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THE NEXT TWENTY YEARS**

by

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RESEARCH IN PRICE MEASUREMENT FOR THE NEXT TWENTY YEARS

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Abstract

The paper looks at possible directions for future research in constructing price indexes. Section 1 notes that many innovations in price index research were actually out there in the academic literature for 20 or more years before statistical agencies got around to implementing them. This suggests that future statistical agency innovations could be in the current academic literature. The remaining sections of the paper list some possible current areas of research that could be implemented in the coming years.

Key Words

Index number theory; the consumer price index; the producer price index; hedonics; reservation prices; superlative indexes; constant elasticity of substitution utility functions; scanner data; electronic collection of data; user costs; seasonal adjustment; imputed prices; Becker's theory of the allocation of time.

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C43; C81; D11; D13; D2; D9.

1. Introduction

When Ernie Berndt approached me to participate in this panel discussion, I agreed but at the same time, I thought that it was slightly ridiculous to be looking ahead for twenty years. With the current very rapid pace of technological change, it is difficult to look ahead *two* years, let alone *twenty* years. However, when I reflected on our topic, research in the measurement of prices and quantities, I changed my mind. Many of the "new" developments in the measurement of prices over the past twenty or thirty years took twenty years or more to be implemented. Let me give some examples:

- The Stigler (1961) Commission, which examined the price statistics of the US government, advocated probability sampling for collecting price quotations at the lowest level of aggregation. The Bureau of Labor Statistics did not implement this suggestion until 1978 (and virtually all other countries *still* do not use probability sampling).
- In a chapter in the Stigler report, Zvi Griliches (1961) updated the hedonic research of Court (1939) on adjusting automobile prices for quality change and suggested that statistical agencies should use the hedonic regression technique more widely to adjust prices for quality change.¹ This suggestion was not adopted until the 1980's.²
- Many years ago, Hicks (1940; 114) introduced the idea of a shadow price or a reservation price that would ration the consumer to demand zero units of a new product in the period *prior* to its introduction. This reservation price could then be inserted into an index number formula and the usual bilateral index number theory could be extended (in theory) to deal with the new goods problem. However, the practical problem is: how are we to determine this shadow price? Diewert (1980; 501-503) suggested some econometric methods for this determination but actual empirical implementations of this class of methods for dealing with new commodities did not occur until very recently; see Hausman (1997) (1999).
- Diewert (1976) wrote his first paper on superlative indexes in 1973³ but it took about 20 years for the idea to diffuse into statistical agencies; see Triplett (1992) and Young (1992).⁴
- The Australian economist, Peter Lloyd (1975), derived an exact index number formula for the Constant Elasticity of Substitution (CES) utility function, which depended only on based period expenditure shares, prices in the two periods under consideration and an estimate of the elasticity of substitution between all commodities in the index. Many years later, Brent Moulton (1996) independently derived this index number formula and realized that it could be used to form a close approximation to a superlative index using basically the same information that is required to estimate a Laspeyres index, provided that an estimate of the elasticity of substitution was available. Shapiro and Wilcox (1997) actually implemented this idea for the U.S. Consumer Price Index and found that it worked rather well. This is a very significant development, since it shows that it is not impossible to obtain a good approximation to a superlative index using basically the same information set that is presently used to calculate Laspeyres type consumer price indexes.
- In 1988, while discussing Triplett (1990), Diewert⁵ suggested that scanner data or detailed computerized firm data on sales would be useful for making estimates of

¹ The concept of a hedonic regression dates back to Frederick Waugh (1928) but the term hedonic is due to Court (1939).

² See Cole, Chen, Barquin-Stollerman, Dulberger, Helvacian and Hodge (1986), Triplett (1986) (1987) (1989) (1990), Dulberger (1989) and Silver (1999). For an accessible review of the hedonic literature, see chapter 4 of Berndt (1991; 102-149), "The Measurement of Quality Change: Constructing an Hedonic Price Index for Computers using Multiple Regression Methods".

³ It took me three years to find a journal that was willing to publish this paper.

⁴ See also Boskin, Dulberger, Griliches, Gordon and Jorgenson (1996).

