HOW BEST TO MEASURE WELFARE, REAL INCOME
AND OUTPUT?

A review of T. F. Bresnahan and R. J. Gordon (eds.), *The Economics of New Goods*, The University of Chicago Press, Chicago/London, 1997; B. M. Balk, *Industrial Price, Quantity, and Productivity Indices: The Microeconomic Theory and an Application*, Kluwer Academic Publishers, Boston/Dordrecht/London, and F. M. Fisher and K. Shell (eds.), *Economic Analysis of Production Price Indexes*, Cambridge University Press, Cambridge/New York/Melbourne, 1998.

The Economics of New Goods is directly relevant to recent debates over the properties of the consumer price index (CPI). The CPI is one of the most important numbers in economics. It is used to index wages, pensions and welfare payments, and it is the focus of monetary policy. In the last few years, however, there has been a growing realization that the CPI, as currently measured, is an upward biased measure of changes in the cost of living. In particular, the CPI Commission (see Boskin *et al.*, 1997) claims that for the United States:

> The [CPI] bias looking forward is 1.1 percentage points per year ...
> [O]ver the next decade, [if it continues] this bias would contribute about
> $148 billion to the deficit in 2006 and $691 billion to the national debt
> by then. The bias alone would be the fourth largest federal program,
> after social security, health care and defense.

Most of the bias can be attributed to the failure of the CPI to account for the welfare gains derived from new goods and quality change. *The Economics of New Goods* is a major contribution to this literature. The eleven papers in this volume range from historical studies of particular innovations and their impacts on welfare, to analyses of the actual treatment of new goods and quality change by national statistical offices in their CPIs.

One of the main themes of this review is that it is important to draw a distinction, in a consumer context, between real income and welfare. Such a distinction is particularly relevant to comparisons of living standards over long periods of time (e.g. Nordhaus's comparison, in Chapter 1, between 1800 and 1992). A real income index, typically, assumes that tastes are fixed (which period's tastes should be used as the reference is another matter) and defined in the market domain. In contrast, a welfare index must take explicit account of non-market activities and changes in tastes, which to a certain extent are endogenously determined by technological progress and rising real incomes. As a result, real income and welfare comparisons over long periods of time may diverge significantly. In

general, the increase in welfare will be much smaller than the increase in real income.

Even if we restrict attention to price indexes defined in the market domain, and ignore the problem of changing tastes, it is not clear that we should always be trying to measure changes in the cost of reaching a given level of utility (as is assumed by most of the authors in *The Economics of New Goods*) rather than changes in the price of a fixed basket of goods and services. Which approach is preferable depends on the purpose for which the index is being used.

These criticisms aside, *The Economics of New Goods* is an excellent book that addresses a wide range of issues relating to the impact of new goods, quality change and technological progress on income and welfare. The first four papers are historical reassessments of the impact of new goods and quality change on welfare and the cost of living. Nordhaus shows how innovations in lighting, ranging from the discovery of fire, candles, and oil lamps, through to light bulbs and fluorescent lamps, have caused a dramatic fall in the price of light, which is not captured by standard price indexes. In particular, over the last two centuries, Nordhaus argues that "the traditional price [of light] has risen by a factor of between nine hundred and sixteen hundred relative to the true price." Meanwhile, Raff and Trajtenberg use a hedonic approach to construct quality adjusted prices for the American automobile industry between 1906 and 1940, and Oi discusses the welfare impact of the air conditioner and, more generally, the economics of inventions. The "new good" addressed by Mokyr and Stein is the germ theory of disease. These authors discuss the origin and diffusion of this knowledge, and its impact on behaviour, in the context of a household production model. In this model, households are viewed as producing health for their members, based on prior beliefs on the causes of disease that are revised in the light of new knowledge.

