Retrospectives
Engel Curves

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This feature addresses the history of economic terms and ideas. The hope is to deepen the workaday dialogue of economists, while perhaps also casting new light on ongoing questions. If you have suggestions for future topics or authors, please contact Joseph Persky, Professor of Economics, University of Illinois, Chicago, at ⟨jpersky@uic.edu⟩.

Introduction

Engel curves describe how household expenditure on particular goods or services depends on household income. The name comes from the German statistician Ernst Engel (1821–1896) who was the first to investigate this relationship systematically in an article published about 150 years ago. The best-known single result from the article is "Engel's law," which states that the poorer a family is, the larger the budget share it spends on nourishment (Engel, 1857, pp. 28–29).

We revisit Engel's article, including its context and the mechanics of the argument. Because the article was completed a few decades before linear regression techniques were established and income effects were incorporated into standard consumer theory, Engel was forced to develop his own approach to analyzing household expenditure patterns. We find that his work contains some interesting features in juxtaposition to both the modern and classical literature. For example, Engel's way of estimating the expenditure–income relationship

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resembles a data-fitting technique called the "regressogram" that is nonparametric—in that no functional form is specified before the estimation. Moreover, Engel introduced a way of categorizing household expenditures in which expenditures on commodities that served the same purpose by satisfying the same underlying "want" were grouped together. This procedure enabled Engel to discuss the welfare implications of his results in terms of the Smithian notion that individual welfare is related to the satisfaction of wants. At the same time, he avoided making a priori assumptions about which specific goods were necessities, assumptions which were made by many classical economists like Adam Smith (1776).

We then offer a few thoughts about the modern literature spawned by Prais and Houthakker (1955), and how it built upon Engel's research. Engel curves are now a well-established part of the common language of empirical demand analysis and are used in many areas of economics, including analysis of structural change, growth, international trade, as well as in the measurement of inflation. Nevertheless, some open questions remain: for example, the desirability of developing a theoretical explanation for the shape of Engel curves based on a rich behavioral foundation has been duly noted in the literature, but this issue has not been properly investigated since Engel's time.

Laying Down Engel's Law

Ernst Engel was born in Dresden in 1821. He was initially trained at a mining academy in Saxony and later studied in France and Belgium. During these studies abroad, Engel first became interested in statistics. In Paris, he met Frédéric Le Play, a pioneer in conducting surveys on household budgets. In Brussels, Engel became acquainted with Adolphe Quételet, the inventor of "social physics," a discipline that sought to apply to social phenomena the statistical techniques developed in astronomy. Returning to Germany, Engel was appointed director of the newly-established Statistical Bureau of Saxony in 1850. He left this post in 1858 because he was not able to carry out some administrative reforms. Engel then founded a mortgage insurance society before returning to the public service in 1860 as the appointed director of the Prussian Statistical Bureau in Berlin. For the next 20 years, Engel developed a worldwide reputation for his statistical work. In 1882, after publicly opposing Bismarck's protectionist policies, Engel was relieved from his post on grounds of ill-health. However, even in retirement he remained active, founding the International Statistical Institute in 1885. Engel died near Dresden in 1896, one year after his final book was published.

As Engel began his career in statistics, a wave of civic uprisings took place throughout Europe in 1848, triggered in part by the poor living conditions of newly urbanized workers who had been drawn to cities throughout Europe by the economic opportunities of the Industrial Revolution. Many governments felt an urgent need to evaluate the general welfare of the population and in particular the conditions of poor people. Such conditions had already stimulated some

investigation into workers' consumption budgets by Ducpétiaux (1855) and Le Play (1855). An international congress held in Brussels in 1856 brought together statisticians, including Engel and Ducpétiaux, to discuss methods for measuring the extent to which workers have attained "conditions essential for health and life" (Lumley, 1856).

