The Contributions of Angus Deaton

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Introduction

Angus Deaton was awarded the 2015 Nobel Prize in economics for "for his analysis of consumption, poverty, and welfare". The study of consumption is fundamental to economics and is a crucial input in human welfare. Deaton has been at the forefront of the field throughout his career and much of what he has written has shaped developments in the area, setting research priorities.

Understanding what drives consumption matters for designing economic policies. For example, a government that is contemplating putting a tax on sugar to fight childhood obesity should only do so in full knowledge of how consumption patterns vary across households and how they are likely to respond to such a tax. Angus Deaton's research has provided us with ways of thinking about estimating demand systems and their use in studying taxation.

Many policy debates centre on how living standards have changed as societies develop, in particular how gains (or losses) are distributed. Governments are held to account for their record on such things and a proper empirical and conceptual framework is needed. The same goes for looking at how different regions within a country fare. Any economist or policy analyst who looks carefully at the issues will learn a lot from studying Angus Deaton's work which has examined how the consumption of individuals relates to economic development in society at large, bringing out a series of methodological and practical issues. He has also considered how patterns of mortality, life-satisfaction and morbidity relate to developments in the economy.

Policy makers also spend time worrying about what drives saving behaviour. A range of policies are in place to promote savings, either to provide a buffer stock against unforeseen events or as a source of support in later life. Here too, researchers will encounter Angus Deaton's path-breaking research on savings and incomes.

But while his work is immediately applicable and useful, Deaton's contributions are also intellectually ambitious and rigorous. His work has fuelled debates within the discipline of economics and is taught in classrooms all over the world. The work addresses fundamental questions which lie at the core of economics.

In this short article, I will discuss some of his work to offer the reader a flavour of the many important contributions which led up to his being honoured with a Nobel Prize. My perspective is subjective and sketchy and no substitute for reading his work. The breadth of Deaton's work makes it difficult to do full justice to the full range of his achievements in a short appreciation. He is one of the leading applied economists of his generation. His career spans a period in which empirical work was growing more important and approaches to it were changing, from requiring main-frame computer technology through the "push-button" revolution in applied research. There has also been an enormous increase the quality and quantity of available data. Deaton has been a pioneer throughout his career, pushing forward the research frontier.

It is also difficult to appraise Deaton's contribution in an entirely consistent way since his research style and priorities have evolved as he has developed his views on applied research and new data have created fresh ways of looking at issues. But while his specific interests have also changed over time, there is a common core and a distinctive approach to the way that he has developed his research which I will endeavour to bring out in the remainder of this article as I discuss his work.

Angus Deaton was born and brought up in Scotland. He earned his bachelors and PhD degrees at Cambridge and, from there, worked initially at the Bank of England before returning to Cambridge as a researcher in the Department of Applied Economics. He subsequently moved to the Economics Department at Bristol before moving to Princeton where he remains, with a joint appointment in the Economics Department and Woodrow Wilson School of Public and International Affairs. Among Deaton's important early influences were Richard Stone and W.M. (Terence) Gorman who were his foremost mentor and examiner respectively. While Stone was to became a Nobel laureate, Gorman's pioneering contributions in consumer theory are somewhat less well-known outside the field. From Stone, Deaton inherited an appreciation of the centrality of measurement and not taking the data for granted. Gorman's influence is clearly visible in Deaton's interest in aggregation and his appreciation of the potential straitjacket imposed by restrictive functional form assumptions. His appreciation of the implications of consumer theory in much of his work also brings his contributions close to Gorman's interests.

Deaton has contributed to a number of fields in economics. But his central contribution to knowledge, beginning with work in his PhD thesis, has been in the study of consumer

behaviour and its pursuit through the use of household survey data. He is one of the world's greatest experts in this area and a pioneer in developing empirical analyses of micro data from such surveys. From the mid-1980s onwards, this led to an interest in development economics where household data were becoming increasingly available. He shaped that agenda through his work with the World Bank as it rolled out a major effort in collecting household survey data. He joined, and subsequently became the Director of, the Research Program in Development Studies at Princeton University which W. Arthur Lewis had founded. In his early years at Princeton Deaton focused his work on savings behaviour, and in that period he wrote papers that are experiencing a renaissance in the current macro literature on savings. The 1990s saw him switching increasingly to an interest in determinants of health and wellbeing, which remains grounded in the use of survey data. Reflecting these interests, he also played a key role in founding the Center for Health and Wellbeing at Princeton University.

There are many admirable traits to Deaton's work. He is known for thinking carefully about measurement issues in the data which he uses. His papers have developed original theoretical insights which have underpinned his empirical approach. A hallmark of his work looks at the world from the perspective of individual (and occasionally household) decision making. Deaton's work addresses issues of immense practical significance and, as noted above, he has produced many contributions that inform aspects of policy-making.

Deaton has received many honours already including being a Fellow of The Econometric Society, past President of the American Economic Association, a Fellow of the American Academy of Arts and Sciences, the National Academy of Sciences, the BBVA award in economics and, now the Nobel prize. He has also been a major citizen of the economics profession having served as an associate editor of *The Review of Economic Studies* and editor of *Econometrica*. And as a commentator, he is sought after for his views on a range of issues, both in academia and in the policy world, including chairing a major review of research at the World Bank. Apart from sharing his powerful insights as an economist, he approaches every task with a wealth of personal warmth, wit and charm. Those who have experienced his friendship and guidance first hand are privileged indeed.

In reviewing Deaton's contributions, I will give most weight to his work on consumption, demand estimation, household survey data and the measurement of well-being. These are

areas where he has made landmark contributions on a sustained basis for more than forty years.

Consumer Demand

The study of consumer demand has been a central concern throughout Deaton's career and was the basis of his PhD thesis. There are four aspects of Deaton's studies of consumer behaviour that unify his work and shape his approach in the field. First, a concern for the theoretical structure behind demand systems, in particular how the structure of preferences matters. Second, an interest in what can be done with household data as opposed to looking only at aggregates. Third, he has a strong interest throughout his career in dynamic consumer behaviour. Fourth a concern for how looking at consumer demand and household data can inform welfare comparisons, including the measurement of inequality and poverty. He has throughout all phases of his career had an agenda-setting role in all of these areas.