⁵ This paper was eventually published in full as Diewert (1993a). "Due to the computer revolution, it is now possible to undertake some experiments which could help to determine the extent of the substitution bias. Retail outlets that have computerised price and quantity information on their sales could be sampled. Detailed microeconomic price and quantity vectors p^t and q^t could be constructed

possible substitution biases at the lowest level of aggregation (and perhaps also for estimating new goods bias). The lags in implementing this suggestion were not as long as the above lags—less than 10 years! See Berndt, Griliches and Rosett (1993), Silver (1995), Saglio (1995), Reinsdorf (1996), Bradley, Cook, Leaver and Moulton (1998), Dalén (1998), de Haan and Opperdoes (1998) and Hawkes (1998) for examples of such scanner data studies.

Given the above examples of rather long lags in the implementation of “new” measurement techniques, it is very likely that at least some of the “new” techniques that will be introduced into statistical agency practice over the next twenty years are actually out there right now. Thus in the sections below, we will speculate on what “new” ideas are likely to be implemented by statistical agencies in the coming two decades. In section 2, we speculate on what are the likely main innovations that statistical agencies will introduce. In sections 3 and 4, we look at what theoretical developments in consumer and producer price statistics might be introduced. Section 5 concludes with some notes of caution: measurement problems are likely to become more difficult in the coming years in many respects.

2. The Shape of Things to Come at Statistical Agencies

The main changes that are likely to occur at statistical agencies over the next two decades will be centered around data collection techniques. Present methods that rely on the collection of individual price quotes at retail outlets and by mail questionnaires will gradually be replaced by *electronic data collection techniques*.

- Firms will be asked to submit detailed price and quantity data from their own electronic records via the internet to their statistical agency representative. Firms will also be asked to submit their basic accounting data via the internet. This will be facilitated by the widespread adoption by firms of computer driven accounting packages like Simply Accounting or Quicken for small firms and by customized accounting packages for large firms. This is the *one big survey model* of data collection from firms that is being pioneered by Statistics Canada. This method of business data collection will lead to a vast improvement in the quality of the production accounts because price, quantity and value data will match up or be consistent for each firm across all categories of output and input. In contrast, the present piecemeal survey method of putting together production accounts is rather hap hazard: one survey might collect information on (a few) output prices, another survey collects information on (a few) input prices, yet another survey collects information on values and so on. Putting together this scattered information is like putting together a jigsaw puzzle with most of the pieces missing.

and the Laspeyres, Paasche and Fisher indexes defined by (2)-(4) above could be calculated and compared with corresponding official consumer or producer price indexes that covered the same range of goods. Such firm oriented experiments could provide useful information on the size of the substitution bias.” Diewert (1993a; 59). “ Numerical computation of alternative methods based on detailed firm data on individual prices and quantities where new goods are carefully distinguished would cast light on the size of the new goods bias. Thus the firm oriented experiments suggested at the end of the previous section to cast light on the size of the substitution bias could also be used to study the size of the new goods bias.” Diewert (1993a; 63).

- It is possible that a similar revolution in household data collection could also occur as money for household transactions is replaced by credit and debit card transactions. This switch to plastic away from money opens up the possibility of collecting detailed price and quantity data on individual households *electronically* rather than by the old diary and recall methods. If this comes to pass, again as in the producer case, there will be a vast improvement in the quality of household data. I am less certain that this rosy prospect actually will materialize because of concerns about privacy.
- Recent developments associated with the expansion of internet services make it possible to collect some types of price information cheaply over the internet. For example, there are internet sites that collect information on prices for autos, standard insurance policies, computers and many other products so that consumers can shop for the lowest prices. Internet auction sites might make it possible to collect information on the prices of used durable consumer and producer goods. This would enable statistical agencies to form more accurate information about *economic depreciation rates* for these durable goods. Lack of accurate information on these depreciation rates is one of the major weaknesses of the current statistical system.

