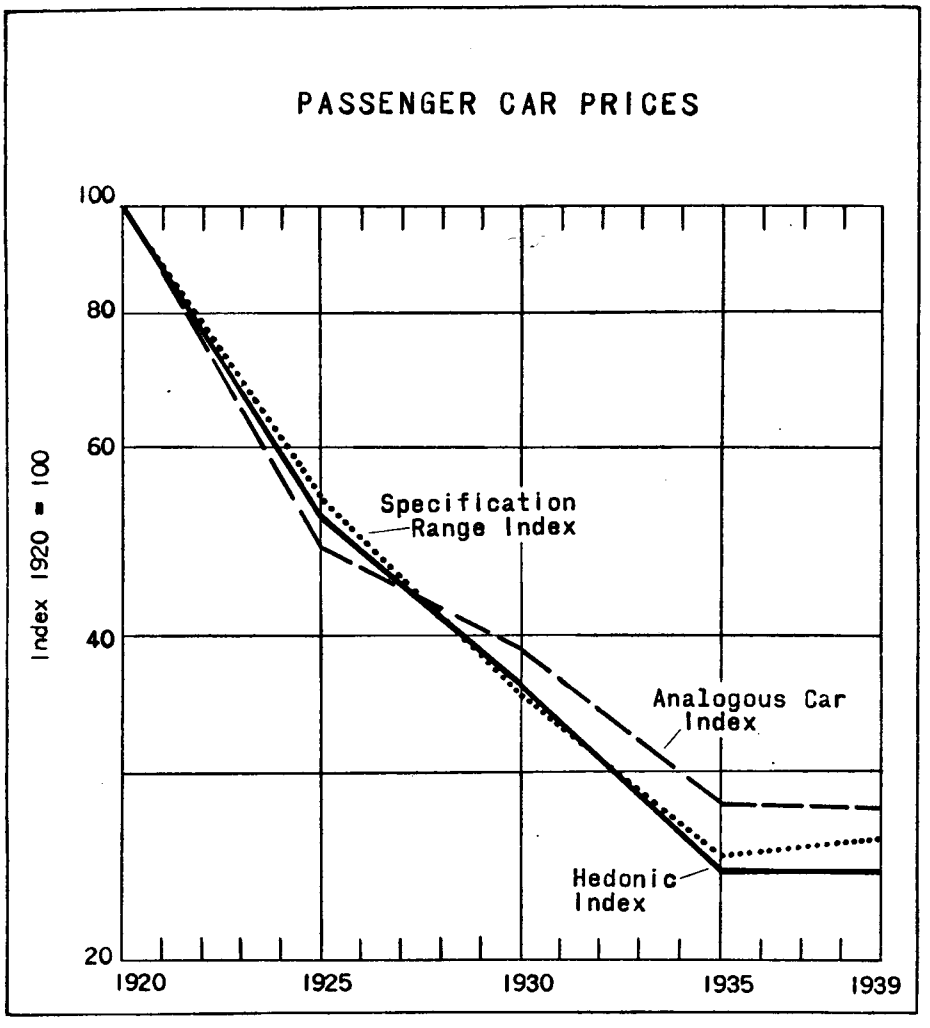

Chart 2

previously. This suggests that recently wheelbase has been less important for car value than it was earlier. If this checks with general engineering observation, other specifications should supplant wheelbase in the analysis.

It must be remembered that car weight, wheelbase and horsepower are used only to illustrate methods with easily available figures. These specifications do not begin to reflect car usefulness and durability.

Data which measure useful and desirable car characteristics are prerequisite to any realistic measurement of net price change by any method.