The next four papers focus on contemporary issues. Hausmann shows how the availability of scanner data, combined with increased computing power, is revolutionizing the construction of price indexes. He develops a framework for measuring the welfare gain of a new good econometrically using Hicks's (1940) reservation price approach. Using this approach, Hausmann finds that the welfare gain in the United States, resulting from the introduction of a new brand of breakfast cereal, is approximately $78 million. As a result of its failure to allow for such welfare gains from the introduction of new brands, the CPI for cereal may be overestimated by about 25 percent. Feenstra and Shiells test for bias in the U.S. import price index resulting from the omission of new product varieties and new foreign suppliers of existing products. This bias is analogous to Reinsdorf's (1993) notion of "outlet substitution bias" in the CPI, with new foreign suppliers taking the place of new retail outlets. Feenstra and Shiells show how to correct for new product varieties and suppliers from observable expenditure share data using a constant elasticity of substitution (CES) model of preferences over varieties. They conclude that the import price index has an upward bias of about 1.5 percentage points annually. The paper by Berndt, Bui, Lucking-Reiley and Urban differs from the other papers in the volume in that, instead of focusing on the implications of new goods and quality change for welfare and price indexes, it focuses on the evolution of the market for a particular new good—

anti-ulcer drugs. Berndt *et al.* consider the role of marketing, product quality and price competition in the development of the U.S. anti-ulcer drug industry, and attempt to explain why an entrant, Glaxo's Zantac, was able to gradually surpass the incumbent, SmithKline's Tagamet, as the dominant drug in the industry. The last paper in this section, by Greenstein, uses a vertical product-differentiation model to measure the economic benefits of technological innovation in the computer industry arising from both the declining price of computing power and the extension of computing capabilities.

The final three papers are concerned with measurement practice in official price indexes. Armknecht, Lane and Stewart focus on the treatment of new goods and quality change in the U.S. CPI, while Reinsdorf and Moulton address the problem of formula bias in the U.S. CPI at the lowest (elementary) level of aggregation. They measure the magnitude of the bias for different headings and show how it can be corrected. Finally, Baldwin, Després, Nakamura and Nakamura consider the treatment of new goods in Canadian and Japanese official price indexes.

Alternatively, inflation can also be measured from a producer perspective. The GDP deflator is probably the most important production price index, because it is used to compute real GDP (one of the fundamental aggregates of macroeconomics). Balk's *Industrial Price, Quantity, and Productivity Indices* and Fisher and Shell's *Economic Analysis of Production Price Indexes* both focus on the economic theory underlying production price and quantity indexes. The main unit of interest for Balk is the firm. Fisher and Shell also start at the level of the firm but then extend their analysis to industry and economy-wide indexes. In this sense, Fisher and Shell's book is more ambitious in its scope, which extends to considering the implications, for production price indexes, of technological progress and different forms of market structure. However, what Balk's book lacks in scope it makes up for in rigour and clarity of exposition. Both books fill a gap in the literature, which has tended to focus disproportionately on consumer price indexes.

Fisher and Shell's book is unashamedly theoretical. It builds on and generalizes the theory of production price indexes developed in Fisher and Shell (1972, Essay II). In many respects, the theory of production price indexes is isomorphic to the theory of the cost of living index. In the production context, however, a distinction must be drawn between input price indexes and output price indexes. Fisher and Shell define their production-theoretic input price index relative to the base period isoquant. This index is, in fact, analogous to the Laspeyres-Konüs price index in the consumer theory context (see Diewert, 1981). Similarly, they define their production-theoretic output price index relative to the base period production possibility frontier (PPF). The main focus of the book is the analysis of how market structure and technological progress affect these production-theoretic indexes. In particular, Fisher and Shell construct bounds on their production-theoretic indexes under various scenarios. A number of market structures are considered, in both input and output markets, ranging from competition to monopoly and monopsony. The types of technological progress analyzed are Hicks-neutral, factor augmenting and a more general specification. The book concludes with a discussion of aggregation issues. Of particular interest are the

circumstances under which firm and industry level deflators can be used to construct economy wide production-theoretic output and input price indexes. The authors find that such aggregation is possible in only a quite restricted set of special cases. (A more detailed discussion on this point is included in an Appendix.) This pessimistic conclusion seems to somewhat undermine the usefulness of Fisher and Shell's approach by implying that it cannot be used to provide rigorous foundations for the GDP deflator.

