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Consumption Deprivation as an Objective Poverty Measure : An Engelian Approach

Dr. G. K. Kadekodi Endowment Lecture delivered at Center for
Multidisciplinary Development Research (CMDR), Dharwad on
February 13, 2019

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I Introduction

I thank the Organizing Committee of GK Kadekodi Endowment Fund and CMDR for inviting me to deliver this lecture. I was curious why the well-wishers of Professor Kadekodi who raised funds for this Endowment missed me as one of his well-wishers. Professor Kadekodi explained that perhaps it is because I was his teacher. I am glad to be here to deliver the endowment lecture. I had known Professor Kadekodi from the days he started his B.Stat. at Indian Statistical Institute, Kolkata in 1961. During those days I took classes for him and his batch on conducting physics experiments using designs of experiments, and at night I used to have dinner with him in the hostel mess. We both shared the fortune of being the students of the same two professors who influenced our professional careers in statistics, econometrics, and economics, Professor C.R. Rao in statistics and Professor Gerhard Tintner in econometrics. We both worked on similar topics for our doctoral dissertations, application of optimal control theory and Bellman's principle of optimality in economic planning, but six years apart.

I had always admired his work, particularly on environmental economics. That is an area in which I have very little experience. Hence I will stick to my familiar environment, poverty, on which I have been working sporadically for the past three decades. It is a topic that was first introduced to economists by Ernst Engel in 1857, and most economists since then had ignored it for the purpose it was introduced. His main result of that pioneering work was, however, used and celebrated by economists in other ways as Engel's law, Engel curve, and Engel elasticity (Engel,1857). But he used that construct to focus his investigation of the level of living of poor industrial workers, and to demonstrate that they spend most of their income on food, thereby depriving themselves of consumption of other goods. To him consumption deprivation was poverty. Strangely enough, today his contribution to poverty is forgotten and instead poverty is misunderstood, misinterpreted, and mis-measured as income inequality of a set of people whose income is below an arbitrarily and subjectively chosen poverty line level of income.

This talk is based on a joint research effort I carried out over nearly three decades with others. First in 1980s and 1990s I worked on this topic with a biochemistry and biotechnology researcher and professor V. Sitaramam of National Institute of Nutrition and University of Pune, and with a statistics professor of University of Pune, Anil Gore. Then in 2007 and beyond I worked with my former graduate student and then an economics professor at University of London, Sushanta Kumar Mallick. More recently I have been working with a professor of

¹ The author thanks Professor V. Sitaramam for pointing out an error in an earlier draft of the paper that had been corrected.

applied physics Amit Kumar Chattopadhyay of Aston University, Birmingham. There are a few others who collaborated with us².

II Two Roads to Poverty

There are two roads to poverty studies in economics, one with the poverty line and the other without the poverty line. The traditional or main stream approach to poverty studies, the one with the poverty line, predominantly uses a poverty index that is truncated income inequality. It is only indirectly related to consumption, as consumption expenditure is constrained by income, and directly related to consumption only at the poverty level of income as its choice was associated with consumption of basic necessities. At that poverty line lie very few consumption deprived people who, in fact, are the richest of the poor! For the rest, how consumption deprived they are, is not captured by the traditional poverty index. The other road to poverty studies is through a study of changes in levels of living and of food consumption(over time and space) as income varies, without any specific threshold like a poverty line. The difference between these two approaches arose due to a misunderstanding of the basic concept of poverty and the basic purpose of measuring poverty. The original path to poverty studies laid by Engel had become only a pedestrian path while the path with poverty line had become a main thoroughfare traversed by the mainstream economists. Needless to say I chose the pedestrian route shown to me by Professor V. Sitaramam, a biochemistry and biotechnology professor of National Institute of Nutrition and University of Pune.

Soon after the industrial revolution there was a migration of rural people in search of industrial employment and their living conditions in urban areas or urban fringe turned out to be much inferior to those of other urban population, generating a deep economic policy concern regarding their levels of living. Economic historian Arnold Toynbee puts the period of industrial revolution as 1760 to 1840. It was in this context, and to address a warning issued by T R Malthus that unchecked population growth might increase beyond the means to sustain the population, that Engel undertook his study on “The Consumption-Production Relations in the Kingdom of Saxony”(Engel,1857; Chai and Moneta,2010). His main focus was to study the changes in levels of living through consumption pattern as income varies. His main observation was:

“The poorer is a family, the greater is the proportion of the total outgo [family expenditures] which must be used for food. ... The proportion of the outgo used for food, other things being equal, is the best measure of the material standard of living of a population.” (Engel, 1857, as quoted in Zimmerman, 1932).