An approach to the problem of objectively weighting car specifications for use as measures of value has been outlined. Three comments seem appropriate:

1. Before any results of this or any other statistical analysis are accepted as significant measures, they should be examined for probable error and net significance of determination after allowance for degrees of freedom.
2. For purposes of the simplified example, the regression between actual specification and the logarithm of price was assumed to be straight line. A completely adequate analysis would recognize the real nature of the relationship between specifications and usefulness.
3. This whole approach rests on the assumption that the significance of any specification for car usefulness and desirability can be measured approximately in terms of the net association of variations in the specifications and in price as between various makes and series *within* any period. There are two corollaries:

   a. It is necessary in the second approach to inject enough flexibility into the trend factor to permit every period under consideration to find its own best level without any limiting assumptions.

   b. If variations in any specification and in price show no net association with each other within each of the periods under consideration, there will be no significant net regression of price on that particular specification, and change in that specification *from year to year* will have no effect on the net regression of price on time even though the average change in the specifications from year to year may show some relation to the average change in prices from year to year. This is logical. The determination of the weights to be assigned various specifications hinges entirely on the price-specification relation during the base period.

The two Hedonic suggestions described provide mathematical methods for determining the relation between price and time, while making allowance mathematically for changes in specifications reflecting product usefulness and desirability. If these or any other methods are to yield realistic measures of net price trend, the specifications used in the analysis must truly reflect useful and desirable properties of the product and the lines of net regression must have logical shapes. The weight, wheelbase, and horsepower data used in the examples[13] are inadequate. In fact, car weight *per se* is undesirable and in a complete analysis would have a negative net regression.

Having set up a technique of computation, the next problem is the development of specifications relevant to the usefulness and desirability of passenger cars.

(13) See footnote 6, p. 105.

Significant Specifications

Inquiry of the sales and engineering staffs of automobile and parts manufacturing companies, and of fleet operators who have kept detailed records, has given much new information. Since the data from different sources were not always comparable as between makes, however, it seemed unwise to attempt to use them directly in a Hedonic analysis.

These data, in the form of industry averages, are charted below under

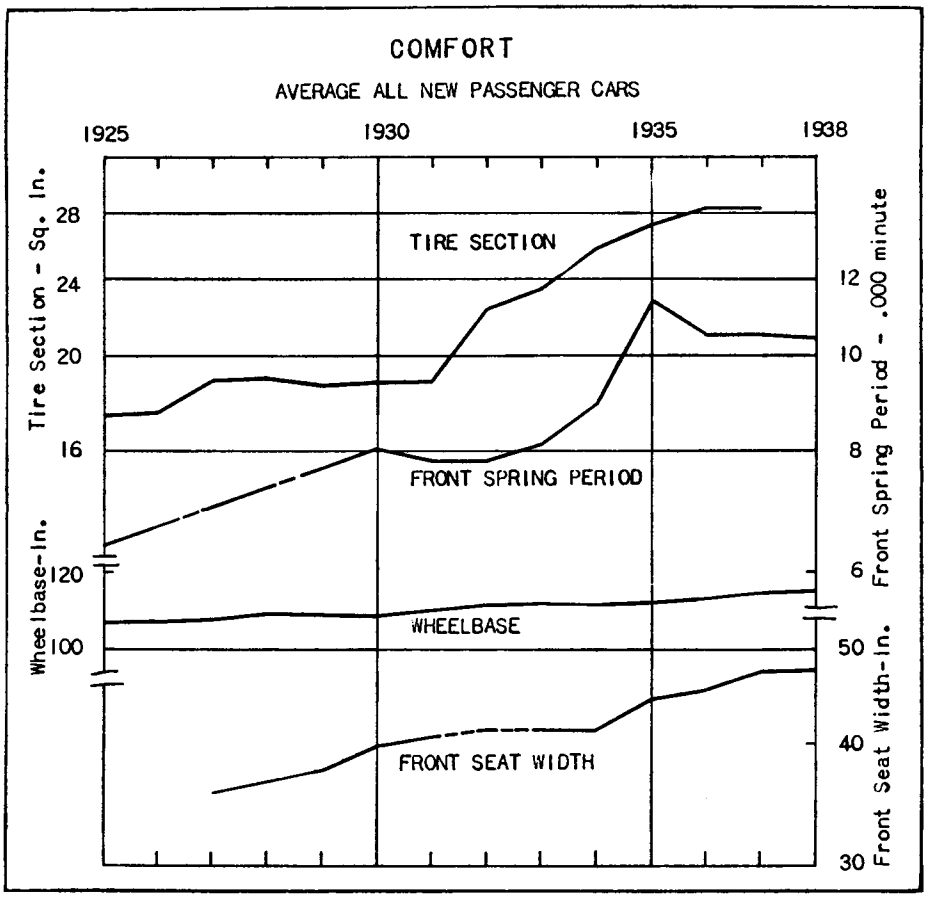

Chart 3

broad classifications. The averages are weighted by sales of the various makes and are based on data covering all important makes. An exception is the chart on economy which is based on an unweighted average of operating costs of six large fleets of popular priced passenger cars. Better cars,