Economic Analysis of Production Price Indexes certainly advances our knowledge of the theory of production price indexes. However, the book is also somewhat unusual in that very little use is made of producer duality theory (which makes the book harder to follow), and because it focuses primarily on just one approach to constructing production-theoretic price and quantity indexes. Fisher and Shell define their production-theoretic input price index as the cost ratio of producing the first period's output, at least cost, given the prices of both periods. They justify using the first period's output rather than the second period's as the reference on the grounds that it answers the question: would today's consumers be better or worse off in a world with yesterday's or today's production system? The same question about yesterday's consumers, it is claimed, is less interesting since yesterday's consumers are no longer relevant to policy decisions. While this may be true, these are not the only options available. For example, the production-theoretic input price index could be defined as the geometric mean of input price indexes computed using, respectively, the base and current periods' isoquants as the reference. Similar criticisms apply to the quantity index. Fisher and Shell derive their input quantity index implicitly by deflating the cost ratio by the input price index. Again this is not the only option. Instead, the quantity index could be defined directly and the price index implicitly. Two ways of defining the quantity index directly are as the ratio of two distance functions, i.e., a Malmquist (1953) index—see Diewert (1992), or, for input indexes, as the cost ratio of producing each period's output, at least cost, given a reference price vector. This latter index is analogous to the Allen (1949) quantity index in a consumer context. Which approach is best may depend on how much variability there is in the price and quantity data—see Allen and Diewert (1981).

A more serious problem with *Economic Analysis of Production Price Indexes* is the complete lack of empirical applications. Nothing is said about how production price indexes should be computed in practice. This is particularly a concern given that the indexes developed in the text are based on unobservable isoquants and PPFs.

Perhaps the main contribution of Fisher and Shell's book is the insights it provides into the similarities and differences between producer and consumer price indexes. It shows that in many respects the two approaches are isomorphic. However, at the same time a number of extra complications arise in a producer context. In particular, a rigorous treatment of producer price indexes cannot ignore the problem of market structure.

Balk's book, unlike Fisher and Shell's, is solidly grounded in producer duality theory. Price, quantity, efficiency and productivity indexes, for inputs and outputs, are developed in terms of cost, revenue and distance functions. Also, it is shown how a change in productivity can be decomposed into a technological

change, an efficiency change and a returns-to-scale effect. Like Fisher and Shell's indexes, none of Balk's indexes are directly observable since they all depend on the underlying production function. However, Balk shows how they can be computed when the cost, revenue or distance functions are assumed to have specific flexible functional forms. Using this methodology, price, quantity, efficiency and productivity indexes are computed for 18 Dutch firms in a panel data set covering the period 1978–92. The book concludes with a discussion of quality change and new (and disappearing) inputs and outputs. It is shown how quality change can be modelled using a hedonic approach, while new inputs and outputs can be modelled using either Hicks's (1940) reservation price approach or Feenstra's (1994) approach based on constant elasticity of substitution (CES) revenue functions.

The main weakness of Balk's book is that it does not discuss aggregate production indexes such as the GDP deflator. Furthermore, both Balk and Fisher and Shell completely ignore probably the most important current research issue in the production price index literature—the problem of measuring output and productivity in the service sector, especially in health, education and financial services. In these sectors, the approaches followed by Balk and Fisher and Shell are not applicable since the outputs are typically not well defined. When measuring real GDP in these hard-to-measure service industries it is typically assumed that output rises proportionately with inputs, thus ruling out productivity improvements by assumption. This imparts a serious upward bias to the implicit price deflators for these industries. Given that the share of such hard-to-measure sectors of the economy is growing (see Griliches, 1994), such practices may go a long way towards explaining the so-called productivity paradox. If we want to know what is actually going on in the economy, it is time that economists start taking the service sector seriously.

The consumer and producer index number literatures are linked by the household production model. For example, Nordhaus, in his innovative paper, argues that purchased goods (such as light bulbs, cars and air-conditioners) are inputs that are used to produce service characteristics (such as illumination, transportation and temperature) and that the latter rather than the former are the appropriate elements in the utility function. A similar approach is followed by Mokyr and Stein in their paper on the germ theory of disease.