Deaton's work on consumer behaviour has always had, as a hallmark, the interplay between theory and data. When Deaton began his career, duality theory as pioneered by Gorman and McFadden was beginning to be absorbed into the study of consumer behaviour where it could exploit the fact that the natural exogenous variables in consumer demand were prices. Thus, all the relevant information about preferences could be embodied in cost and indirect utility functions which had simple basic relations to observables such as consumer demand through "envelope properties" such as Shephard's Lemma and Roy's Identity. Widespread appreciation of these ideas was given a boost by Varian's graduate text (Varian 1978) and Deaton and Muellbauer's book (Deaton and Muellbauer, 1980a) which I discuss further below.

Although knowledge of duality was growing in the 60s and 70s, it was not entirely clear how these ideas would transform applied research. Depending on the problem at hand, a whole suite of preference representations was now available. Deaton later exploited this idea in the study of optimal taxation as discussed further below. But the real challenge, which has been central to his career, was using these ideas in practice, both estimating demand systems and understanding household behaviour. Using duality is also immensely useful in making welfare comparisons as it gives a transparent way of thinking about how price information is aggregated through theory-based welfare comparisons. Before these approaches, price indices were largely thought of in statistical terms, i.e. computing some kind of chain-weight averages rather than in terms of how these mapped back to consumer demand. But cost

functions made this clear. This had powerful implications for making comparisons of household welfare (and, by extension, national welfare) across households with different demographic compositions, those at different locations and over time in response to growth and economic change.

When Deaton started his career in the early 1970s, estimating demand systems was a challenging econometric and computational exercise, especially where there were efforts to impose properties from theory such as either testing or imposing the property that the Slutzky matrix of compensated demands is negative semi-definite. This was a big issue since this is one of the main implications of "rationality" in demand systems. It is essentially the Hessian of the cost function whose theoretical properties do not depend on strong assumptions about underlying preference properties apart from some fairly weak consistency requirements. So, to a point, this work was actually testing one of the most basic ideas of economic theory based on optimization under linear constraints. But even on modest amounts of data, it posed a challenge to computer power. However, there were good data available which had mostly been collected for the purposes of constructing price indices. Much of the early literature had for computational purposes used the linear expenditure system (sometimes known as the Stone-Geary utility function in honour of the pioneers of early applied demand research). This put severe restrictions on own and cross-elasticities and on the shape of Engel curves. Before Deaton's work, there was relatively little estimation of demand *systems* and he pushed this field to a new level of sophistication. In the process, he was able to show how difficult some of the issues were and to point the way for the next generation of researchers to find further improvements in methods.

Two of Deaton's earliest papers, both published in 1974, set the stage for much of his subsequent work. The first of these was published in *Econometrica* (Deaton 1974a) on estimating a demand system on aggregate data. This was a seminal paper and was awarded the first Frisch medal of the Econometric Society. From a technical point of view, the paper focused on the need to make a host of special parametric assumptions to be able to estimate a demand model. It thus raised a range of issues that remain at the core of applied research where there are always important decisions about what to assume and how to measure important concepts from the theory. Deaton's work was a pioneering contribution with a special place in the history of applied economics. It was, at the time, the most sophisticated work which considered how to bring theory and data together in demand estimation which became a burgeoning field, in part due to his influence. Deaton (1974a) was among the very

first papers in economics to formulate and estimate a demand system following the earlier efforts of Stone (1954) and Barten (1969). It is hard to understand the achievement from a modern perspective when computer power is now so easily available and data so plentiful how challenging it was at the time to estimate the Slutzky matrix of a demand system (albeit for only a nine commodity grouping). He tested some of the key properties of demand systems and found qualified support for a neoclassical consumer demand model in the data; the Slutsky matrix did not seem to be negative semi-definite , but interestingly, with only one positive eigenvalue. This work influenced all subsequent developments in the area, becoming a standard reference.

As already noted, discussion of functional forms needed to make the estimation tractable was a central issue. Deaton was one of the first people to recognize that this had significant implications for demand estimation which could impose unwelcome properties on the data from the theory *by assumption.* His *Economic Journal* (Deaton 1974b) paper was influential at the time among those who had proceeded, seemingly without thinking, from models with additive preferences. Deaton's interest in functional form and its implications has continued throughout his work on consumption (see, for example, Deaton, 1981a on functional form choices when estimating models which simultaneously look at demands and labour supply together) and his development of the Almost Ideal Demand System which I will discuss below.

Deaton's early interest in consumer behaviour led him to be one of the first economists to apply non-parametric estimation to a practical problem. He studied the shape of Engel curves from the consumption of rice in Thailand. Typical of Deaton's work, this arose from the practical problem of gauging the distributional consequences of rice subsidies and how far they were effective as an anti-poverty measure. The shape of the Engel curve needed to be flexible enough to estimate this rather than imposing the answer through choosing a particular functional form as had always been typical in the past. In a paper published in the *Economic Journal*, (Deaton, 1989a) Deaton showed how non-parametric estimation was feasible at a time when this was not part of any push-button routine in econometric packages and choices had to be made about the form of Kernel, bandwidth etc. The paper was pioneering and also provided a foundation for studying distributional effects for policy purposes. This would now be viewed as a routine exercise in a package like Stata.