In this context, Engel (1857) wrote his famous article entitled "The Consumption–Production Relations in the Kingdom of Saxony." On a theoretical level, Engel entered the longstanding debate concerning Malthus' (1798) conjecture that unchecked population growth expands more rapidly than the means for its subsistence. This conjecture had sparked concern that the rapid pace of population growth, which emerged with the Industrial Revolution, could result in a social catastrophe. Engel argued that, even if there are no natural constraints on population growth, it was possible to avoid catastrophe if the economy's production capacity could be balanced with growing demand. This balancing is possible if the composition of goods and services supplied adapts to the evolving demand patterns of the population. For this reason, it was fundamental for Engel to investigate how the pattern of demand changes as household income changes. The finding that an increase in household income leads to a less than proportional increase in household food expenditures allayed fears that food demand grows at the same (geometrical) rate as the population. This finding enabled Engel to claim that population growth does not necessarily lead to a decline in welfare. Moreover, such a change in the composition of demand implies that, as the economy grows and per capita income increases, new resources can be dedicated to the production of other goods unrelated to food (Engel, 1857, p. 50).

Another goal of the article was to measure the living standards of a population by investigating their consumption patterns. Engel used for this goal Ducpétiaux's (1855) data on 199 family budgets of Belgian families and Le Play's (1855) data on 36 budgets of workers surveyed across Europe. However, only the former dataset was used to infer the law, since Engel considered Le Play's sample not large enough to be representative. Furthermore, Engel did not hesitate to extend the validity of an empirical regularity inferred from Belgian data to project demand in Saxony.

For a modern economist, a common first step in the investigation of the relationship between income and a kind of expenditure, like food expenditure, would be to plot the points on a graph like Figure 1 and to fit an equation to them using ordinary least squares. Engel, however, preferred tabular rather than graphical presentations of data.[1] Moreover, although the method of least squares had been developed by Gauss and Legendre between the eighteenth and nineteenth centuries, regression analysis was only developed in the 1880s and 1890s, by Galton, Edgeworth, Pearson, and Yule. Hence, Engel did not find a readily available curve-fitting technique.

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[1] We do not find many diagrams in his published work. Even in his 1861 study on demand, Engel analyzed the relationship between harvested quantity and price of rye in Prussia only through tables.

Figure 1
Le Play and Ducpétiaux Data on Food Expenditures
(in Belgian francs)
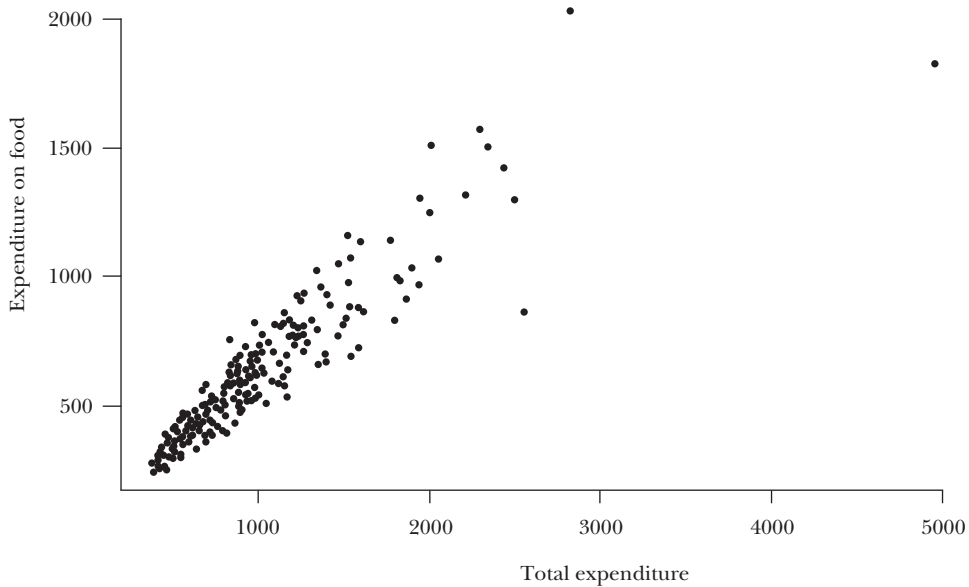
Using Ducpétiaux's (1855) data, Engel's (1857) approach was to construct Table 1, displaying how three different types of working-class families allocated, on average, their budget shares across nine categories of expenditures. In Ducptetiaux's study, families were grouped into three different socioeconomic classes. However, these three family types do not coincide perfectly with separate classes of incomes. Although the average income is increasing from the first to the third class, some households located at the top of the middle socioeconomic class have higher incomes than some households situated at the bottom of the upper socioeconomic class.