An interesting implication of the household production model is that the CPI, as it is currently measured, is a consumer input price index, while the cost of living index is a consumer output price index. Framing the problem this way provides a useful link between the three books, since Balk and Fisher and Shell provide detailed analyses of the relationship between production input and output price indexes. Applying their methodologies to the household production model might shed light on the relationship between the CPI, as currently measured, and the cost of living index. Any such links would be useful since the consumer output price index (the index of primary interest for Nordhaus, Mokyr and Stein) is much harder to measure than the consumer input price index.

The main attraction of the household production model is that it provides a conceptual framework for dealing with new goods and quality change, both of which represent falls in the shadow price of existing output characteristics. New

goods rarely translate into new characteristics. For example, light bulbs supply illumination and automobiles provide transportation. Both the illumination and transportation characteristics existed before the invention of the light bulb and automobile, respectively. In fact, if service characteristics are defined sufficiently broadly, it may be possible to dispense with new characteristics almost entirely. The main drawback with this approach is that the characteristics are typically unobservable, and hence their shadow prices are hard to compute. Although Nordhaus manages, with considerable ingenuity, to compute shadow prices for light, most other characteristics will prove less tractable.

Two further questions emerge from the household production approach. First, is the resulting cost of living index dependent on how the output character- istics are defined? This is important since often it is not clear what the appropriate characteristics are. For example, take the themes of the papers by Oi (air-condi- tioners) and Mokyr and Stein (the germ theory of disease). The service provided by air-conditioners could be temperature control or, more generally, comfort, while the service provided by the germ theory of disease could be health or, more specifically, days of illness per month. It is not always clear what the appropriate level of abstraction is, which gives a certain arbitrariness to the characteristics approach. Second, are we concerned only with service characteristics supplied by the market mechanism? For example, a person's family has an impact on their utility. Therefore, should changes in family services affect the cost of living index? This depends on how the cost of living index is defined. Pollak (1989) distingu- ishes between a conditional cost of living index, defined only on the market domain, and an unconditional cost of living index that also includes non-market factors.[1] In other words, changes in family services affect the unconditional cost of living index, but not the conditional cost of living index. Once we move away from the goods actually purchased to the underlying service characteristics, how- ever, the distinction between market and non-market activities, and hence between the conditional and unconditional cost of living index becomes somewhat blurred.

At this point it is important to distinguish between a real income index and a welfare index.[2] A real income index is obtained by deflating nominal income by the conditional cost of living index. Since the conditional cost of living index is only defined in the market domain, the same applies to the real income index. In contrast, a welfare index is obtained by deflating nominal income by the uncon- ditional cost of living index. Factors that affect welfare but are not in the market domain (such as stress, job security, status, leisure time, crime, the environment, and household production) are included in the welfare index but are excluded from the real income index. That the distinction between these indexes is some- what blurred is illustrated by the example of health. Clearly health services are within the market domain, while other factors that affect health, such as stress,

[1] Both Diewert (1997, 1999) and Hill (1999a, b) stress that the choice of domain for a cost of living index is conceptually difficult, and of critical importance. The issues extend far beyond Pollak's simple taxonomy of conditional and unconditional cost of living indexes.

[2] Hill (1999a, b) draws a similar distinction. He then explores the impact of factors such as the weather, earthquakes and crime rates on conditional and unconditional cost of living indexes, income and welfare.

are not. Reading some of the articles in *The Economics of New Goods* it is not always clear whether the authors are trying to measure changes in real income or welfare. A few attempts have been made to construct welfare indexes. One example is the Genuine Progress Indicator of Cobb, Halstead and Rowe (1995). However, welfare and unconditional cost of living indexes are of little use in practice since the measurement problems are so severe that one can have little confidence in the resulting aggregate.

In an admittedly speculative section at the end of his paper, Nordhaus attempts to move beyond the estimation of the shadow price of light to the measurement of changes in real income over the last two hundred years. According to the conventional wisdom, real wages have grown by a factor of 13 over this period. In contrast, Nordhaus argues that, when full account is taken of new goods and quality change, real wages have risen by a factor of between 40 and 190. Hulten in his comments on Nordhaus's paper draws attention to the implications of these results.

> It suggests that the average colonial should prefer living in the America of today, with as little as $90 per year [the lower bound obtained by deflating current average income by 190], to staying put in the late eighteenth century. It is hard to imagine anyone wanting to live in modern America with an income of $90; it is only just imaginable that anyone would want to live with an income at the upper end of the Nordhaus range.