Another major change that is likely to occur in statistical agency practice is that *families* of indexes will replace *single* indexes. Some possible examples are:

- The present single CPI (Consumer Price Index) may be replaced by two indexes: one that is timely (like the present index) and another that would be produced with a lag so that current quantity information could be used (to reduce substitution bias) and quality adjustments could be incorporated. This is a recommendation of the Boskin (1996) Commission.
- Multiple CPI's may be calculated that reflect different index number purposes or methodologies. For example, some users may feel that a *rental equivalence* or *user cost* approach to major consumer durable goods like housing is more appropriate than a *money purchases* or *acquisitions cost* approach. Thus statistical agencies may provide alternative indexes that reflect the two approaches. Similarly, some users may want a CPI that has incorporated hedonic quality adjustments or adjustments for increases in the size of consumer choice sets. On the other hand, other users may regard such adjustments as lacking in *objectivity* and *reproducibility* and demand a CPI without such adjustments. Finally, some users may want a price index for the domestic *purchases* of consumer goods and services while other users may want a price index that reflects domestic *sales*. Of course, this demand for multiple indexes is already being met by the statistical system: the first index is a traditional household CPI while the second index is part of the system of producer price indexes that is imbedded in the national accounts of each country.
- Two decades ago, Ralph Turvey (1979) sent around an artificial data that had seasonal commodities in it that were not available in every month of the year. He then asked each statistical agency to use their normal seasonal adjustment procedures on this data set and to report the results back to him. Needless to say, he found a disconcerting spread in the resulting answers. This is to be expected since it is difficult or impossible to compare the price of grapes in the present month when they are in season with the price of grapes in another month when they are simply not available. Diewert (1999) recently took another look at this

very old problem and recommended that statistical agencies should construct at least three families of consumer price indexes to deal with this problem. The *first index* should be a short term month to month index defined over *nonseasonal commodities*. This index should be useful for the purpose of monitoring short run inflationary trends in the economy. The *second index* should be a year over year index, where the prices in January are compared to the January prices of a base year, the prices in February are compared to the February prices of a base year, etc. This index should give an accurate measure of year over year inflation, which is free from seasonal influences. The *third index* should be an annual one⁶, which compares a moving total of 12 months with 12 base year months. This type of annual index can serve as a substitute for the present classes of seasonally adjusted price indexes that rely on “black box” time series methods for seasonal adjustment. Thus again, there is a demand for a family of indexes rather than a single CPI.

Another major change that is likely to occur in statistical agency practice is that the collection of information on *service industry* output prices and quantities will finally receive the attention that this sector deserves. The broad outlines of the present statistical system date back to the 1940's and 1950's. During that period, economic activity has shifted tremendously from primary industry and the manufacturing sector to the service sector. However, the collection and organization of data by the statistical system never shifted towards better measurement of service industry outputs and inputs. This gap will surely be filled over the next two decades.⁷

We turn now to a discussion of some of the theoretical developments that are likely to take place with respect to household statistics.

3. Theoretical Innovations and Consumer Price Indexes.

Over the next twenty years, many theoretical innovations in modeling the behavior of households will be incorporated into the design of consumer price indexes. Some likely candidates for incorporation include:

- **Implementation of Becker's (1965) theory of the allocation of time.** In Becker's model of consumer behavior, households combine their time with market goods and services to produce finally demanded “commodities” that yield direct utility. For example, a consumer combines the services of a bed with time to produce “sleep utility”. The theory also takes into account the disutility of time spent working on the external market and the disutility of the time spent commuting to work. The advantage in implementing this theory is that it will give a more complete picture of household activities: the time costs spent on

⁶ This index can be built up from the second class of year over year indexes.

⁷ The recent development of the North American Industry Classification is a major step in the right direction since it has a very detailed classification of service sector industries. Corresponding product codes are now being developed and over the coming two decades, there will be a wealth of new information about service sector outputs and prices.

each consumption activity will be valued at some opportunity cost of time and added to cost of purchasing goods and services from the marketplace.⁸