This observation also suggested that Malthus warning need not be taken seriously as the food needs decrease as and when production and incomes increase, and hence the title of his paper. While he examined the family budget data of 199 households in Brussels during the year 1855 he did not label any of them as poor or non-poor. Instead he had three categories of households, those who are on relief receiving support (whose income is not adequate to meet the

² The other collaborators are S.A Paranjpe, professor of statistics at University of Pune, J.G. Sastry, a statistician at the National Institute of Nutrition, Hyderabad, Jayaram Holla and Puja Guha, then doctoral students at Indian Institute of Management, Bangalore, and Iain Rice of Arden University, UK.

expenditure), those who are independent (whose income is enough to meet the expenditure and yet do not save), and those who are comfortable (with incomes exceeding consumer expenditure and thus have savings) (see Chai and Moneta, 2010 for details).

Rowntree (1901) undertook a more detailed study, with several thousand workers surveyed, on the working conditions of the industrial workers in York, England. He laid the main ground work for defining a poverty line as scientifically as possible by consulting nutrition scientists. He thus paved the way to define poverty as a quality possessed by 'the poor', defined as those whose income is less than a poverty line of income. This was followed by Bowley and Burnett-Hurst (1915), and Bowley and Hogg (1925), both using the poverty line to separate the poor and the non-poor. The rest is history and almost everyone since then started examining the issue of poverty through a bifocal lens with a poverty line being the focus for the shortsighted look at poverty.

I say short sighted, as starting from Sen's seminal work on poverty index (Sen, 1976), poverty line had become the focus and income and not consumption has been used to measure poverty. Sen's poverty index gave a respectable mathematical structure to poverty measurement, stripping off its basic low levels of consumption description altogether. He gave Rowntree's concept of poverty line a new respectable title 'Focus axiom', making it difficult for mathematically equipped economists to question the axiom, making poverty line and hence poverty, seemingly axiomatic, when in fact it is not. Poverty line and the focus axiom made it necessary for economists to create a mythical straw man, the richest of the poor, with an income equal to the poverty line of income. As Engel's work was in French and not easily accessible for English readers, the dominating American and British economists embraced Rowntree's and Sen's approach and not Engel's. The acceptance of poverty line is so deep and pervasive that the first paper we wrote on poverty without a poverty line was rejected outright by both referees of a famous development economics journal with a stroke of a red line "How can there be a measure of poverty without a poverty line?"

To summarize this section we can say that there are two ways to define poverty. One way is as an adjective associated with the noun 'people-(all people)', a low level of living reflected by a consumption pattern that deprives people of consuming the desired level of even some essential goods and services. This is poverty without a poverty line. The second way is, as an adjective associated with the noun 'the poor', (poorly defined) and proxied by income of the poor. This is poverty with a poverty line. Johnson (2010) compared poverty measurement using both relative consumption deprivation and truncated income inequality and concluded that both are similar but one should prefer relative consumption deprivation. Klassen (2000) compared income and consumption measures of poverty in South Africa and observed that they are different and preferred using the consumption deprivation measure.

III A Brief Review of Literature on Economics of Poverty

As the literature on economics of poverty is very large I shall limit myself to its origin and its maturity around 2010 by citing main guideposts to place this paper in proper perspective. I had already cited the two earliest works of Engel (1857) and Rowntree (1901). Since 1901 poverty is defined and measured as a property that the poor have, with the intensity of it being measured through a proxy 'income'. Bowley and Burnet-Hurst (1915) studied the

poverty in several British towns using poverty line definition. Poverty was measured first as percent poor or Head Count Index. As it considers all poor as equal and did not measure how poor the poor are, a new index called 'poverty gap index' was introduced, which is the average of percent shortfall from the poverty line income. Sen (1976) then came up using an axiomatic approach with a general poverty index that was a function of the Head Count Ratio, Poverty Gap, and the Gini coefficient for people below the poverty line. Sen related it to welfare economics by using public finance calculus of Dalton and Pigou on how income transfers between people increase or decrease welfare. Townsend (1979) defined poverty as relative consumption deprivation that needs to be measured objectively. He examined consumption deprivation and societal norms for consumption using British household survey data³. Foster-Greer and Thorbecke (1984) defined a new class of poverty indices (called α measures) of which all the other existing indexes are special cases. Atkinson (1987) gave a general form for a wide class of poverty measures that can be derived from a deprivation function which is a convex function of income. He thus bridged the gap between poverty through consumption deprivation and through income inequality. He hinted that most of the existing poverty indices have an abrupt jump or a discontinuity at the poverty line and that a general poverty index with a well-defined deprivation function need not have such a discontinuity. The way poverty is defined and measured is thus dependent crucially on who the poor are and what the poverty line is, and how that poverty line is determined, as well as on the income distribution. Let us now examine how the poverty line is determined rather arbitrarily in various countries around the world.