From these results, Engel noticed that the share that households tend to spend on "nourishment"—a category which included food expenditure—changes when income increases: "the poorer a family is, the greater the proportion of total expenditure it must devote to the provision of nourishment" (pp. 28–29). He claimed this was a "law" in the sense that it holds for any population of consumers in any economy, although the underlying data included only Belgian worker households. It was in fact a tentative empirical generalization, which later, after several empirical studies, has turned out to be one of the most robust and established in economics (Houthakker, 1987). By labeling this empirical generalization a "law," Engel reveals a methodological position in which statistical analysis has the power of discovering, through induction, new empirical regularities which can provide economic theory with empirical foundations.

Table 1

Percentage Composition of Belgian Workmen's Family Budget

Category of expenditure	Family type		
	1. On relief	2. Poor but independent	3.Comfortable
Nourishment (*Nahrung*)	70.89	67.37	62.42
Clothing (*Kleidung*)	11.74	13.16	14.03
Housing (*Wohnung*)	8.72	8.33	9.04
Heating and lighting etc. (*Heizung*)	5.63	5.51	5.41
Appliances and means for work etc. (*Geräte*)	0.64	1.16	2.31
Intellectual education etc. (*Erziehung*)	0.36	1.06	1.21
Public safety etc. (*öffentliche Sicherheit*)	0.15	0.47	0.88
Health, recreation, self-maintenance etc. (*Gesundheitspflege*)	1.68	2.78	4.30
Personal service (*Dienstleistungen*)	0.19	0.16	0.40
Total on all wants (*Bedürfnisse zusammen*)	**100**	**100**	**100**
Average income (francs)	565	797	1198
Average expenditure (francs)	649	845	1214
Minimum expenditure (francs)	370	440	541
Maximum expenditure (francs)	1256	1769	2823

Sources: Lines 1–10 from Engel (1857, p. 27, table 6); lines 11–14 from Stigler (1954, p. 98, table 3).

Precursor of Nonparametric Estimation?

Parametric estimations, like ordinary linear least squares regressions, require the researcher to prespecify the functional form to be estimated. Nonparametric techniques permit the researcher to estimate the dependence of one variable on another variable without imposing a functional form a priori. This line of research has quite a long history, but only recently has become popular in econometrics (DiNardo and Tobias, 2001). The empirical analysis of consumer behavior has represented an important area of application (Banks, Blundell, and Lewbel, 1997, and references therein). Härdle (1990) and Engel and Kneip (1996), who have contributed to the recent development of nonparametric statistics, have referred to Engel as a precursor of the nonparametric regression method.

In some key aspects, Engel's exercise does indeed look very similar to what is today called a "regressogram." A regressogram is like a histogram, except that the latter estimates a probability density function, while the former estimates a regression function. Consider, for example, a sample of households, like the one examined by Engel. The measured variables are X, income (or total expenditure), and Y, expenditure on, say, food (or food budget share). We construct a histogram to study the income density by dividing the income data into a certain number of "bins," each of them corresponding to a range of income, and we calculate the proportion of observations falling into each bin. We then divide this proportion by

the width of the corresponding bin (a normalization which guarantees that all bin areas sum to one), and we thus obtain an estimate of the income density function $f(X)$. A regressogram is built in a similar fashion, except that for each bin, we calculate the local average of Y instead of the proportion of X. In this manner, for each observation x_0 of income, we obtain an estimate of the conditional expectation $E(Y|X = x_0)$. Just as the histogram is the simplest nonparametric estimation of a density, so the regressogram is the most basic method of estimating the regression function (Engel and Kneip, 1996).