In other words, it seems that something must be wrong with Nordhaus's results. In fact, the problem is not with the results, but with the interpretation. A 190-fold increase in real-income does not imply a 190-fold increase in welfare. Changes in welfare are likely to be much smaller than changes in income because changes in income induce changes in tastes and because welfare, like poverty, is to a certain extent a relative concept.

Focusing on the former first, why might we expect tastes to have changed between 1800 and 1992? As Bresnahan and Gordon point out in the introduction to the volume, in addition to satisfying a previously unmet need, new goods also frequently induce a change in tastes. For example, the invention and development of the automobile (itself the subject of Raff and Trajtenberg in Chapter 2) led to the growth of suburbs, and a change in preferences over geographical location. The fall in the cost of transportation made suburbs more accessible and, as a result, public services in city centers declined, which further re-enforced the desire to move to the suburbs. Similarly, Oi in Chapter 3 describes how air-conditioners destroyed the front porch society of Dixie. Both these examples illustrate a multiple equilibrium aspect to tastes. If everyone else wants to live in the suburbs (city center) then so will you. Likewise, being on your front porch is much less fun if everyone else is indoors. In both cases technological progress caused tastes (at least in the United States) to shift from one equilibrium to the other.

It follows that rapid technological progress since 1800 may have caused a dramatic change in tastes. As tastes diverge, the results of a real income comparison between 1800 and 1992 will become more and more sensitive to the choice of reference utility function. As a result, the observed real income differential

between 1800 and 1992 may be much larger if based on 1992 tastes than if based on 1800 tastes.

That welfare is at least partly a relative concept has been noted by, amongst others, Duesenberry (1949), Pollak (1976) and Easterlin (1995). For example, Easterlin states that:

> Happiness, or subjective well-being, varies directly with one's own income and inversely with the incomes of others. Raising the incomes of all does not increase the happiness of all, because the positive effect of higher income on subjective well-being is offset by the negative effect of higher living level norms brought about by the growth in incomes generally.

Or as Karl Marx puts it:

> A house may be large or small; as long as the surrounding houses are equally small it satisfies all social demands for a dwelling. But if a palace rises besides the little house, the little house shrinks into a hut (as quoted in Easterlin, 1995).

Easterlin finds empirical support for this hypothesis in survey data for the United States, Japan and a number of European countries. Essentially, what Easterlin is saying is that an individual's utility function is increasing in their income, and decreasing in average income. Trying to increase everyone's happiness is like trying to make everyone taller than average. The relative nature of the concept makes this goal impossible to achieve. Therefore, Easterlin's theory implies that rising real income, by itself, also changes tastes by lowering the marginal utility obtained from all goods.

Sen (1999) provides an alternative, but related, reason why welfare has a relative component.

> Utilities may sometimes be very malleable in response to persistent deprivation. A hopeless destitute with much poverty, or a downtrodden labourer living under exploitative economic arrangements, or a subjugated housewife in a society with entrenched gender inequality, or a tyrannized citizen under brutal authoritarianism, may come to terms with her deprivation. She may take whatever pleasure she can from small achievements, and adjust her desires to take note of feasibility (thereby helping the fulfilment of her adjusted desires).

Sen emphasizes the importance of expectations. If one expects little, one will be easily satisfied. Since what one expects depends largely on the experiences of one's peers, Easterlin's and Sen's perspectives are two sides of the same coin. Given the endogeneity of tastes, in response to changes in income, it is important that changes in real income are not confused with changes in welfare.