President Lyndon B. Johnson announced his mission on war on poverty in his Presidential inaugural address in 1964. In order to develop the economic policies to address his promise the policy makers needed to articulate who the poor are. Policy makers were looking at all available existing works on poverty and found one that had mentioned a level of income needed to afford a low cost nutritious diet. This was a study of 1961 by a US Government economist Molly Orshansky titled "Children of the Poor". For this study she used the low cost food plan of the US Department of agriculture to price the cost of that food basket. She used 1955 US Food Survey conducted by the US Department of Agriculture to determine that food expenditure constituted one third of the total expenditure for a median family of three or more children. Thus the official US poverty line estimate is three times the cost of the low cost diet determined by USDA (for details and references see Fisher, 2008)⁴.

The poverty line in India is based on a pioneering study made by Dandekar and Rath (1971). It is also based on the cost of a food basket that provided the minimum calories needed. Government of India recommended 2400 Calories (Kilo calories) for normal active rural adult and 2100 Calories for normal active urban adult. From that food expenditure the income or

³ We show in Section IV below a better alternative way of determining an objective relative consumption deprivation index.

⁴Orshansky had a choice between two food plans, the economy food plan and the low cost food plan. She calculated the poverty line using both and preferred the low cost food plan as the poverty numbers so arrived at matched the rough estimates of the number of poor in the US as estimated by the Council of Economic Advisors (CEA) and the CEA estimate of course was arrived at roughly and subjectively. This reminds me of my first experience as researcher in official statistics in 1961. I noted that the National Income Committee in India assumed the income from house property as a percentage of a "guessed" value of housing stock. Later the first estimate of capital stock in India used for the value of housing stock a multiple of the income from house property! I rest my case here on my assertion that the official poverty line in USA is arbitrarily chosen.

total expenditure is read off as the average total expenditure associated with average food expenditure that can provide the minimum calories. That income is taken as the poverty line of income. Various committees appointed by the Government of India examined and set the official poverty lines in India. In its recent report Rangarajan Committee in 2012 recommended adding to calories needed minimum needs for proteins, fats, housing, clothing, and education. It has also used different methodology wherein a household is considered poor if it is unable to save. They were all variants of Dandekar and Rath's nutrition based index with emphasis on energy intake (calories consumed) approach. The World Bank used the minimum living standards in 15 of the poorest countries in terms of food, clothing, housing, health, and education, and arrived at a global poverty line which was in 1990 US\$1 per day in purchasing power parity terms. In 2008, it was revised upwards to \$1.25 and thereafter to \$1.90 in 2012, and is still prevailing.

The European Union uses as its poverty line 60 percent of median per capita income of an adult equivalent. As we can see all these measures of poverty, since Rowntree's work of 1901, are based on a poverty line, and we can also see how these poverty lines are subjectively, and exogenously defined, and calibrated in terms of consumption or level of living only at one point, the poverty line.

There were two other major approaches to study poverty defined as consumption deprivation. P.C. Mahalanobis was not only focused on planning for economic growth but also on income inequality, living standards, and consumption of cereals, as cereals constitute the basic denominator of the food basket (Mahalanobis, 1960, 1963, 1964). He developed his Fractile Graphical Analysis (FGA) mainly to compare objectively the rural food consumption expenditure distributions over time to see if there has been an improvement in standard of living (Mahalanobis, 1960), Iyengar and Bhattacharya, 1965)⁵. Sukhatme, as the Director of Statistical Research at the Food and Agriculture Organization (FAO) of United Nations (1951-71), made the first systematic scientific attempt to measure food consumption deprivation and hunger. Noting that he lacked credibility among nutrition scientists to receive their support, he published papers in nutrition science before he presented his paper on "World's Hunger and Future Needs of Food Supplies" before the joint meetings of the Royal Statistical Society and the Nutritional Society of Great Britain (Sukhatme, 1961). He argued that what afflicts the developing countries is calorie deficiency and not protein deficiency. He maintained that this calorie deficiency was due to the poor people not being able to consume enough food (food-consumption deficiency). Sukhatme (1961) measured extent of hunger around the world by estimating the number of persons whose food consumption in energy equivalent calories was less than what was required for healthy living and performing normal functions.

Poverty measurement and the use of such poverty measures for poverty alleviation programs have been in place for several decades now. The experience shows poverty line has been used to identify the beneficiaries of state run poverty alleviation programs. As poverty line is income based, and as income is difficult to measure as it varies from period to period,

⁵His FGA method, unlike other poverty measures, had built into it a measure of reliability of the estimated difference in levels of living, through the introduction of his interpenetrating sub-samples. It is this reliability issue that was addressed in Kumar, Gore, Sitaramam (1996) paper not usually a concern in many papers on poverty measures.

particularly for the main beneficiaries who are casual workers, there have been both criticisms of this approach and its misuse. There have been suggestions that the beneficiaries may be chosen by other criteria such as the nature of work (casual workers), unemployed, homeless, etc. These considerations make poverty line useless. The arbitrariness and the measurement difficulties and ambiguities associated with the poverty line calculation had given rise to extensive debates in academic as well as the policy circles on which types of data to use for determining the poverty line (the reader may see Kadekodi and Murthy, 1992, Deaton and Kozel, 2005, and Pogge and Reddy, 2006).