Table 1, from which Engel inferred his law, comes close to being a regressogram as it represents an estimate of the local average of the budget share of consumption for three different groups of families. Yet it is not strictly a regressogram because of the aforementioned overlap of incomes across the socioeconomic classes. Another problem is that Table 1 has only three groups or "bins" across the entire spectrum of income, which seems a rather thin empirical foundation upon which to build an argument about a so-called law. A regressogram, like a histogram, does not have the "best" number of bins, because the "true" shape of the distribution function is not known in advance (DiNardo and Tobias, 2001). However, certain techniques permit a researcher to find a satisfactory bandwidth (in both the histogram and regressogram, the bandwidth is the width of the bin divided by two) as a function of the sample size and the sample standard deviation. For example, according to "Silverman's rule of thumb" (DiNardo and Tobias, 2001) the optimal number of bins in Engel's data is closer to nine than to three.

Even if Engel had used an appropriate regressogram, this is probably not what today's researcher would use. Regressograms are mostly used for teaching purposes, since (like histograms) they present obvious weaknesses in terms of discontinuities which usually determine bad measures of fit. Modern statisticians have developed techniques to obtain smooth estimates of density and regression functions through the kernel method (Härdle, 1990).

Engel, perhaps sensing the weakness of Table 1, presented another table in which both the level and the budget share of food expenditure is shown for 29 clearly separated classes of income, which is shown in here as Table 2. However, Engel did not precisely state how he obtained the numbers in Table 2, which has been the source of some debate. Most of these numbers appear to have been extrapolated in order to get a smooth relationship between expenditure and income. The extrapolation is apparent as four entries in the table refer to classes of income that were not in the original data. This issue has been clarified by Perthel (1975), who argued that Engel took two points from previous estimations belonging to two different and nonadjacent bins. Engel then calculated the first difference between these two points and divided it into three parts following a geometric rate. In this manner, he attained the estimation of two bins situated between the original points. Then, having derived estimation for four adjacent bins in this manner, Engel went on to derive the other 25 estimates by projecting the second difference of the four estimated points across the spectrum of income. In sum, the numbers in Table 2 are based on an ad hoc calculation rather than on statistical estimation. This projection does not seem to adhere to

Table 2
Engel Curve for Nourishment in Tabulated Form

Annual income	Food expenditure	
	In percentage	*In francs*
200	72.96	145.92
300	71.48	214.44
400	70.11	280.44
500	68.85	344.35
600	67.70	406.20
700	66.65	466.65
800	65.69	525.52
900	64.81	583.39
1000	64.00	640.00
1100	63.25	695.75
1200	62.55	750.60
1300	61.90	804.70
1400	61.30	858.20
1500	60.75	911.25
1600	60.25	964.00
1700	59.79	1016.43
1800	59.37	1068.66
1900	58.99	1120.81
2000	58.65	1173.00
2100	58.35	1225.35
2200	58.08	1277.76
2300	57.84	1330.32
2400	57.63	1383.12
2500	57.45	1436.25
2600	57.30	1489.80
2700	57.17	1543.59
2800	57.06	1597.68
2900	56.97	1652.13
3000	56.90	1707.00

Source: Columns on annual income and on food expenditure in percentage are from Table 8 of Engel (1857, pp. 30–31).

any simple mathematical formula, and Engel (p. 30) himself stated that his law "cannot be brought into a precise mathematical formulation."