In the 1970s and 80s, Deaton published a number of papers which further our understanding of demand estimation, many combining methodological advances with practically relevant parameter estimation (such as Deaton, 1987b). Estimating a demand system in the presence of quality heterogeneity is a central challenge in his paper on quantity, quality and spatial price variation published in the *American Economic Review* (Deaton, 1988). It is motivated by a simple issue – supposing that individuals consume not only different quantities of goods but also different qualities. However, household survey data only gives aggregates for commodity groupings rather than fine-grained data on the quality of the goods consumed. Moreover, when household data is collected by clusters, there are often spatial differences in prices for particular goods which could reflect quality as well as "true" price differences. Deaton begins from a theoretical model of quality and quantity choice and uses this to generate an estimable approach to the demand for commodity groupings. He applies the ideas in a concrete setting using data from Cote d'Ivoire. The paper has many admirable qualities: a practical motivation, developing a new theoretical framework to guide the empirics, innovative methods of wider significance and an application to illustrate the idea at work.

Although his early work looked at aggregate behaviour, Deaton was among the first researchers to worry about aggregation issues in applied demand analysis. And he found an ally in thinking this through in John Muellbauer. Although Deaton had a keen interest in work on aggregate consumption, largely I suspect as a means of making progress in estimation, his work always suggested that he appreciated that it was necessary to understand the underlying behaviour of heterogeneous households. Theoretical concerns about aggregation were of long standing, especially the seminal contributions of Terence Gorman. The Gorman polar form did suggest a wider class of preferences. But in practice, homotheticity was assumed as a means of getting a representative consumer which is extremely restrictive as a practical matter.

It was down to Deaton, working with Muellbauer, to find a more general, yet applicable, empirical approach. The latter had been independently working on how to move beyond homothetic preferences by defining a representative consumer as distinct from a consumer with average income (see Muellbauer, 1975, 1976.) This collaboration resulted in the development of the Almost Ideal Demand System which featured in a joint paper with Muellbauer in the *American Economic Review* (Deaton and Muellbauer, 1980b). This has more than 3500 Google Scholar cites and even thirty years on remains a cornerstone of

demand estimation. Their basic idea was to specify a model which could be estimated on aggregate data without imposing too much structure on demand elasticities and the shape of Engel curves. The approach also allowed a notion of a "representative consumer" that made sense theoretically, but generalized Gorman's conditions by allowing for the possibility of "geometric" rather than "mean" representativeness, i.e. one could work with other kinds of weighted averages of incomes so that income distribution matters. This approach became a staple in applied demand analysis: for example, Blundell et al, (1993) and Banks et al (1997).

Consumption Dynamics and Savings Behaviour

Deaton maintained a close interest in aggregate savings behaviour and how consumption/savings decisions are made. This has resulted in a number of landmark contributions.

Among Deaton's earliest work on consumption was his paper on how levels of inflation affected savings which was published in the *American Economic Review* (Deaton, 1977). This spoke to a debate at the time on why it appeared that savings seemed to have risen rather than fallen in the high inflationary climate of the 1970s which defied simple standard logic. Deaton hypothesized that consumers confused absolute and relative price changes. The paper had a major influence in debates at the time. This would be described as "behavioural economics" today. However, in terms of what it says about Deaton as an economist, it shows that he was (and remains) willing to look beyond any conventional view and to try to bring theory to the data in addressing apparent empirical puzzles.

This was also characteristic of Deaton's paper with John Campbell (Campbell and Deaton, 1989) published in *The Review of Economic Studies* which challenged the conventional wisdom at that time that consumption is smooth because permanent income is smoother than measured income.[1] They showed in their work that permanent income is in fact less smooth than measured income, so that the smoothness of consumption cannot be straightforwardly explained by standard permanent income theory. They looked at post-war quarterly U.S. data on aggregate consumption and argued consumption is smooth in these data because it responds with a lag to changes in income.

Intertemporal choice and inequality were explored together in (Deaton and Paxson, 1994) which studied the implications of the permanent income hypothesis among cohorts of

[1] This built on Deaton (1987a).

individuals. Beginning from a standard model of intertemporal choice, they observe that the theory implies that in any cohort of people born at the same time, inequality in both consumption and income should grow with age. They investigate the prediction using cohort data in the UK, US and Taiwan, showing that within-cohort consumption and income inequality measures do indeed increase with age in the three economies and that the rate of increase is similar in all three. They argued that the evidence on the spread of inequality can therefore be used to help quantify the extent to which private and social arrangements moderate the impact of risk on the distribution of individual welfare.

In the late 1980s, Deaton became interested in buffer stock models of savings (Deaton, 1989, 1990). In the absence of borrowing opportunities, consumers can periodically cash out their savings as part of an optimal savings strategy. Such models were particularly appealing in the development literature due to restrictions on borrowing opportunities. Little was known about the empirical properties of these models before Deaton's work. Deaton took a conventional model with non-negative savings and iid income shocks to look at patterns of consumption and saving. He characterized the consumption function using dynamic programming methods and then simulated the model to get a feel for its empirical predictions.

One striking feature of Deaton's savings and buffer-stock model is how a stationary economic environment results in serial correlation in consumption behaviour. This made his work relevant immediately to the study of precautionary savings. The literature on precautionary savings at the time was mainly being motivated by the assumption that a consumer had a positive third derivative to their utility function. But the buffer stock model provided a much more natural way of thinking about such issues based on an economic constraint (the absence of borrowing opportunities). Deaton's work became a cornerstone contribution in the subsequent literature and was pioneering in using simulation methods to study dynamic paths from an underlying dynamic programing model. There was a lot of interest in related issues at the time. For example, Zeldes (1997) was pursuing an interest in the importance of borrowing constraints working from the Euler equation with an "extra" Lagrange multiplier used to represent the liquidity constraint when it was binding. This approach is illuminating for empirical purposes but what becomes clear from the Deaton analysis is that a complete understanding of the solution requires studying the *global* structure of the policy function which is hard to learn about from looking at first order

conditions. There was also a link to wider debates about the "excess" sensitivity of consumption to current income following Hall (1978) which was a seminal piece in the area.