Poverty is inflicted on the individuals who have inadequate means to fulfill consumption of essentials. The list of essentials includes what are purchased in the market place as well as what are provided by the state and other non-profit and philanthropic institutions. Differentiating poverty from low development Sen and Anand (1997) came up with a new definition of a Human Development index. This is an aggregate index without any (poverty) line differentiating the deprived from others, and it included health (including expenditure on public health provided by the state) and education expenditure, both private and public. Recognizing and emphasizing that the essential commodities could include items other than food Alkier and Foster (2011) defined a multi-dimensional poverty index. However, while including other dimensions it complicated the one-dimensional index by requiring as many poverty lines as there are dimensions, magnifying the degree of subjective and arbitrary components of the index. There are two types of multidimensional poverty indices, one more inclusive than the other. The more inclusive or less restrictive is the one that includes all persons who are poor on at least one dimension (Alkier and Foster, 2011; Bourguignon and Chakravarty, 2003). The more restrictive one is where one is considered poor if he/she is poor in all dimensions (Alkier and Santos, 2010). Deaton (2015) related his extensive work on consumer demand with measurement of poverty using the survey data and he received the Nobel Prize in economics for his work.

At the start of this millennium setting up the millennium development goal of reducing the global poverty by half by 2015 had given rise to the need for a global poverty line and conversion of country-specific poverty lines to a global poverty line employing the purchasing power parity for conversion. The controversies involved in measuring global poverty through a global poverty line are discussed in Anand, Segal and Stiglitz (2010). Most of the criticisms in that debate relate to the choice of poverty line and the choice of using truncated income inequality measure instead of a consumption deprivation or a level of living measure.

IV Poverty Measurement: An Engelian Approach

Poverty is always understood as the negative of welfare, and as welfare decreases poverty increases. Welfare is understood and measured in terms of consumption, and hence poverty must relate to consumption deprivation. Given this understanding of poverty, its definition and measurement must be related to microeconomic theory of consumption as well as economics of production and distribution that determine incomes. This is how Engel conceived and designed his investigation in 1857. As income and prices constrain consumption it is necessary for us to relate how poverty can be alleviated through income

transfers and price subsidies. Measures of poverty that are dependent only on income are not as desirable as the ones that depend both on income and prices.

Engel's study classified all goods and services into a hierarchical class of needs, identifying food, liquor and tobacco as constituting the most essential need (which he called nutrition). Being unaware of Engel's 1857 study, but being aware of the saturating concave Engel curves for essential commodities, Sitaramam et.al., (1996) and Kumar, Gore and Sitaramam (1996), also observed a hierarchy of consumer needs and noted that cereals occupy the category of the most essential commodity in the Indian context. They used the cereal consumption deprivation from the observed saturation level of the Engel curve, which is a convex deprivation function (as in Atkinson, 1987), as a poverty index. This was a relative consumption deprivation index without a poverty line. The relative consumption deprivation is measured relative to the observed saturation level of consumption of most essential commodity, cereal. This was devoid of any subjectively determined poverty line. In that study we used a kinetic equilibrium analogy between rates of flow of consumption and income, consumption saturating at some finite level. We used a functional form for the Engel curve that is much different from what economists normally use, and that functional form, Michaelis-Menten equation, was suggested by Sitaramam from his extensive biochemistry work involving enzyme kinetics. Kumar, Holla, and Guha (2008), and Kumar, Mallick and Holla (2009) used the same approach to estimate poverty without a poverty line, with large quinquennial National Sample Surveys of 43rd Round (1987-88), 50th Round (1993-94), and 55th Round (1999-2000) to examine in great detail the trends in cereal consumption deprivation in several Indian states, separately for rural and urban India before and after economic reforms. They termed that index for the first time as Sitaramam Poverty Index, due to the major contribution made by Sitaramam for this line of research. In PV Sukhatme Memorial lecture delivered by me before the Indian Society of Probability and Statistics in November 2007 (see Kumar, Holla, and Guha, 2008), it was demonstrated that the functional form used by Sitaramam for Engel curve was much better than several demand function based Engel curves used by economists.

Engel stopped short of developing a poverty index. He only enunciated the Engel law and suggested using the proportion of income spent on food as an index of level of living. Sitaramam Poverty Index work is an extension of Engel's work and hence we term it as Engelian, or in the tradition of Engel. We extend his work by operationalizing the objectivity aspect of arriving at a relative consumption deprivation. We argue that people observe pattern of consumption in the community in which they live and aspire to achieve the saturation level of consumption of the most essential commodity. It is obvious that this data-driven threshold varies from time to time and place to place and country to country. With that as a norm we arrive at an index of community's relative consumption deprivation. After seeing the review article by Chai and Moneta (2010) on the original study by Engel (1857), which was in German, we applied Kumar, Gore, Sitaramam's approach to the original data on 199 households collected by Ducpetiaux (1855), the data supposedly used by Engel and came up with the following results⁶:

⁶ I thank Manisha Chakravarty, a member of faculty of Indian Institute of Management, Kolkata, for providing me EXCEL file of Engel's data. I thank my former student at George Washington University, Yinfei Zhang, and my grand students in India Lakshmikant Hari and Shailaja Sarangi for their help with the computations reported here.