- **Implementation of an extended version of Becker's model to cover household market production.** Becker's model of consumer behavior is concerned with how the household combines purchases of consumer goods and services with its time to "produce" final "commodities" that are demanded by that household to satisfy wants. However, in recent years, as self employment and contracting out of services have grown, many households are producing goods and services at home that are *sold* to other users. This home production for market sale is *not* taken into account in Becker's model and so it needs to be extended. The implications of this extension for the cost of living index are profound. Instead of just collecting information on typical consumer goods and services like food, clothing, housing etc., the extended COL to cover household market production would have to include production type inputs like materials (if a product was being made at home) or office equipment (if a business service was being provided) and various traditional consumer purchases (like heating fuel, telephone services, transportation, home computers etc.) would have to be allocated between business and personal use. In addition to putting these business intermediate inputs into the scope of the COL, it would be necessary to account for the outputs produced as well.
- **Implementation of an extended version of Becker's model to medical economics.** Illness, disease and accidents reduce capabilities. For example, if I break my leg, playing tennis or jogging is not feasible. If my vision deteriorates (and I do not get new glasses or have an eye operation), then reading a book or watching television may not be feasible. In the context of Becker's theory of the allocation of time, *accident or disease adds extra constraints to the consumer's utility maximization problem* and of course, this addition of constraints will reduce welfare. Conversely, certain medical treatments will treat the disease or illness and will remove or lessen these extra constraints, thus adding to consumer welfare. This extension of Becker's theory opens up the possibility of providing welfare based evaluations of the effects of certain medical treatments.
- **Many of the problems associated with the existing theory of the cost of living index will be solved.** There are many technical and conceptual problems with the existing plutocratic⁹ theory of the cost of living index that will be addressed in the coming decades. Some of these problems include:

- (1) Current theories for group cost of living indexes assume that each household in the reference population faces the same price for each commodity.¹⁰ This is obviously not true.

⁸ Pollak and Wachter (1975) note that it will be difficult to accurately determine the full price (including its time cost) of each finally demanded "commodity". However, for the purpose of constructing a cost of living index, it is not necessary to construct these full prices: all that is required is information on the household's purchases of market goods and services, an opportunity cost of time (usually an external market wage rate) and information on the household's allocation of time across activities.

⁹ This is a term coined by Prais (1959). It refers to the current concept of the consumer price index, which weights households according to their expenditures, so that rich households get more weight in the index than poor households.

¹⁰ See Pollak (1980) (1981) or Diewert (1983).

- (2) The existing theories for group cost of living indexes assume that the reference population is the same in the two periods being compared. However, births, deaths and immigration make this assumption untrue.
- (3) The theory of the COL index assumes that tastes remain unchanged in the two periods being compared. However, education, experience, the process of getting older and advertising will systematically change tastes over time.
- (4) The theory of the COL index assumes that various environmental and or demographic factors are the same in the two periods being compared (or alternatively, that preferences are separable from these environmental variables—an unrealistic assumption). Examples of such environmental or demographic variables are: the weather (it affects fuel consumption for heating and air conditioning and it affects what kinds of leisure activities are undertaken), the presence of a new child in the household, the amount of pollution around the household, the condition of the local transportation infrastructure, etc. For some hints on how these problems could be addressed in the context of COL theory, see Caves, Christensen and Diewert (1982; 1409-1411) and Pollak (1989).

- **Many of the unresolved problems associated with the use of hedonic regression methods for quality adjustment will be solved.** The definitive Handbook of Hedonic Methods has still not been written but it surely will be written over the next two decades.
- **Recent developments in modeling choice under uncertainty will be used to construct quantity or volume measures for risky products.** Current methods for constructing estimates of the real output of the insurance, gambling and options trading industries are not very satisfactory. It is very likely that the vast theoretical economics literature on modeling choice under risk will be used to construct reasonable output or real quantity measures for these inherently risky products.¹¹

We turn now to possible theoretical innovations on the producer side of price and quantity measurement theory.

4. Theoretical Innovations and Producer Price Indexes.

Some of the areas of research in the measurement of prices that will probably work their way into producer price indexes are:

- **The theory of price indexes at the lowest level of aggregation will be refined considerably.** At present, there is considerable uncertainty with respect to the “right” treatment of price quotes from firms at the lowest level of aggregation. Should we use unit values? How should we treat missing price quotes?¹² What should be done about seasonal commodities? What is the right index number formula to use at the lowest level of aggregation?¹³ Over the next two decades,

¹¹ For some hints on how to do this, see Diewert (1993b) (1995a).