One nice feature coming out of studying the global policy function is that one can begin to assess how close "rules of thumb" to guide savings decisions might be close to optimal, an issue which again is pretty hard to debate without an understanding of the globally optimal policy function. This also had echoes of ideas that have become more openly discussed now that the field of behavioural economics has grown. More generally, it would be a mistake to think that the pioneers of consumer theory such as Gorman were unaware of the need to provide models of choice that were psychologically grounded. And one of the key ideas in consumer demand theory, the notion of separable utility function which allowed optimization decisions to be broken into more tractable sub-optimization problems was a case in point.

Commodity Prices

Deaton's work on the buffer stock savings model was linked to a collaboration with Guy Laroque which was aimed at understanding well a model of storage that could be used to fit the time series properties of commodity price series. This work led to two important contributions published in the *Review of Economic Studies* and the *Journal of Political Economy* (Deaton and Laroque, 1992, 1997).

Underpinning this work was an exploration of the theory and evidence on commodity price dynamics with limited storage in a world of stochastic supply. Traders could decide on optimal stocking based on expectations of future prices and output. But there is a lower bound (zero) on storage capacity. This non-negativity constraint makes the problem challenging. Empirically, it implies serial correlation in prices even when shocks are iid. This is because there is gradual building of stocks and the fact that stocks cannot be negative. The second paper studied the empirical implications of the theory and showed that some kind of serial correlation in output shocks was needed for the model to fit the data. These papers are a good example of theory-driven applied research aimed at understanding how to improve the theory.

Thus fuelled Deaton's wider interest in how aggregate commodity prices affected the economies of Africa which was developed in (Deaton and Miller, 1995). The work required thinking about how to construct an index of commodity prices using UNCTAD data and he

suggested a method which reflected his long-standing interest in index numbers. A wider discussion of commodity prices and growth was published as Deaton (1999).

Panel Data

One important idea that came out of Deaton's work on consumption was the analysis of pseudo-panel data by combining household surveys to create a time series of cross-sections. Since many countries have repeated cross-sectional data available but do not follow the same households over time, it is common to be able to do this. The idea is to create "cohorts" in the data and to calculate statistics from them, such as means, medians or variances, which are then estimates of the same statistics from the underlying cohort. Deaton played a key role in systematizing thinking about these issues in a way that shaped the literature. In an influential article published the *Journal of Econometrics*, (Deaton, 1985), he discussed the issues that arise in this exercise, particularly when choosing the size of cohorts (e.g. five year versus one year cohorts).

This research program led to discussions about the merits of a time series of cross-sections versus panel data. This became instrumental in debates at the World Bank which at the time had decided to invest in household data and was wondering whether to make this panel data, i.e. trying to follow the same households over time. As Ashenfelter, Deaton and Solon (1986) noted, it is by no means clear that the biases in tracing households and measurement error would make the effort worthwhile. Studying cohorts would often mitigate the measurement error problem in studying the dynamics of consumption over time.

His thinking on such issues illustrates one of Deaton's important virtues – he studied a practical problem rigorously in order to inform something of great interest to policy-makers (in this case the World Bank). This is the kind of thing that made him a natural successor to his mentor Richard Stone. Moreover, this is indicative of why his work has been so influential. He solves problems that matter and which researchers who follow him can incorporate into their research. Later, and to acknowledge his central role in their work program, the World Bank invited Deaton to write his book on the analysis of household surveys, a work which I discuss further below.

Deaton first applied the idea of studying cohorts in dynamic demand systems in his paper in *Econometrica* (Browning, Deaton and Irish, 1985). They proposed a profit function representation as a way of looking at the data. This approach is in the spirit of Frisch as

demand systems are characterized by taking the marginal utility of income as a conditioning variable. From this perspective, the "price" of utility in a profit function is the inverse of the marginal utility of income. And this evolves stochastically to separate commodity demands and labour supply at a point in time from the dynamic evolution (captured in the evolving price of utility which looks like a standard Euler equation). This creates a very convenient separability between two dimensions of choice (the static and dynamic). Others, such as Heckman and MacCurdy (1980), had exploited similar ideas in studying dynamic labour supply. Hall and Mishkin (1982) also used this idea in their paper on dynamic consumption.

Implications of Household Composition

Deaton also took a keen interest in household composition and consumption patterns. One of the staple issues in consumer behaviour has been how to treat children and a large literature emerged on household equivalent scales as a means of modelling demand patterns and of making comparisons of welfare across households with different demographic composition. A number of methods were suggested including some that made comparisons which depended on the prevailing price vector. This is based on the idea that households with different composition have different consumption bundles which goes back to pioneering contributions by Ernst Engel and Erwin Rothbarth. One key idea is that if goods that are consumed disproportionately by households with children are relatively more expensive, this should be reflected in the equivalence scale used. Although Deaton was not the founder of this literature, he made some important contributions to it. In a paper in the *Journal of Political Economy* Deaton and Muellbauer (1986) discussed some of the different methods of looking at child costs, comparing one method based on Engel curves with Rothbarth's adult good method. They show that these different approaches can yield rather different empirical estimates of child costs. They looked at both Sri Lankan and Indonesian data to look at the different approaches in practice. Moreover, his book with John Muellbauer (Deaton and Muellbauer, 1980) remains a standard reference on the topic of equivalence scales which, despite of the difficulties that they identify, are still used by policy makers, for example, in setting benefit levels for different households. And this interest continued in later work such as Deaton and Paxson (1998).

Deaton also did important work on non-unitary household models that could be thought of as some of the earliest contributions to a now extensive empirical literature. The idea that he pursued was simple, direct and recognized that household data on direct allocation within

households is almost never available. His idea was to make inferences on boy-girl discrimination using household level data by examining whether household consumption patterns were different (controlling for income) according to the gender composition of children. In Deaton (1989b), he proposed looking in particular at consumption of "adult goods" such as alcohol and tobacco. If there is gender discrimination towards boys, consumption of these goods would be lower in households with boys rather than girls for given income. He applied this idea to household data in both Cote d'Ivoire and Thailand finding some discrimination in favour of boys only in the Thai case. This method has been used in many developing country settings but, interestingly, does not generally detect discrimination in favour of boys, even in countries where it is strongly thought to exist. The work is most memorable for its central idea of using heterogeneity in the response of specific consumption goods as a means of looking for discrimination. As with so much of Deaton's work it provoked further extensions and development of the ideas.