We used the following functional form for the Engel curve:

$$C(y) = \frac{Vy}{(K+y)} \dots\dots\dots(1)$$

It can be verified that the parameter V is the saturation level or the limit of C(y) as y tends to infinity, and K is the income needed to consume one half of the saturation level of food. One may note that C(y) increases with income, while CD(y) decreases with income and K is the point of income where C(y) equals CD(y). One may use this data-driven, and objectively determined, parameter estimates as bench marks in place of an arbitrary poverty line.

$$\text{Consumption Deprivation} = V - C(y) = V - \frac{Vy}{(K+y)} = \frac{VK}{(K+y)} \quad (2)$$

$$\text{Poverty} = \text{Consumption Deprivation as a proportion of saturation level} = \frac{K}{(K+y)} \quad (3)$$

The Sitaramam poverty index (SPI) is defined as average proportional shortfall from the saturation level of food consumption:

$$SPI = \frac{1}{n} \sum_{i=1}^n \frac{K}{(K+y_i)} \quad (4)$$

The estimated nonlinear regression results for Engel data are as follows:

Goodness of Fit Statistics

Source	SS	df	MS		
Model	57070407.9	2	28535203.9	Number of obs =	176
Residual	2405075.59	174	13822.2735	R-squared =	0.9596
Total	59475483.4	176	337928.883	Adj R-squared =	0.9591
				Root MSE =	117.5682
				Res. dev. =	2175.445

Parameter Estimates:

food	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
V	2137.09	411.2609	5.20	0.000	1325.388	2948.792
K	2115.286	570	3.71	0.000	989.8895	3240.683

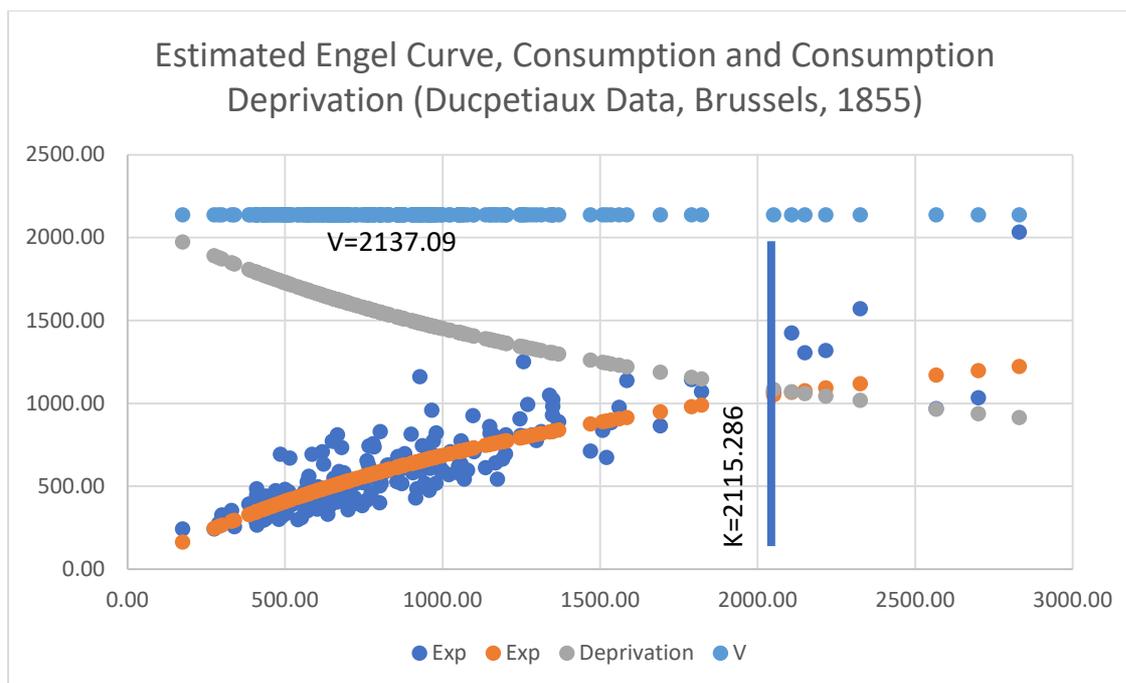


Figure 4.1 Actual data and Fitted Engel Curve

Appendix A gives the data of 199 households with income, food expenditure, and predicted food expenditure

We note that the fit is good with an R- square of 0.9596 and significant parameter values for V and K. We found even better fits with higher R-square values for a variety of data sets for India, China, and Korea. The extended Engelian poverty index for Ducpetiaux data for Brussels in 1855 is estimated as 0.72 (the index is so constructed as to lie between 0 and 1).