¹² See Armknecht and Maitland-Smith (1999) and Feenstra and Diewert (2001) on this topic.

¹³ See Dalén (1992) and Diewert (1995b) for material on elementary indexes.

surely at least some of these questions will be answered in a more or less definitive manner.

- **The user cost of capital will work its way into standard national income accounting.** The present system of national income accounting does not recognize interest as a cost of using a durable capital input nor does it recognize any capital gains on the asset as a cost offset; only depreciation is recognized as a cost of using capital. In the coming two decades, I expect that interest less capital gains (or equivalently, real interest) will be added to depreciation as a capital cost item and the user cost of capital will become acceptable to national income accountants. However, many practical problems associated with the construction of user costs will be extensively debated. For example, what depreciation rate should be used in the user cost formula? What interest rate should be used? Should we construct an *ex ante* user cost where *expected* capital gains are used or should we construct an *ex post* user cost where *actual* capital gains on the durable input are used? Also, should user costs be constructed for land and inventories or just be restricted to reproducible capital stock items (such as structures, machines and equipment)?¹⁴
- **Natural resource and environmental accounting will also work its way into standard national income accounting.** It makes sense to include the growth of forests and other natural resources as a benefit to national output and resource depletion as a cost. Also, improvements (or deprovements!) in various types of pollution should be regarded as benefits (or costs) in the system of accounts. Of course, the practical problem is to find acceptable ways of *valuing* these changes in the environment but over the next twenty years, I believe that progress will be made and a consensus system of valuation will emerge.
- **The problems involved in constructing transfer prices and a geography based system of accounts will be solved.** When multinational firms trade inputs and outputs between their production units in different countries, the problem arises of how to *value* these internal to the firm international transactions. This is known as the *transfer price problem*. Unfortunately, there are a number of alternative ways for determining these transfer prices¹⁵ and so there is a need for a consensus to emerge on how these prices should be calculated. The transfer pricing problem also occurs *within* a country when we attempt to construct a consistent system of geography based *regional accounts*: if a national company has regional subsidiaries that trade with each other, then in order to form a system of regional accounts, it is necessary to have agreement on how to calculate these interregional transfer prices. This problem has not received a lot of attention in national income accounting circles but surely it will over the next two decades. Of course, this all ties in with the computer and internet revolution. If each establishment (a business unit with a specific geographical location) is able to report its price and quantity information for an accounting period to the statistical agency *and* the transfer pricing problem is “solved”, then, in principle, it should be easy to aggregate up and form any system of regional accounts that is desired!
- **Many difficult accounting problems will be solved.** Some examples of difficult accounting problems are: how should one of a kind assets like a movie or a painting be depreciated over time? Should assets be valued at replacement cost or

¹⁴ For some discussion of these matters, see Diewert (1980), Harper, Berndt and Wood (1989) and Hulten (1990).

¹⁵ For some example of different conceptual frameworks, see Diewert (1985).

their net realizable value? How should transactions costs or installation costs be treated on the asset accounts? How should goodwill be treated? How should research and development capital be depreciated? What is the proper accounting treatment of stock options? What is the “right” way to do current cost accounting? Surely some of these questions will be answered in the years ahead.

5. Conclusion

Although the next two decades will see great progress in measuring price and quantity change more accurately, I believe that in many ways, measurement problems for statistical agencies will become more difficult.

The problem is that the pace of change seems to be accelerating. Why is this a problem? Rates of change for prices and quantities in some domain of definition can only be determined if *the same commodities* (and the same consumers or producers) *are being compared in the two periods under consideration*. Accelerating technological progress means that the pace of new product formation is increasing, which in turn means that all of the new goods and services that appear in the present period cannot be readily compared with the old goods and services of the previous period. Large reductions in trade barriers since the end of World War II and reductions in real transport costs have led to a massive increase in international trade and a further proliferation in products that are new to the local marketplace. This in turn has led to the disappearance of many local firms, which of course creates problems for the measurement of real output change.¹⁶ Conversely, there is a movement towards increased self employment¹⁷, which of course has led to an influx of new firms. In either case, it is difficult to compare like with like.