Optimal Commodity Taxation and Preference Structure

Deaton's expertise on consumer demand made it natural for him to take an interest in problems of optimal commodity taxation where demand structure can matter for conclusions that are reached. For example, there has been a long-standing debate in optimal tax theory about when consumer demand implies that taxes on groups of goods are optimally uniform. After all, we do not see governments finely differentiating tax rates in many cases. Of course, this could be due to administrative complexity but there is also a question about the welfare gains due to deviations from uniformity. In standard optimal tax models, the implications of Ramsey rules would normally suggest that taxation should be differentiated based on differences in own and cross-price elasticities. However, there were a variety of results suggesting that separable sub-groups of commodities should be taxed uniformly.

Deaton brought his understanding of consumer demand to the literature on optimal commodity taxation in two key ways. First, he studied questions about how preference structure matters. He realized that, for the purposes of optimal tax theory, it was better to think in terms of choosing quantities rather than prices as this would naturally yield solutions which characterized prices which "support" the quantities when consumers optimize. This led him to explore the properties of a particular conical, i.e. homogenous, representation of preferences called the distance function (more commonly known as a gauge function in

convex analysis). A pair of creative papers in the *Review of Economic Studies* (Deaton, 1979) and *Econometrica* (Deaton, 1981a) had a large impact in the community which was studying optimal tax theory at the time. One useful feature of the distance function approach, which came out of his reformulation, is that derivatives are like shadow prices and hence can be used to infer properties of tax rates which are characterized as from the hyperplane supporting a particular consumption allocation.

In these works, Deaton showed that this representation would be useful in various applications, including index numbers and optimal taxation. This allowed him to reframe a long-standing question on when it would be optimal to have uniform taxation – the separability condition coming out of the first order conditions was what Gorman had called "implicit separability" and was weaker than what had previously been believed to be necessary to generate this kind of result. In related work, Deaton and Stern (1986), explored how the case for uniform taxation depended on heterogeneity and how group specific lump-sum grants could be used in the case for uniform taxation.

In the end, these results for linear taxation were somewhat less significant than the seminal Atkinson and Stiglitz (1976) result which allowed for non-linear taxation of labour supply (all taxes were linear in Deaton's work). Nonetheless, it was a significant leap forward for a range of debates and the fact that Deaton was aware of the more applied literature meant that he could see the importance of these issues for policy. Although optimal commodity taxation has now become a topic of somewhat specialized interest, Deaton's work in the area showed how understanding this issue was a good deal more subtle than had previously been thought. And the issue of how to link knowledge of commodity demands to taxation remains a central policy concern.

His second contribution to optimal taxation and the study of tax reform was more practical and, in many respects, more important. Deaton was well-placed to use his insights and knowledge since such exercises require using estimated demand parameters to derive properties of optimal tax systems. In Deaton (1986), he pointed out that widely used demand systems, such as the Linear Expenditure System, implied results for optimal taxation which had nothing to do with the data but were simply implications of the model of preferences being used. Deaton (1986) also explored this issue more generally and argued that without more flexible demand estimation, matching theory and data in optimal tax theory was going to be problematic in so far as the aim was to ask the data to inform the theory. He illustrated

these ideas using some of the findings from the household data emerging at the time. Deaton (1986) had a major influence on thinking about whether optimal taxation theory could be applied.

Welfare Measurement and Poverty Reduction

One of Deaton's central interests has been in making welfare comparisons, across time, across households and across countries. Deriving index numbers to deflate nominal incomes across time and space is a central issue in the literature. Deaton has always understood (as did Richard Stone his mentor) that getting index numbers right is at the heart of many practical debates (including those that influence policy). Two strands of Deaton's work illustrate these issues and their importance.

The first of these is from his work on the debate about how much economic growth in India has reduced poverty (as well as why things come out as they do). Deaton was among the first applied economists to use the data from India's National Sample Survey (NSS) which is one of the richest and most long-standing survey data sources available for any country (let alone a developing country). He has used these data to look at classic debates about how nutrition and income are related (Deaton and Subramanian, 1996). And in recent times, he used the NSS to revisit debates about the rate of poverty reduction in India (for example, Deaton and Dreze, 2002 and Deaton and Kozel, 2005).

One intriguing finding from Deaton's work on India with Jean Dreze has emerged from their study of the decline in the consumption of calories in India. This speaks to debates in the development literature on efficiency wages, i.e. the idea that there is a productivity-nutrition relationship. Their work discusses possible explanations and uses a price-theoretic framework to understand the mechanisms at work which suggests the possibility that calorie consumption should first decline then rise as country's develop, something which has not been explored in the development literature. This shows the value of putting original theory and data together to widen our understanding of an issue.

This work is part of a wider long-standing interest in poverty measurement over time and space. Deaton (2003b) discusses how household data have been brought to bear in monitoring the Millennium goal to halve global poverty. He raised a range of methodological issues which have practical relevance. And tracking progress over time was also the subject of Deaton (2005). Much of his work was summarized in masterful fashion in

his Presidential address to the American Economic Association, which is published in the *American Economic Review* (Deaton, 2010b). It summarises a lifetime of understanding of the topic. He discusses the measurement of world poverty and inequality paying particular attention to the role of PPP price indexes. He shows that global inequality increased with the latest revision of the ICP, and this reduced the global poverty line relative to the US dollar. Moreover, he argues that the apparent large revision which put nearly half a billion more people into poverty was due to an inappropriate update of the global poverty line rather than revisions to price indices. He concludes this project with a plea for greater attention being towards self-reported well-being which echoes his recent thinking in this area and which I discuss below.