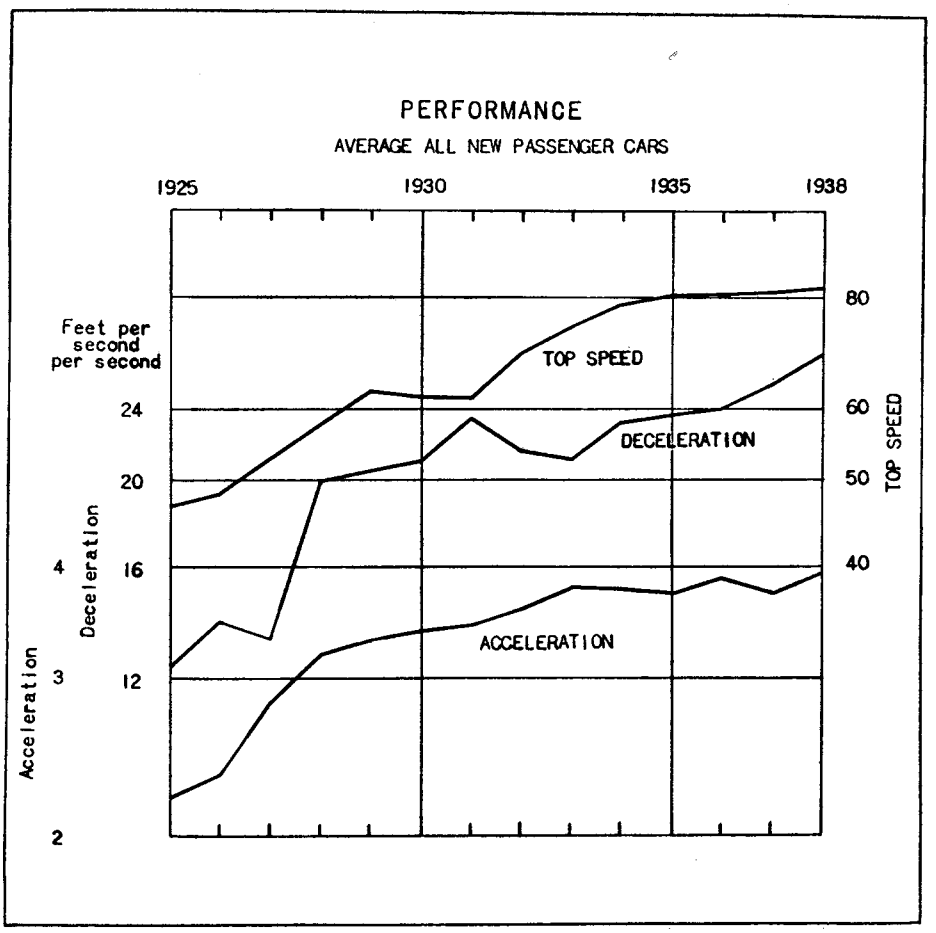

Chart 4

better roads, fuels, oils, and tires, and more intelligent fleet management and simplified repair procedure have all contributed substantially to these gains.

Summary

These Hedonic proposals seem rather complicated, when all the qualifications and precautions are enumerated. However, the basis of computation is simply the *measurement of the relation of price to time, holding usefulness (as reflected by specifications) constant.* The statistical technique involved is standard multiple regression procedure.