On the household side of things, it is a similar story of increasing measurement difficulties. Generally lower transport costs and increasing real income have led to a large increase in international tourism. As households purchase an increasing share of their goods and services abroad, it is increasingly difficult to compute a consumer price index. A closely related problem is the growth of internet shopping, which leads to an increasing share of goods being bought abroad. Also, international business consulting is increasing so that consumer workers increasingly purchase their consumer bundles in a variety of countries. Again, this creates difficulties for the accurate construction of a domestic household CPI.

In conclusion, over the next twenty years, statistical agencies will make remarkable improvements to their measurement of basic price and quantity movements but many problems will remain to be solved. Some of these problems will be impossible to solve.

¹⁶ Ideally, we would want to compute establishment specific rates of output and input growth at the lowest level of aggregation. If an establishment is present in only one of the two periods under consideration, the ideal computation becomes impossible.

¹⁷ Whether this is driven by the tax system, which generally favours self employment, or the contracting out phenomenon or the new internet technology, remains unknown. All we know is that in most OECD countries, the proportion of self employed workers has been increasing in recent years.

REFERENCES

- Armknrecht, P. A. and F. Maitland-Smith (1999), "Price Imputation and Other Techniques for Dealing with Missing Observations, Seasonality and Quality Changes in Prices Indices," IMF Working Paper 99/78, Statistics Department, International Monetary Fund, Washington, D.C.
- Becker, G.S. (1965), "A Theory of the Allocation of Time", *The Economic Journal* 75, 493-517.
- Berndt, E.R. (1991), *The Practice of Econometrics, Classic and Contemporary*, Reading, MA: Addison-Wesley Publishing Co.
- Berndt, E.R., Z. Griliches and J.G. Rosett (1993), "Auditing the Producer Price Index: Micro Evidence from Prescription Pharmaceutical Preparations", *Journal of Business and Economic Statistics* 11, 251-264.
- Boskin, M.J., E. Dulberger, R. Gordon, Z. Griliches and D. Jorgenson (1996), *Toward a More Accurate Measure of the Cost of Living*, Final Report to the U.S. Finance Committee, Government Printing Office, Washington, D.C.
- Bradley, R., B. Cook, S.E. Leaver and B.R. Moulton (1998), "An Overview of Research on Potential Uses of Scanner Data in the U.S. CPI", pp. 169-181 in *Proceedings of the Third Meeting of the International Working Group on Price Indices*, Voorburg, April 16-18, 1997, B. Balk (ed.), Statistics Netherlands, Voorburg.
- Caves, D.W., L.R. Christensen and W.E. Diewert (1982), "The Economic Theory of Index Numbers and the Measurement of Input, Output and Productivity", *Econometrica* 50, 1393-14-14.
- Cole, R., Y.C. Chen, J.A. Barquin-Stolleman, E. Dulberger, N. Helvacian and J.H. Hodge (1986), "Quality-Adjusted Price Indexes for Computer Processors and Selected Peripheral Equipment", *Survey of Current Business* 66:1, 41-50.
- Court, A.T. (1939), "Hedonic Price Indexes with Automotive Examples", pp. 99-117 in *The Dynamics of Automobile Demand*, General Motors Corporation, New York.
- Dalén, J. (1992), "Computing Elementary Aggregates in the Swedish Consumer Price Index", *Journal of Official Statistics* 8, 129-147.
- Dalén, J. (1998), "Experiments with Swedish Scanner Data", pp. 163-168 in *Proceedings of the Third Meeting of the International Working Group on Price Indices*, Voorburg, April 16-18, 1997, B. Balk (ed.), Voorburg: Statistics Netherlands.
- De Haan, J. and E. Opperdoes (1998), "Estimation of the Coffee Price Index Using Scanner Data", pp. 183-201 in *Proceedings of the Third Meeting of the International Working Group on Price Indices*, Voorburg, April 16-18, 1997, B. Balk (ed.), Voorburg: Statistics Netherlands.
- Diewert, W.E. (1976), "Exact and Superlative Index Numbers," *Journal of Econometrics* 4, 115-146; reprinted as pp.223-252 in *Essays in Index Number Theory, Volume 1*, W.E. Diewert and A.O. Nakamura (eds.), Amsterdam: North-Holland, 1993.
- Diewert, W.E. (1980), "Aggregation Problems in the Measurement of Capital", pp. 433-528 in *The Measurement of Capital*, Dan Usher (ed.), University of Chicago Press, Chicago.
- Diewert, W.E. (1983), "The Theory of the Cost of Living Index and the Measurement of Welfare Change", pp. 163-233 in *Price Level Measurement*, W.E. Diewert