It is also important to distinguish between cost of living indexes and fixed basket price indexes.[3] Diewert (1999) and Hill (1999b) both refer to a fixed basket

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[3]It should be emphasized that a fixed basket price index does not necessarily imply using either Paasche or Laspeyres. In fact, to maximize characteristicity, it is better to use a symmetric mean of the baskets of the two periods as the reference basket. Such price indexes have almost as long histories as Paasche and Laspeyres. In particular, Edgeworth (1925; p. 213—originally published in 1887) and Marshall (1887) suggested using the arithmetic mean, while Walsh (1901) suggested the geometric mean—see Diewert (1993) for more details.

price index as a *pure* price index. It is pure in the sense that the only thing that changes between the two periods is the prices. Most of the authors in *The Economics of New Goods* take it as given that the appropriate measure of inflation, in a consumer context, is the change in the (conditional) cost of reaching a given level of utility rather than the change in the price of a fixed basket of goods and services. This is not necessarily the case. A pure price index is usually discarded on the grounds that it depends on the choice of basket. A similar criticism, however, could be made of a cost of living index. It depends on the choice of reference consumer and reference utility level (unless preferences are homothetic). A pure price index is also criticized because the basket becomes less characteristic of current consumption patterns over time. This problem can be addressed by chaining the price index, i.e. updating the basket every period. It is also criticized for lacking economic foundations, i.e. it is not couched in a utility maximization framework. As has been argued above, however, the foundations of the economic approach are not as solid as one would like to think. As soon as the objective shifts from measuring changes in the cost of a fixed basket of goods to changes in the minimum cost of reaching a given level of utility, we must confront problems of preference aggregation across consumers, changing tastes, the treatment of new goods and non-market activities, and the link between income and welfare.

Whether a cost of living index or a pure price index is more appropriate depends on the purpose for which the index is being used. It is far from clear, for example, that a cost of living index should be used to index public sector wages and salaries. As Easterlin notes, people are concerned about preserving their position in the income distribution, and, typically, have this in mind when they use the CPI as a point of reference in wage negotiations. Hence it might make more sense to index wages to a pure price index or an index of hourly earnings than to a cost of living index.[4]

What price index should a central bank be targeting? Since central banks are interested, primarily, in monetary phenomena, the change in the price of a representative fixed basket of goods is of greater relevance than the change in the minimum cost of reaching a given level of utility. Furthermore, it is not clear why it should be particularly interested in targeting only the prices of consumer goods. If the underlying objective of monetary policy is to smooth out the business cycle, then the domain of the target price index should be extended to include asset prices, particularly shares, bonds and property, since rapid rises in wealth can feed through to consumption and cause the economy to overheat.[5] Conversely, a stock market crash can cause a recession. The idea of including asset prices in the target price index is not new. In fact, it dates back to Fisher (1911), who argued that there is a close relationship between asset prices and monetary growth (see *The Economist*, May 9, 1998, and September 25, 1999). Once assets are included, it becomes harder to link the index directly to utility as assets, in general, do not provide utility of themselves. Therefore, the GDP deflator may, in principle, be a better target for monetary policy than the CPI since it, at least, includes the

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[4]Since it ignores the contribution of new goods to utility, a pure price index would rise faster than the cost of living index. This would be good for public servants if their wages were indexed to inflation, but bad for the government's budget.

[5]Although the CPI generally ignores asset prices, one important exception is housing.

prices of newly produced assets.[6] Even the GDP deflator is deficient, however, since it excludes the prices of already existing assets.

Recently, some national statistical offices (notably Australia and the United Kingdom) have started experimenting with more broadly defined price indexes. If central banks targeted a price index that includes asset prices, this would reduce the likelihood of stock market crashes by encouraging governments to take preventive action before a speculative bubble bursts. Hence, it is surprising that it has taken so long for national statistical offices to start taking an interest in such indexes. In all likelihood, given the current bull-run on Wall Street, a more broadly defined pure price index, that included assets, would, over the last decade, have risen rather faster than the consumer price index. Hence perhaps recent inflation is, in fact, being underestimated (the CPI Commission notwithstanding).

This survey has touched on a number of topical issues in index number theory. In a producer context perhaps the most pressing problem is the measurement of output and productivity in the service sector of the economy. In a consumer context, the treatment of new goods in the CPI, and the associated claims of upward bias, have recently attracted much interest. However, two issues that have not received enough attention are the treatment of asset prices, especially in a central bank's target price index, and the distinction between changes in purchasing power (real income) and changes in welfare. Welfare, unlike purchasing power, is to a certain extent a relative concept, and hence tends to rise more slowly over time. In comparisons between distant time periods it is important that these concepts are not confused.

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[6]One significant advantage of the CPI, in practice, is timeliness.

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