The results of any Hedonic analysis can be checked for rough accuracy using the established specification range technique. The Hedonic procedure

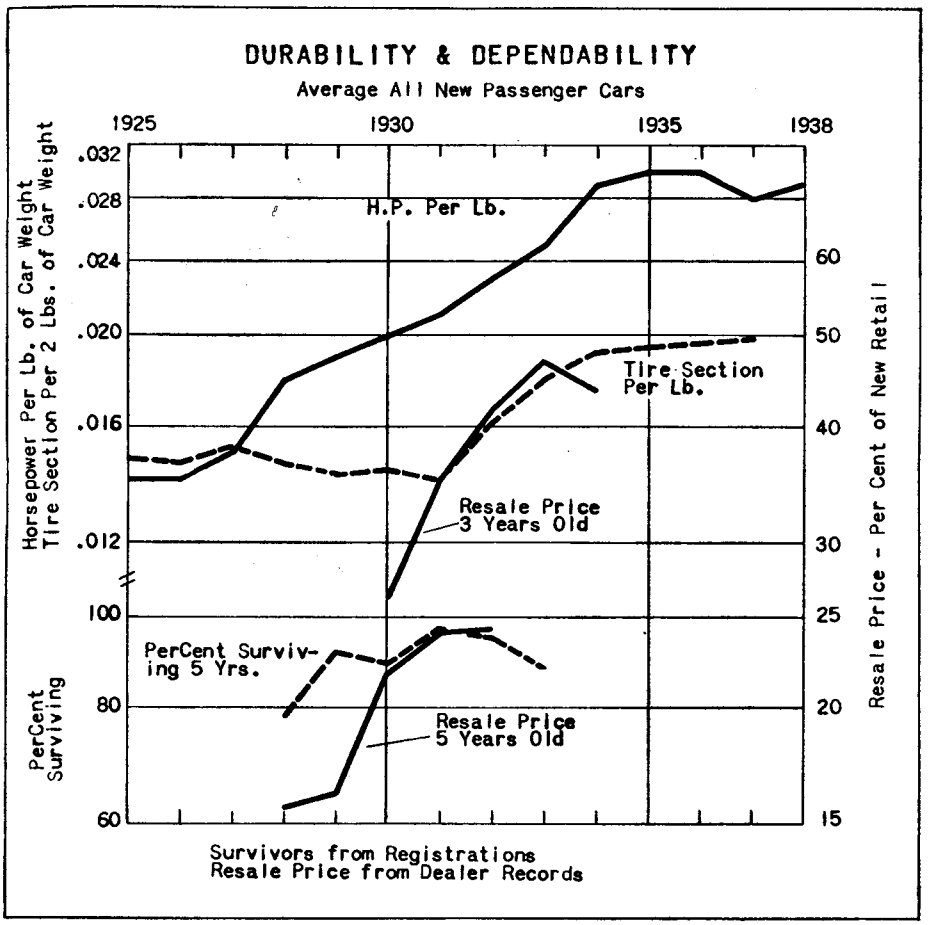

Chart 5

has several advantages over specification ranges: it is free from exaggerated movements; it can recognize many more specifications simultaneously; it uses all observations; validity of results is subject to testing through established procedures.

Whether the Hedonic or specification range procedure be used, it is most important that price comparisons be made in terms of truly comparable objects. When identification is based on brand name alone or some other equally immaterial characteristic, the resulting price comparisons can be misleading.

Price indexes in gross error have been widely used as the basis for serious, official discussions of national policy.

Realistic measures of the price trends of manufactured goods are vitally important to the intelligent consideration of national economic problems.