It is not known whether Engel faced any criticism for these limitations in his statistical methods. However, he himself was clearly not completely satisfied. Indeed Engel revisited some of his results and came closer to constructing a fully-fledged regressogram almost 40 years after the publication of his 1857 article. In a book on the living costs of Belgian worker families, published in 1895, Engel reworked the original Table 1 as shown in Table 3, making two important changes. First, he used income classes rather than socioeconomic classes.[2] Second, Engel used a scale by

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[2] This change may have been spurred by the fact that Carroll Wright's 1875 English translation of Engel's 1857 article reported the socioeconomic classes as if they were nonoverlapping income classes (Stigler, 1954).

Table 3
Budget Shares from Engel (1895)

Category of expenditure	Income 0–80 marks	Income 80–100 marks	Income 100–120 marks	Income 120–200 marks
Nourishment (*Nahrung*)	66.28	66.27	65.80	64.90
Clothing (*Kleidung*)	12.19	14.07	14.96	15.66
Housing (*Wohnung*)	11.51	10.09	8.92	8.79
Heating and lighting (*Heizung u. Beleuchtung*)	5.07	5.03	5.37	4.59
Health (*Gesundheitspflege*)	0.82	1.03	1.56	1.26
Others	3.54	2.61	3.39	4.77
Total	**100**	**100**	**100**	**100**

Note: Francs have been converted into marks.

which families could be reduced to equivalent adults, based on a proposal he made in an article published in 1866. It was indeed the first use of "equivalence scale" in a consumption study. The basic unit by which all families should be measured was called the "quet"—dedicated to Quételet. In the context of his 1895 book, it was meant to control for average differences in family size between two countries. For example, Engel calculated that the typical Belgian worker family, consisting of parents and four children, measured 14.10 quets. There is also a slight improvement in the number of bins: four, one more than in the original article.

Although some of Engel's choices are ad hoc, his work was clearly inspired by a data-driven approach to empirical economics, in which the form of a functional dependence should be inferred from the data and not imposed. A similar methodological spirit imbues much of the recent nonparametric approaches to the estimation of Engel curves (Engel and Kneip, 1996). Thus, Houthakker's (1957, p. 532) praise of 50 years ago still applies: "Engel's successful attempt to derive meaningful regularities from seemingly arbitrary observations will always be an inspiring example to [econometrics] the more so because in his day economic theory and statistical techniques were of little assistance in such an attempt."

An Inductive Approach to Measuring Consumer Welfare?

The main goal of Engel's article was to measure the state of household welfare, which he argued can be discerned from household consumption patterns. Engel (1857) emphasized that his approach was inductive, which he described as the art of uncovering a law "from the assembly and classification (*Zusammenstellung*) of facts and observations" (p. 28). He understood this to be a research method in which the scholar's own a priori theories of how the world works are left aside in favor of deriving meaningful relationships purely from gathering and observing

data.[3] In contrast, a deductive approach begins with the researcher formulating a hypothesis which is subsequently tested with data. In other words, via induction new theoretical relationships are *discovered* rather than *confirmed*.

To what extent was Engel's method inductive? In his work, "assembly and classification" entailed two core parts: classifying household expenditure categories into broad, functionally similar groups; and empirically analyzing these expenditure groups. As we have seen, an inductive approach is present in the second part of this approach, where "assembly and classification" involved estimating, for each income class, the average budget share for a number of expenditure groups. Yet the first step was not entirely inductive. This first step involved discerning which types of household expenditure could best approximate household welfare, and the task was not a simple one, given the very diverse range of expenditures in the data sample.

Engel started from the Smithian notion that the ultimate measure of welfare is the degree to which individuals are able to satisfy their "wants" (*Bedürfnisse*). Wants are innate tendencies, such as hunger, thirst, and status seeking, that motivate consumption (Witt, 2001). Engel (1895, p. 1) defines public welfare in the following way:

> Every individual directs (out of his own impulse) his highest interest to the continuous satisfaction of those wants that stem directly from his human nature, to the expansion of these wants, and also to the attainment of the necessary means to satisfy the higher, expanded wants. The condition which makes all of this possible for the inhabitants of a State is the national or public welfare and the more this range of opportunity is open to all the citizens, the greater is the welfare.[4]

Engel (1857) sought to uncover which wants are most important to human welfare by examining expenditure patterns connected to each particular want (p. 6). In doing so, Engel made a clear break from the past literature in two ways. First, Engel shifted the focus of research away from examining how expenditure is distributed across individual goods consumed, towards focusing on how it is distributed across wants, which goods ultimately satisfy.