- and C. Montmarquette (eds.), Ottawa: Statistics Canada, reprinted as pp. 79-147 in *Price Level Measurement*, W.E. Diewert (ed.), Amsterdam: North-Holland, 1990.
- Diewert, W.E. (1985), "Transfer Pricing and Economic Efficiency", pp. 47-81 in *Multinationals and Transfer Pricing*, Alan M. Rugman and Lorraine Eden (eds.), Croom Helm, London.
- Diewert, W.E. (1993a), "The Early History of Price Index Research", pp. 33-65 in *Essays in Index Number Theory*, Volume 1, W. E. Diewert and A. O. Nakamura (eds.), North-Holland, Amsterdam.
- Diewert, W. E. (1993b), "Symmetric Means and Choice Under Uncertainty", pp. 355-433 in *Essays in Index Number Theory*, Volume 1, W. E. Diewert and A. O. Nakamura (eds.), North-Holland, Amsterdam.
- Diewert, W.E. (1995a), "Functional Form Problems in Modeling Insurance and Gambling", *The Geneva Papers on Risk and Insurance Theory* 20, 135-150.
- Diewert, W.E. (1995b), "Axiomatic and Economic Approaches to Elementary Price Indexes", Discussion Paper 95-01, Department of Economics, University of British Columbia, Vancouver, Canada, January.
- Diewert, W.E. (1999), "Index Number Approaches to Seasonal Adjustment", *Macroeconomic Dynamics* 3, 48-68.
- Dulberger, E. (1989), "The Application of a Hedonic Model to a Quality Adjusted Price Index for Computer Processors", pp. 37-75 in *Technology and Capital Formation*, D.W. Jorgenson and R. Landau (eds.), Cambridge, MA: MIT Press.
- Feenstra, R.C. and W.E. Diewert (2001), "Imputation and Price Indexes: Theory and Evidence from the International Price Program", Discussion Paper, Department of Economics, University of British Columbia, Vancouver, Canada, V6T 1Z1, April.
- Griliches, Z. (1961), "Hedonic Price Indexes for Automobiles: An Econometric Analysis of Quality Change", pp. 137-196 in *The Price Statistics of the Federal Government*, G. Stigler (Chairman), NBER, New York: Columbia University Press.
- Harper, M.J., E.R. Berndt and D.O. Wood (1989), "Rates of Return and Capital Aggregation Using Alternative Rental Prices", pp. 331-372 in *Technology and Capital Formation*, D.W. Jorgenson and R. Landau (eds.), The MIT Press, Cambridge, MA.
- Hausman, J.A. (1997), "Valuation of New Goods under Perfect and Imperfect Competition", pp. 209-237 in *The Economics of New Goods*, T.F. Bresnahan and R.J. Gordon (eds.), University of Chicago Press, Chicago.
- Hausman, J.A. (1999), "Cellular Telephone, New Products and the CPI", *Journal of Business and Economic Statistics* 17, 1-7.
- Hawkes, W.J. (1998), "Reconciliation of Consumer Price Index Trends in Average Prices for Quasi-Homogeneous Goods Using Scanning Data", pp. 145-161 in *Proceedings of the Third Meeting of the International Working Group on Price Indices*, Voorburg, April 16-18, 1997, B. Balk (ed.), Voorburg: Statistics Netherlands.
- Hicks, J.R. (1940), "The Valuation of the Social Income", *Economica* 7, 105-140.
- Hulten, C.R. (1990), "The Measurement of Capital", pp. 119-158 in *Fifty Years of Economic Measurement*, E.R. Berndt and J.D. Triplett (eds.), Chicago: the University of Chicago Press.