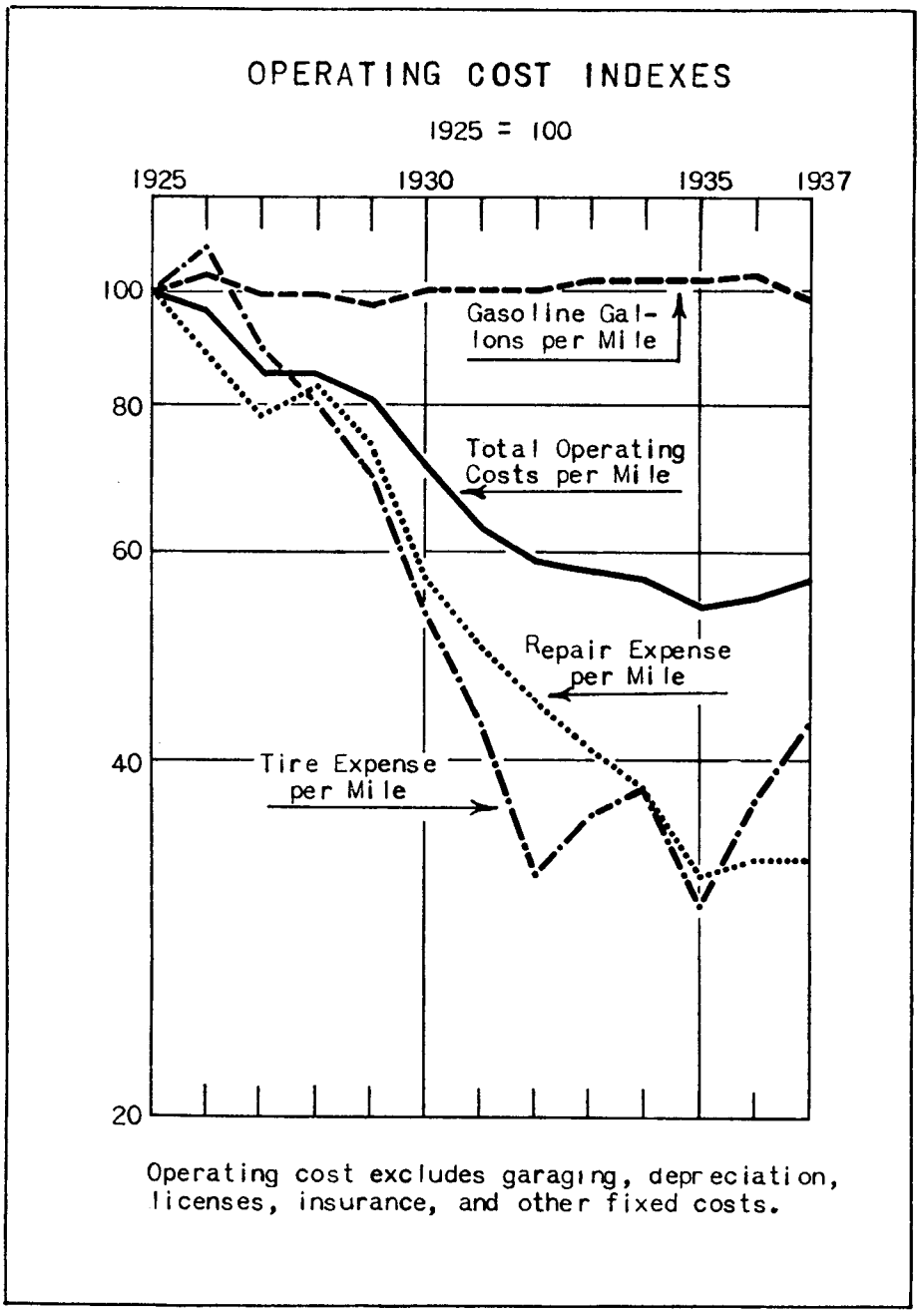
OPERATING COST INDEXES
1925 = 100
1925
1930
1935
1937
100
80
60
40
20
Gasoline Gallons per Mile
Total Operating Costs per Mile
Repair Expense per Mile
Tire Expense per Mile
Operating cost excludes garaging, depreciation, licenses, insurance, and other fixed costs.

Chart 6

DISCUSSION OF MR. COURT'S PAPER ON HEDONIC PRICE INDEXES

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Agricultural Adjustment Administration

The gist of Mr. Court's paper on Hedonic Price Indexes is (1) that in measuring automobile prices and values we take into account the fact that a car today differs greatly from that of 20 years ago and (2) that the effect of changes in quality factors can be determined statistically and thus a price series obtained which would represent the hedonic value of a car to the consumer on the assumption that the characteristics of the car in the same base period be held constant. There can be little argument on the first point. The second calls for precautionary remarks.