The functional form borrowed from saturation kinetic models in biochemistry seems to work much better than a variety of demand function models used by economists as shown by Kumar, Holla, and Guha (2008).

The index can be improved by introducing possible shifts in Engel curve for different types of families, say by family size and composition and employing adult equivalent scales, as was done in Kumar, Mallick, and Holla (2009).

As the title of Engel's paper indicates Engel concluded that income depends on production, and production on labor input. In order to understand what factors affect consumption of essential commodity (food) one need to integrate demand for food (represented by the Engel curve) with the labor market, other commodity markets, and the asset markets. This part was missing in the earlier work of Kumar, Gore, and Sitaramam (1996) and in Kumar, Mallick, and Holla (2009). Chattopadhyay, Kumar, and Mallick (2017) extended the earlier work by embedding the Engel curve for food within a broader agent-based market exchange models for three kinds of markets, labor markets, commodity markets, and asset markets. They gave an operational procedure for making an objective decision on what constitutes the relative consumption deprivation (Townsend, 1979). Engel curves play a central role. We assume that people observe the community's consumption behavior pattern as revealed by the Engel

curves. They then aspire to move upwards along the Engel curve by improving their earnings through a dynamic adaptive model, the agent-based market exchange model with an additive stochastic market disturbance term. That lead them to use a Brownian motion model of physics to seek a solution in the form of Fokker-Planck equation, solve it numerically and test it against the real data. Their model so developed fitted the Indian data extremely well (see Chattopadhyay, Kumar, and Mallick, 2017) for details).

Chattopadhyay, Rice, and Kumar (2019) extended the agent-based model still further by enlarging the essential commodity bundle to include food, other food, and non-food items and present a multi-dimensional poverty index. This index uses machine learning algorithm to reduce a multidimensional vector to a scalar using nonlinear projection in a Euclidian space.

V Conclusions

The choice between the two approaches mentioned in Section II should be based on:

1. what we normally mean by poverty and whether the economic definition meets that common sense notion?;
2. which approach integrates better with the rest of economic knowledge?;
3. Which approach is more useful for policy?;
4. Which approach is more objective and is devoid of subjective constructs?; and
5. Which approach agrees well with data on consumption deprivation?

It is argued here that poverty is usually understood as deprivation in consumption of essential goods. Of the two approaches the consumption deprivation approach of Engel is in better agreement with this commonly understood notion of poverty. Both Kumar, Gore, Sitaramam (1996) and Chattopadhyay, Kumar, and Mallick (2017) papers integrate the poverty index with microeconomic theory and hence are preferable to the other approach. Poverty line income is difficult to determine to identify the poor, as they the poor do not have regular income. It becomes necessary to identify them by other criteria such as homelessness etc. Hence poverty line based definition is not useful in identifying the poor. There is considerable controversy on identifying the poor through the poverty line and in choosing the poverty line. The approach of Engel avoids all that controversy as it does not depend on identifying the poor. Poverty alleviation policies are often in terms of price controls, as in the case of public distribution system, or income supplements. How to choose the poverty alleviation schemes depend on the working of the commodity markets. The Engel approach links poverty measurement to the markets and is thus preferable. It has been empirically tested with sample survey data of India for several years and it fitted the original data used by Ernst Engel, as demonstrated here in Section IV above. The Engelian poverty index is based on estimation of Engel curves from the consumer expenditure survey data and its parameters are entirely determined by the data and there are no subjectively or arbitrarily determined parameters in its calculation. Hence this method should be preferred.

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Appendix A

Table showing the data for 199 households on income and food expenditure (Ducpetiaux data for households in Brussels 1855), along with the predicted food expenditure from the estimated Engel curve