Second, Engel made a clear break from the common tendency amongst classical economists to assume that some "basic" goods are inherently more important to human welfare than other "luxury" goods (for example, Smith, 1776; Senior, 1836). Engel (1857, p. 5) argued that such a distinction is subjective, since "it is difficult to say where useful consumption ends and luxury begins, since luxury is a relative, and not an absolute, concept. It would be a grave mistake to define luxury

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[3] Engel (p. 28) referred to the work of the neo-Kantian philosopher Ernst Friedrich Apelt (1854) to justify the possibility of inferring laws just from observations.
[4] Engel borrowed this definition from Joseph Lang (1811). Engel did not define welfare explicitly in the 1857 article, although he did make it clear that measuring welfare was a main goal of the article.

as only the unproductive use of material goods. Luxury is possible in all spheres of consumption."

Engel (1857) proceeded to distinguish and classify expenditures according to the wants they served before undertaking empirical analysis. Table 4 shows how the expenditure categories recorded in Ducpétiaux's household survey (1855) were aggregated into larger groups.[5] Engel aggregated the expenditure categories found in Ducpétiaux's household survey (right-hand column) into larger groups corresponding to a series of wants (left-hand column). Engel based his entire analysis on these aggregate expenditure groups. Thus, while Engel's law is commonly related to food expenditure, actually Engel never analyzed food expenditure in its own right. Rather, he examined expenditures on "nourishment," which included expenditure on alcohol and tobacco, among other things. Engel (p. 6) explicitly stated that he aimed to group goods and services according to the purpose of consumption rather than according to the industry responsible for their production.

This method presents some drawbacks. In some cases, it was difficult to identify the wants that some goods and services satisfied. For example, Engel classified all goods that served the same want together regardless of the fact that they were of very different natures. Thus, expenditure on travel was grouped with recreational expenditure as Engel reasoned that both expenditures served the same want for recreation. He also constructed a special category for goods that could serve more than one want, which he labeled "appliances and means for work," as well as a special category for services. He acknowledged that these categories are rather "superficial" (p. 7) and need more attention in the future as such expenditures do not serve their specific wants but are incurred by consumers in the process of satisfying other wants.

From his analysis, Engel established that "nourishment" was the most basic want as it dominated household expenditure patterns at low income levels. In Engel's thinking, lowering income acts like a litmus test on the consumer's priorities: it crowds out expenditures related to wants that are less basic and leaves those expenditures related to more fundamental wants. Hence a good approximation for household welfare can be attained by investigating *how little share* of the consumer budget is dedicated to the most basic type of want—which turned out to be the want for nourishment (p. 50). This insight explains why Engel's law was originally couched in terms of how an increase in the budget share of food expenditure occurs when income declines, while today it is commonly described in terms of a decline in budget share that accompanies an increase in household income.

Engel (1857, p. 27) also argued that his results revealed a hierarchy amongst wants, where the want for nourishment was the most important want, followed by wants for clothing, for accommodation, and for heating and lighting. He noted that the observed hierarchy is in line with what one typically observes to happen in families experiencing a decline in income levels: when a family cannot properly

[5] Ducpétiaux (1855) recorded data about expenditure categories, including public safety and outdoor recreation, through face-to-face interviews with households.