In recent years, Deaton has taken a keen interest in the International Comparisons Project (pioneered by Alan Heston, Irving Kravis and Robert Summers at the University of Pennsylvania and now located at the World Bank). The project was the impetus behind the widely-used Penn World Tables. These data lie at the core of comparisons of income levels across countries and over time. There are a range of methodological issues, particularly in the construction of PPP price indices and Deaton has published extensively on this (for example, Deaton and Heston, 2011 and Deaton and Depriez, 2011). It is arguable whether many economists who use the Penn World Tables are aware of the methodological issues and whether the methods are sound. But the economics profession can take some comfort when people of Deaton's calibre are playing a key advisory role in the way that the data are produced.

There is a long-standing global debate on the effectiveness of foreign aid and whether econometric analysis of policy effectiveness has a role to play in informing policy. Deaton has been active in these debates and more recently in discussions about the value of Randomized Control Trials (RCTs), particularly as they are used in evaluating development policies. The use of RCTs has been a major innovation of recent years and is now used in a wide variety of contexts thanks to the pioneering work on J-Pal at MIT.

Deaton has offered a characteristically careful appraisal of a range of issues raised by this development in Deaton (2009, 2010a). He tackles head on the claim that RCTs are a magic bullet which allows researchers to dispense with a traditional reliance on theory and avert some of the problems of more standard instrumental variables estimates. He reminds us that the standard concerns of applied researchers do not go away even when the data are bespoke

and the intervention is randomized. Specifically, Deaton argues that there RCTs have no special ability to create more credible knowledge compared to other methods. Many experiments as carried out in practice encounter problems which limit the reach and validity of the findings.

His work reminds us that, in the end, we make progress by understanding the mechanisms of economic development. Thus, there is a need for a continued focus on theoretical mechanisms which drive development, a message that easily gets lost when the focus is on the evaluation of programs and projects (see Deaton, 2010c). This message squares well with his earlier work with a concern for the importance of theory and also understanding heterogeneity in behaviour which this leads to.

Health, Inequality and Development

In recent years, Deaton has worked on the link between health and inequality. There is an extensive literature, mostly away from economics, on links between health, social status and inequality. Among the most well-known work is based on the Whitehall studies which argued for a link between status hierarchies and health (see Marmot et al., 1984, and Marmot et al., 1991). It was a natural area for Deaton to study these issues given his previous interests. And it is no surprise that he produced a series of important papers which brought both rigorous thinking and a very careful look at the data to this area.

One of the core discussions is how far inequality (however conceived) results in adverse health consequences. A key difficulty lies in finding suitable data and a persuasive source of variation in inequality. Deaton (2003) looks at a body of evidence and delves into a range of claims that have been made and assesses their validity. He also provides some analysis based on his research. This work program culminated in his book *The Great Escape* (Deaton 2013a) which is aimed at bringing the implications of his work on health, nutrition and poverty to a wider audience. The core messages of the book are based on his lifetime of research on factors that lead people to be wealthier and to live longer, core themes throughout his research. Only someone who was equally familiar with the research in developed and developing countries could produce the range of insights that he generates. And is careful to stay within the bounds of what evidence from his work, and that of others, has taught us.

Deaton (2013a) also develops the insights from his work for long-standing debates about the effectiveness of aid which brings him close to a range of contentious policy debates. For the

first time in his work, this led him to embrace discussions about political economy and the role of effective government in promoting development. And his recent work has seen him engage in discussions about the political economy of measurement, not only the power of numbers to influence the direction of debates but also the political nature of the decision about what to measure. Recent discussions about the Millennium Development Goals have without question changed the focus on poverty measurement given even greater resonance to the links between Deaton's research program and policy.

Measuring and Understanding the Determinants of Subjective Well-being

Much of Deaton's recent work has been studying a unique resource from a series of Gallup Surveys to which he has access. He has become interested in the literature on self-reported happiness and what can be learned from it. (Deaton, 2008, provides an overview.) He has approached the issues mostly from an empirical point of view trying to understand how stable and reliable the findings are from those data. He has argued persuasively that there is no Easterlin paradox in the Gallup data and that this is likely because Easterlin's findings came from having such a limited sample of countries to look at and functional form assumptions. It also raises issues for some of the work on subjective happiness by showing that care is needed in the way that surveys are conducted. For example, some measures appear sensitive to arbitrary features of survey design such as the order in which questions are asked. Deaton's work has elevated the level of debate in this area.

One particularly influential piece is Deaton and Kahneman (2011) which also uses the Gallup data to explore a classic question of whether happiness and income are linked. A key finding is that high income buys life satisfaction but not happiness. They also find that low income is associated both with low life evaluation and low emotional well-being. Deaton (2013b) brought his interests in measurement of subjective well-being to our understanding of the impact of the Great Recession on well-being using the Gallup survey data. His work shows a mixed picture and concerns about how the data can be used given that question order seems to make a difference to the answers that people give.

Deaton's work on wellbeing should be thought of as an extension of his lifetime interest in household behaviour and the importance of measurement. As with all of his work in this area, there are frequent reflections on how preferences can be used for welfare purposes. It

ties also to his long-standing interests in comparing living standards and the role of index number adjustments where the difficulties of doing this well have steered him more to use these direct measures of wellbeing for looking at living standards and comparing them over time and across space.

Three Major Books on Consumption

Deaton's work on consumer behaviour and the use of household data have been brought together in three major books each of which has become standard reference in the areas covered. These books demonstrate the depth of his understanding of the fields in which he has worked and appraise the strengths and weaknesses of different paths that have been taken.

Economics and Consumer Behaviour Deaton and Muellbauer, 1980a) remains to this day an important guide to demand theory/estimation. Of course, there have been empirical developments since and a more recent book would likely have much more discussion of behavioural economics. Given Deaton's own interests, there would also likely be more on health and more on subjective well-being in a newly written book. The more orthodox literatures on estimating demand systems on micro data is now also much more extensive than when this book was written. But this book remains the most authoritative statement of a corpus of accepted core knowledge on price theory, utility theory and demand estimation which remains central to our discipline. Moreover, there are many of the areas discussed in the book where the subject has not moved a great deal since it was written and any graduate student would still learn a lot from studying the ideas in the book in detail.