income	Food Exp	Pred. Food Exp	Food Cons Deprivation	Poverty= $K/(K+y)$
175.00	242.32	163.29	1973.80	0.92
275.00	242.32	245.87	1891.22	0.88
289.70	276.56	257.43	1879.66	0.88
300.00	327.42	265.45	1871.64	0.88
330.00	354.64	288.41	1848.68	0.87
339.50	255.84	295.56	1841.53	0.86
385.05	392.60	329.11	1807.98	0.85
392.00	338.00	334.12	1802.97	0.84
405.00	333.84	343.42	1793.67	0.84
409.00	284.80	346.26	1790.83	0.84
409.00	335.00	346.26	1790.83	0.84
410.00	485.52	346.97	1790.12	0.84
410.00	444.56	346.97	1790.12	0.84
411.00	266.00	347.68	1789.41	0.84
415.44	305.44	350.82	1786.27	0.84
428.00	372.32	359.64	1777.45	0.83
429.00	296.92	360.34	1776.75	0.83
433.28	297.57	363.33	1773.76	0.83
440.00	442.00	367.99	1769.10	0.83
440.52	306.52	368.35	1768.74	0.83
444.10	386.36	370.82	1766.27	0.83
450.00	361.40	374.89	1762.20	0.82
457.00	353.60	379.68	1757.41	0.82
461.00	403.00	382.41	1754.68	0.82
470.00	473.20	388.52	1748.57	0.82
471.00	401.32	389.19	1747.90	0.82
480.00	301.00	395.26	1741.83	0.82
486.00	693.68	399.27	1737.82	0.81
490.00	317.72	401.94	1735.15	0.81
495.00	418.60	405.27	1731.82	0.81
499.75	408.50	408.41	1728.68	0.81
500.00	482.58	408.58	1728.51	0.81
500.52	360.88	408.92	1728.17	0.81
505.00	338.00	411.88	1725.21	0.81
511.00	468.00	415.82	1721.27	0.81
514.80	670.80	418.30	1718.79	0.80
516.20	452.40	419.22	1717.87	0.80
523.24	390.60	423.80	1713.29	0.80
540.29	419.64	434.80	1702.29	0.80
541.20	299.20	435.38	1701.71	0.80
551.79	310.96	442.14	1694.95	0.79
560.00	377.78	447.34	1689.75	0.79
562.64	468.00	449.01	1688.08	0.79
570.00	526.76	453.64	1683.45	0.79

571.27	353.49	454.43	1682.66	0.79
575.00	561.20	456.76	1680.33	0.79
576.20	395.76	457.51	1679.58	0.79
576.34	423.28	457.60	1679.49	0.79
586.00	693.68	463.61	1673.48	0.78
592.36	424.32	467.54	1669.55	0.78
593.21	443.56	468.06	1669.03	0.78
601.80	361.52	473.34	1663.75	0.78
605.00	497.32	475.30	1661.79	0.78
606.00	444.86	475.91	1661.18	0.78
615.00	385.32	481.38	1655.71	0.77
618.00	708.90	483.20	1653.89	0.77
620.00	412.36	484.41	1652.68	0.77
622.80	633.12	486.10	1650.99	0.77
630.00	427.80	490.43	1646.66	0.77
636.00	331.00	494.02	1643.07	0.77
640.00	378.00	496.40	1640.69	0.77
640.00	431.10	496.40	1640.69	0.77
640.16	466.96	496.50	1640.59	0.77
650.00	771.45	502.34	1634.75	0.76
652.00	436.00	503.52	1633.57	0.76
655.00	772.76	505.29	1631.80	0.76
655.00	483.48	505.29	1631.80	0.76
655.20	548.60	505.41	1631.68	0.76
664.75	404.04	511.01	1626.08	0.76
666.00	810.68	511.74	1625.35	0.76
668.00	496.60	512.91	1624.18	0.76
671.00	588.52	514.66	1622.43	0.76
671.69	495.56	515.06	1622.03	0.76
671.88	503.40	515.17	1621.92	0.76
680.00	734.24	519.88	1617.21	0.76
680.23	512.72	520.02	1617.07	0.76
687.00	581.20	523.92	1613.17	0.75
687.45	538.75	524.18	1612.91	0.75
696.00	508.80	529.09	1608.00	0.75
696.60	442.00	529.43	1607.66	0.75
699.60	357.64	531.14	1605.95	0.75
700.00	429.04	531.37	1605.72	0.75
704.60	383.46	533.99	1603.10	0.75
705.00	448.45	534.22	1602.87	0.75
720.00	433.00	542.70	1594.39	0.75
725.00	397.00	545.51	1591.58	0.74
730.00	522.70	548.30	1588.79	0.74
745.37	383.94	556.84	1580.25	0.74
748.48	522.60	558.55	1578.54	0.74
759.40	416.40	564.55	1572.54	0.74
760.00	654.60	564.88	1572.21	0.74
763.00	577.91	566.52	1570.57	0.73
764.16	550.73	567.15	1569.94	0.73
764.70	630.76	567.44	1569.65	0.73
766.18	742.53	568.25	1568.84	0.73
773.40	462.90	572.17	1564.92	0.73
780.00	757.12	575.74	1561.35	0.73