- Lloyd, P.J. (1975), "Substitution Effects and Biases in Nontrue Price Indices", *American Economic Review* 65, 301-313.
- Moulton, B.R. (1996), "Constant Elasticity Cost-of-Living Index in Share Relative Form", Bureau of Labor Statistics, Washington D.C., December.
- Pollak, R.A. (1980), "Group Cost-of-Living Indexes", *American Economic Review* 70, 273-278.
- Pollak, R.A. (1981), "The Social Cost-of-Living Index", *Journal of Public Economics* 15, 311-336.
- Pollak, R.A. (1983), "The Theory of the Cost-of-Living Index", pp. 87-161 in *Price Level Measurement*, W.E. Diewert and C. Montmarquette (eds.), Ottawa: Statistics Canada; reprinted as pp. 3-52 in R.A. Pollak, *The Theory of the Cost-of-Living Index*, Oxford: Oxford University Press, 1989; also reprinted as pp. 5-77 in *Price Level Measurement*, W.E. Diewert (ed.), Amsterdam: North-Holland, 1990.
- Pollak, R.A. (1989), "The Treatment of the Environment in the Cost-of-Living Index", pp. 181-185 in R.A. Pollak, *The Theory of the Cost-of-Living Index*, Oxford: Oxford University Press.
- Prais, S.J. (1959), "Whose Cost of Living?", *The Review of Economic Studies* 26, 126-134.
- Reinsdorf, M. (1996), "Constructing Basic Component Indexes for the U.S. CPI from Scanner Data: A Test Using Data on Coffee", BLS Working Paper 277, Bureau of Labor Statistics, Washington, D.C.
- Saglio, A. (1995), "Comparative Changes in Average Price and a Price Index: Two Case Studies", *Proceedings of the First Meeting of the International Working Group on Price Indices*, Ottawa, October 31-November 2, 1994, L.M. Ducharme (ed.), Statistics Canada, Ottawa.
- Shapiro, M.D. and D.W. Wilcox (1997), "Alternative Strategies for Aggregating Prices in the CPI", *Federal Reserve Bank of St. Louis Review* 79:3, 113-125.
- Silver, M. (1995), "Elementary Aggregates, Micro Indices and Scanner Data: Some Issues in the Compilation of Consumer Price Indices", *Review of Income and Wealth* 41, 427-438.
- Silver, M. (1999), "An Evaluation of the Use of Hedonic Regressions for Basic Components of Consumer Price Indices", *The Review of Income and Wealth* 45:1, 41-56.
- Stigler, G. (Chairman) (1961), *The Price Statistics of the Federal Government*, NBER, New York: Columbia University Press.
- Triplett, J.E. (1986), "The Economic Interpretation of Hedonic Methods", *Survey of Current Business* 66:1, 36-40.
- Triplett, J.E. (1987), "Hedonic Functions and Hedonic Indexes", pp. 630-634 in *The New Palgrave: A Dictionary of Economics*. Volume 2, J. Eatwell, M. Milgate and P. Newman (eds.), London: The Macmillan Press.
- Triplett, J.E. (1989), "Price and Technological Change in a Capital Good: A Survey of Research on Computers", pp. 127-213 in *Technology and Capital Formation*, D.W. Jorgenson and R. Landau (eds.), Cambridge, MA: MIT Press.
- Triplett, J.E. (1992), "Economic Theory and BEA's Alternative Quantity and Price", *Survey of Current Business* 72:4, 49-52.
- Turvey, R. (1979), "The Treatment of Seasonal Items in Consumer Price Indexes", *Bulletin of Labour Statistics* 4th Quarter, International Labour Office, Geneva, 13-33.

- Waugh, F.W. (1928), "Quality Factors Influencing Vegetable Prices", *Journal of Farm Economics* 10:2, 185-196.
- Young, A.H. (1992), "Alternative Measures of Change in Real Output and Prices", *Survey of Current Business* 72 (April), 32-48.