In 1991, Deaton was invited to give the Clarendon lectures and he used it as an opportunity to take stock on models and evidence of aggregate consumption, pulling together a whole body of work including his own. The resulting book entitled *Understanding Consumption* (Deaton, 1992) is a *tour de force*. A major message was the failure of models based on a representative consumer to do justice to the data, something which comes out in many of his works previous to this and since. But apart from being critical, Deaton also mapped out a new research program based on ideas that have since been taken up in part by him. These include, studying liquidity constraints and ways of modelling heterogeneity across age

cohorts and households. And much of Deaton's own efforts in studying consumption belong to a wider research program which gets beyond aggregate behaviour.

The third important book is on *The Analysis of Household Surveys* (Deaton, 1997). The book has an Olympian quality ranging from a series of practical issues, which are often overlooked by those who download and use data, to more involved technical issues. Anybody with a serious interest in household data (whether in a developing country or not) will learn a huge amount from reading this book. Much of the material covered should remain at the forefront of researchers' minds since so many of the issues that the book deals with are timeless. One feature of the book, in line with his approach to all research, is a reminder of thinking about basic issues in data collection and design of surveys. Many economists use data uncritically without thinking about these issues but Deaton points out that overlooking them can be a major pitfall. These are in fundamental areas when using household survey data such as the implications of sample clustering or considering different forms of measurement error.

Concluding Remarks

Many of the issues that Angus Deaton has worked on bear on what have traditionally been core topics in economics curriculum. That said, time devoted to the coverage of price theory and the study of consumption have been squeezed in the core curriculum in recent years. There is even a risk that a gulf will open up between the knowledge imparted to a typical economics graduate student and key areas of expertise where practical economic input is required such as the making welfare comparisons.

It is now so easy to download and analyse data without a proper appreciation of what is being measured and how. For example, many people who use the PPP income numbers when they use the Penn World Table seem to have paid scant attention to the methods that are used to create them and the caveats that apply to claims that these can tell us something about the global distribution of income.

Those who study Angus Deaton's work and learn from it are reminded that it is essential that the study of consumer behaviour remains at the heart of what we learn as economists. It is core to a range of economic debates, particularly those where economists and statistical agencies need to work together. I strongly advise all the younger readers of this article, particularly those whose research interests are still evolving, to read Deaton's works, to be inspired by them and to work to emulate the qualities that they display.

References to Works by Angus Deaton

"The Analysis of Consumer Demand in the United Kingdom, 1900-70," *Econometrica*, Vol. 42, 1974a.

"A Reconsideration of the Empirical Implications of Additive Preferences," *Economic Journal*, Vol. 84, 1974b.

"Involuntary Savings through Unanticipated Inflation," *American Economic Review*, Vol. 67, pp. 899–910, 1977

"The Distance Function and Consumer Behaviour with Applications to Index Numbers and Optimal Taxation," *Review of Economic Studies*, Vol. 46, pp. 391-405, 1979

Economics and Consumer Behavior, New York: Cambridge University Press. (450 pp.) (with J. Muellbauer)., 1980a

"An Almost Ideal Demand System," *American Economic Review*, Vol. 70, pp. 312-26 (with J. Muellbauer), 1980b

"Optimal Taxation and the Structure of Preferences," *Econometrica*, Vol. 49, pp. 1245-60, 1981a.

"Functional Forms for Labour Supply and Commodity Demands with and without Quantity Restrictions," *Econometrica*, Vol. 49, pp. 1521-32, 1981b.

"A Profitable Approach to Labor Supply and Commodity Demands Over the Life Cycle," (with M. Browning and M. J. Irish), *Econometrica*, Vol. 53, pp. 503-43, 1985

"Panel Data From Time Series of Cross-Sections," *Journal of Econometrics*, pp. 109-126, 1985.

Collecting Panel Data in Developing Countries: Does It Make Sense? (with O. Ashenfelter and G. Solon), Living Standards Measurement Study, WP 23, The World Bank, Washington, DC.

"On Measuring Child Costs in Poor Countries" (with J. Muellbauer), *Journal of Political Economy*, Vol. 94, pp. 720-44, 1986.

"Optimally Uniform Commodity Taxes, Taste Differences and Lump-Sum Grants" (with N.H. Stern), *Economics Letters*, Vol. 20, pp. 263-6, 1986.

"Econometric Issues for Tax Design in Developing Countries," in D. Newbery and N.H. Stern (eds), *The Theory of Taxation for Developing Countries*, New York. Oxford University Press for the World Bank, 1986.

"Life-Cycle Models of Consumption: Is the Evidence Consistent with the Theory?" in T. Bewley (ed.), *Advances in Econometrics*, New York. Cambridge University Press, 1987a.

"Estimating Own-and Cross-Price Elasticities from Survey Data," *Journal of Econometrics*, Vol. 36, pp. 7-30, 1987b.

"Quality, Quantity and Spatial Variation in Price," *American Economic Review*, Vol. 78, pp. 418-30, 1988

"Rice Prices and Income Distribution in Thailand: A Non-parametric Analysis," *Economic Journal*, Vol. 99, supplement, pp. 1-37, 1989a.

"Looking for Boy-girl Discrimination in Household Expenditure Data," *World Bank Economic Review*, Vol. 3, pp. 1-15, 1989b.

"Why is Consumption So Smooth?" (with J. Y. Campbell), *Review of Economic Studies*, 56, pp. 357-74, 1989.

"Saving in Developing Countries: Theory and Review," *World Bank Economic Review*, (*Proceedings of the World Bank Annual Conference on Development Economics 1989)*, pp. 61-96, 1990.

"Saving and Liquidity Constraints," *Econometrica*, Vol. 59, No. 5, pp. 1221-1248, 1991.