I do not want to appear to minimize the importance of having prices that represent the same kind of commodity in our work with index numbers and with price analysis; but Mr. Court's suggestion that prices of automobiles be placed on a hedonic basis to represent the growing amount of consumer satisfactions by holding certain factors like weight, wheelbase and horsepower constant deals with only one-half of the problem. The other half is the changing consumer. The consumers' appraisal of values and the nature of their satisfactions tend to change simultaneously with improvements. It is true that a 1939 car is a much more comfortable and useful vehicle than the 1919 car was, but this does not mean that it gives the 1939 consumer more satisfaction in the light of what a 1939 consumer expects than the 1919 consumer got in terms of his 1919 expectations. A real hedonic index must deal with both sides of the problem, but since that would call for dealing quantitatively with subjective factors, the practical utility of Mr. Court's suggestion as a device that can be used in index number making is not all that Mr. Court claims for it. Certainly there are a multitude of problems involved that Mr. Court hasn't hinted at or, I am afraid, surmised.

Mr. Court overestimates the contribution that multiple correlation can make to this problem. In spite of the existence of standard methods for multiple correlation analysis, there are pitfalls that the standard methods serve to hide or fail to deal with realistically. Our own experience with much simpler problems in price analyses where market prices are related to well-known and readily measured supply and demand factors suggests that it is not at all easy to determine a generalized price change holding weight constant during the period, and that this procedure cannot easily be extended to cover several value specifications held constant, getting the net effect of time on price. Quite often because of difficulties that inhere in time series, such as intercorrelation among the independent variables, it is almost impossible to determine the effect of one factor on price holding other factors constant. In such cases, the time factor cannot be determined with any degree of accuracy in spite of very high correlation coefficients.

Mr. Court's experience with this correlation device is also not at all promising. An examination of his Chart 1 where the bracket indicates a decline of a little less than fifty per cent will reveal that the margin of error in the location of the upper regression of weight on price is unusually great and increases with the weight of the cars involved. A different location of the upper regression or the use of a different formula than the logarithmic would give other analysts entirely different results.

Those interested in Court's suggestion of the use of correlation in studying the effect of quality factors on price may also be interested in Dr. F. V. Waugh's study published by Columbia University Press in 1929 entitled *Quality as a Determinant of Vegetable Prices, A Statistical Study of Quality Factors Influencing Vegetable Prices in the Boston Wholesale Market.*

In our efforts to study the relations of volume of production and consumption to price and their bearing on current questions of competitive or monopolistic practices in the automobile industry, Court's hedonic index is not likely to be particularly useful. Such work as we have done in this field suggests that volume has a definite bearing on price. In an industrial product like automobiles, producers quite naturally undertake to protect themselves against loss of demand by reducing volume and thus in effect create scarcity value as a support for a policy of relatively stable prices. For a given business situation there is a fairly definite proportion of the national consumer purchasing power that is spent for automobiles. The facts as to (1) the way a rise in demand serves to offset the tendency of price to fall with increasing volume and (2) the way reduced volume serves to offset the tendency of prices to fall with falling demand, would not be revealed by the hedonic price measure. Such relationships are, however, revealed if the price series favored by Mr. Scoville are used, namely, the average price of all cars sold. In analyses of this sort the hedonic price measure would have to be related to volume series constructed on the same hedonic basis and subject to the same inaccuracies and uncertainties due to efforts to deal quantitatively with subjective factors.

It is generally assumed that because the automobile industry has so vastly improved its product, a greater share of the consumer's budget is being spent for automobiles, and that this is a direct reflection of the fact that the number of hedonic units created by the automobile industry is much greater than that indicated by the number of cars sold. Actually, however, this test does not support the implications of Mr. Court's hedonic price measure, for the wholesale or retail value of cars sold has shown no material increase in relation to national income. In each of the relatively prosperous years—1923, 1926, 1929, 1937—the wholesale value of cars sold represented 3.6 to 3.7 per cent of the national income.

Mr. Court's interesting work should be carried much further, as he suggests. We should, however, not be disappointed if neither public agencies nor trade associations adopt the policy of publishing prices, values and index numbers based on the relatively tricky results that one is sure to get by applying the device of multiple correlation. The only group who would sponsor such a procedure would be the non-existent National Association of Experts in Multiple Correlation, the demand for whose services would be enormously increased.