783.12	737.82	577.42	1559.67	0.73
784.40	553.15	578.11	1558.98	0.73
800.00	400.80	586.45	1550.64	0.73
800.80	572.08	586.88	1550.21	0.73
801.10	503.36	587.04	1550.05	0.73
802.48	830.96	587.77	1549.32	0.72
805.00	520.00	589.11	1547.98	0.72
807.54	576.28	590.45	1546.64	0.72
820.82	591.20	597.45	1539.64	0.72
825.00	628.45	599.64	1537.45	0.72
830.00	628.00	602.25	1534.84	0.72
832.00	620.80	603.29	1533.80	0.72
854.93	528.33	615.13	1521.96	0.71
855.40	658.84	615.37	1521.72	0.71
858.00	679.44	616.70	1520.39	0.71
859.40	588.35	617.41	1519.68	0.71
862.00	631.80	618.74	1518.35	0.71
868.60	621.12	622.10	1514.99	0.71
871.00	515.62	623.32	1513.77	0.71
874.80	624.70	625.24	1511.85	0.71
877.00	637.55	626.35	1510.74	0.71
880.00	696.80	627.87	1509.22	0.71
900.00	815.36	637.88	1499.21	0.70
905.00	582.54	640.36	1496.73	0.70
906.00	588.52	640.85	1496.24	0.70
907.10	621.12	641.40	1495.69	0.70
914.56	430.34	645.08	1492.01	0.70
919.00	485.68	647.26	1489.83	0.70
920.00	600.48	647.76	1489.33	0.70
928.00	1162.00	651.67	1485.42	0.70
929.41	640.12	652.36	1484.73	0.69
930.00	590.62	652.65	1484.44	0.69
931.50	614.76	653.38	1483.71	0.69
936.00	745.34	655.56	1481.53	0.69
943.10	518.96	659.00	1478.09	0.69
950.00	728.40	662.33	1474.76	0.69
950.40	650.00	662.52	1474.57	0.69
957.06	476.32	665.72	1471.37	0.69
958.66	680.42	666.49	1470.60	0.69
960.68	608.64	667.45	1469.64	0.69
961.86	700.44	668.02	1469.07	0.69
965.83	959.52	669.91	1467.18	0.69
971.00	774.80	672.37	1464.72	0.69
975.00	681.76	674.26	1462.83	0.68
979.20	517.92	676.25	1460.84	0.68
980.00	821.60	676.63	1460.46	0.68
990.00	619.64	681.33	1455.76	0.68
996.00	588.64	684.14	1452.95	0.68
1000.00	593.17	686.00	1451.09	0.68
1019.82	570.52	695.17	1441.92	0.67
1025.00	708.48	697.55	1439.54	0.67
1050.00	621.12	708.92	1428.17	0.67
1050.00	580.22	708.92	1428.17	0.67

1050.00	680.00	708.92	1428.17	0.67
1058.50	775.02	712.75	1424.34	0.67
1058.83	633.80	712.90	1424.19	0.67
1063.27	750.32	714.89	1422.20	0.67
1068.75	543.40	717.33	1419.76	0.66
1078.84	596.84	721.82	1415.27	0.66
1096.06	925.58	729.41	1407.68	0.66
1100.00	708.76	731.13	1405.96	0.66
1136.00	612.56	746.70	1390.39	0.65
1150.00	860.60	752.66	1384.43	0.65
1151.00	820.00	753.08	1384.01	0.65
1160.00	811.20	756.89	1380.20	0.65
1168.00	640.48	760.25	1376.84	0.64
1174.00	543.88	762.76	1374.33	0.64
1186.00	761.28	767.76	1369.33	0.64
1190.00	664.20	769.42	1367.67	0.64
1200.00	696.20	773.54	1363.55	0.64
1201.00	811.58	773.95	1363.14	0.64
1203.57	795.34	775.01	1362.08	0.64
1245.70	907.40	792.08	1345.01	0.63
1248.00	807.36	793.00	1344.09	0.63
1257.00	1250.97	796.59	1340.50	0.63
1260.00	801.35	797.78	1339.31	0.63
1270.00	993.96	801.74	1335.35	0.62
1284.00	810.90	807.24	1329.85	0.62
1298.00	776.76	812.69	1324.40	0.62
1312.66	830.96	818.35	1318.74	0.62
1340.00	1049.88	828.79	1308.30	0.61
1348.50	929.76	832.00	1305.09	0.61
1350.00	983.00	832.56	1304.53	0.61
1350.00	1022.32	832.56	1304.53	0.61
1368.00	890.24	839.30	1297.79	0.61
1469.00	712.10	875.87	1261.22	0.59
1508.00	837.80	889.45	1247.64	0.58
1520.00	674.95	893.57	1243.52	0.58
1535.00	883.28	898.68	1238.41	0.58
1560.00	977.00	907.10	1229.99	0.58
1585.16	1138.16	915.47	1221.62	0.57
1691.32	865.32	949.53	1187.56	0.56
1790.00	1143.42	979.54	1157.55	0.54
1822.00	1071.46	988.95	1148.14	0.54
2051.10	1067.95	1052.08	1085.01	0.51
2108.00	1424.80	1066.70	1070.39	0.50
2150.00	1305.72	1077.24	1059.85	0.50
2216.00	1318.80	1093.39	1043.70	0.49
2325.00	1570.40	1119.01	1018.08	0.48
2566.00	968.40	1171.42	965.67	0.45
2700.00	1033.57	1198.30	938.79	0.44
2830.00	2032.68	1222.98	914.11	0.43

Average=
0.72