"On the Behavior of Commodity Prices" (with G. Laroque), *Review of Economic Studies*, Vol. 59, pp. 1-23, 1992.

Understanding Consumption, Oxford. Clarendon Press, 242 pp. (The 1991 Clarendon Lectures in Economics.), 1992.

"Intertemporal Choice and Inequality" (with Christina Paxson), *Journal of Political Economy*, Vol. 102, No. 3, pp. 437-467, 1994.

International Commodity Prices, Macroeconomic Performance, and Politics in Sub-Saharan Africa." (with Ron Miller), *Princeton Studies in International Finance No. 79, 1995*

"The Demand for Food and Calories" (with Shankar Subramanian), *Journal of Political Economy*, Vol. 104, No. 1, pp. 133-162, 1996.

The Analysis of Household Surveys: A Microeconometric Approach to Development Policy, Baltimore, Johns Hopkins University Press for the World Bank, 1997.

"Competitive Storage and Commodity Price Dynamics" (with Guy Laroque), *Journal of Political Economy*, Vol. 104, No. 5, pp. 896-923, 1997.

"Economies of Scale, Household Size, and the Demand for Food" (with Christina Paxson), *Journal of Political Economy*, Vol. 106, No. 5, pp. 897-930, 1998.

"Commodity Prices and Growth in Africa." *Journal of Economic Perspectives* 13 (3): 23-40, 1999.

"Poverty and inequality in India: a reexamination" (with Jean Drèze), *Economic and Political Weekly*, pp. 3729–3748, 2002

"Health, inequality, and economic development," *Journal of Economic Literature*, 41, 2003, 113–58, 2003a.

"How to monitor poverty for the Millennium Development Goals, *Journal of Human Development*, 4(3), 353–78, 2003b.

"Measuring poverty in a growing world (or measuring growth in a poor world)," *Review of Economic Statistics*, 87(1), 1-19, 2005.

"Data and dogma: The great India poverty debate," (with Valerie Kozel), *World Bank Research Observer*, 20(2), 177—199, 2005.

"Income, health and wellbeing around the world: evidence from the Gallup World Poll," *Journal of Economic Perspectives*, 22(2), 2008.

"Instruments of development: randomization in the tropics and the search for the elusive keys to development," Keynes Lecture, British Academy, London, October 7th, 2008, *Proceedings of the British Academy 2008 Lectures,* 162, Oxford University Press, 123–160, 2009.

"Instruments, randomization, and learning about development," *Journal of Economic Literature*, 48 (2), 424–55, 2010a.

"Price indexes, inequality, and the measurement of world poverty," (Presidential Address) *American Economic Review*, 100(1), 5–34, 2010b.

"Understanding the mechanisms of economic development," *Journal of Economic Perspectives*, 24(3): 3–16.

"High income improves evaluation of life but not emotional well-being," (with Daniel Kahneman), *Proceedings of the National Academies of Science,* 107(38), 16489–93, 2011.

"Understanding PPPs and PPP-based national accounts," (with Alan Heston), in *American Economic Journal Macroeconomics*, 2(4), 1–35, 2011

"Purchasing power parity exchange rates for the global poor," (with Olivier Dupriez), *American Economic Journal Applied*, 3:2. 137–66, 2011.

The Great Escape: health, wealth, and the origins of inequality, Princeton. Princeton University Press, 2013a.

"The financial crisis and the well-being of Americans," Hicks Lecture, Oxford, *Oxford Economic Papers*, 64(1), 1–26, 2013b.

Other References

Atkinson, Anthony B. and Joseph E. Stiglitz, "The Design of Tax Structure: Direct versus Indirect Taxation," *Journal of Public Economics* 6 (1-2): 55–75, 1976

Banks, James, Richard Blundell, and Arthur Lewbel, "Quadratic Engel Curves and Consumer Demand," The Review of Economics and Statistics, 79(4), 527-539, 1997.

Barten**,** Anton P., "Maximum likelihood estimation of a complete system of demand equations," *European Economic Review***,** (1) 7–73, 1969.

Blundell, Richard, Panos Pashardes and Guglielmo Weber, "What do we Learn About Consumer Demand Patterns from Micro Data?," *The American Economic Review*, Vol. 83, No. 3, pp. 570-597, 1993.

Hall, Robert E. "Stochastic Implications of the Life Cycle-Permanent Income Hypothesis: Theory and Evidence," *Journal of Political Economy*, 86 (6), 971-87, 1978.

Hall, Robert E. and Frederic S. Mishkin, "The Sensitivity of Consumption to Transitory Income: Estimates from Panel Data on Households," *Econometrica*, 50, 461-81, 1982.

Heckman, James J. and Thomas Macurdy, "A Life Cycle Model of Female Labour Supply," *The Review of Economic Studies*, 47(1), 47-74, 1980.

Marmot, Michael G., Martin Shipley and Geoffrey Rose. "Inequalities in Death—Specific Explanations of a General Pattern," *Lancet* 1(8384), 1003–1006, 1984.

Marmot, Michael G., George Davey-Smith, S. Stansfeld, C. Patel, F. North, J. Head, I White, Eric Brunner and A. Feeney, "Health Inequalities among British Civil Servants: The Whitehall II study," *Lancet* 337 (8754), 1387–93, 1991.

Muellbauer, John, "Community Preferences and the Representative Consumer," *Econometrica* 44, 979-99, 1976.

Muellbauer, John, "Aggregation, Income Distribution and Consumer Demand," *Review of Economic Studies*, 62, 525-43, 1975.

Stone, Richard, "Linear expenditure systems and demand analysis: an application to the pattern of British demand," *Economic Journal* 64, 511–27, 1954.

Varian, Hal, *Microeconomic Analysis*, W.W. Norton & Co., New York, 1978.

Zeldes, Stephen P., "Consumption and Liquidity Constraints: An Empirical Investigation," *The Journal of Political Economy*, 97(2), 305-346, 1989.