Table 4

Classification of Expenditure Categories According to the Wants They Serve

Wants	Relevant expenditure
1. Nourishment (*Nahrung*)	Daily nourishment from meals and beverages, spices, stimulants (e.g. alcohol, coffee), tobacco, occasional dining out, etc.
2. Clothing, linen, and toiletries	Clothing and shoes of all kinds; underwear, jewelry, and toiletries; clothing accessories
3. Housing	Shelter, furniture, household appliances; beds and bedding; insurance for housing and furniture.
4. Heating and lighting	Wood, coal, and gas heating; lighting via candles, oil, and gas
5. Appliances and means for work	Tools, machines, mechanical instruments; crockery and vessels etc.; all kinds of metal, earths, stones, glass, porcelain, leather, pulp, rubber, etc.; wagons, boats, saddles and equipment; means of communication
6. Intellectual education	Education, tuition; church; tools for education, schooling, and worship; scientific equipment, literary and artistic production; intellectual rejuvenation and education, music, theater, etc.; musical instruments
7. Public safety	Legal protection; administration; police; state defense; care for the poor, etc.
8. Health, recreation, self-maintenance	Medical treatment and pharmaceutical expenses, bathing; outdoor recreation, play, recreational travel, life insurance
9. Personal service	Personal services attained from use of domestic servants of all kinds

Source: Engel (1857, pp. 5–6).

satisfy all of its existing wants, it tends to sacrifice the satisfaction of higher-order wants to satisfy more basic wants. In this way Engel, like many modern scholars, apparently considered the Engel curve to reflect how individual households change their expenditure patterns in light of income changes.

Engel's approach is not entirely free of assumptions, either. As seen in Table 4, his classification method was based on prior reasoning about the types of wants consumers have as well as how particular types of goods and services were used to satisfy these wants. Implicit here is the assumption that goods and services do not have multiple purposes, since no type of good is linked to more than one want. Moreover, Engel implicitly assumed that this schema is universally applicable in that all individuals share the same basic wants, such as hunger, and possess the same potential for developing higher-order wants, such as education. It is also implicitly assumed that there is no difference across households in the purpose for which goods and services are consumed. For example, all households consume food specifically for nourishment and not for any other purpose. It is not known whether Engel was criticized for making these assumptions, although the concept

of wants was used by many economists in his era, in particular by the protagonists of the marginalist revolution, such as Gossen (1854), Menger (1871), and Wieser (1889), as well as by Marshall (1890).

Much later, in his 1895 book, Engel revisited the issue and provided a further justification for his reliance on the notion of wants. He explicitly identified wants as the main object of his research and stated that "nobody knows why, but, as a matter of fact, all living beings are born with a series of wants, whose non-satisfaction leads to death. Man is no exception. Also in him the urge to satisfy [these wants] is strongly present" (Engel, 1895, p. 8). In this way, Engel constructed a more concrete foundation for the assumption that wants are universally shared by arguing that they are an innate and evolved part of human nature.

In sum, classification and aggregation methods are crucial for uncovering empirical regularities. However, aggregating across expenditure categories and individuals can have a significant effect on results (Lewbel, 2008). Hildenbrand (1994) made clear that aggregation may destroy or create properties that do not necessarily correspond to the disaggregate variables. Engel's own work is not immune to this criticism. Even in today's analysis of household expenditure patterns, assumptions are made about the household budgeting process and the separability of preferences that are not entirely testable. When it comes to making such fundamental assumptions, the choice is never easy. Here, Engel's use of human wants to classify household expenditure suggests that it may be fruitful to let assumptions about expenditure patterns be informed by scientific knowledge of the nature of consumer's wants and how these are satisfied (see Witt, 2001). This strategy will not necessarily lead to the creation of perfectly testable assumptions. It will, however, lead to the creation of assumptions that are at least consistent with what is known about the underlying motivations that drive household expenditure patterns.

Engel's Legacy

In the 1967 presidential address to the Econometric Society—entitled "Are There Laws of Consumption?"—Hendrik Houthakker noted that "laws [in economics] are in the first instance empirical regularities, which may originally have been observed without much theoretical basis." Houthakker emphasized the importance of developing theories within which discovered laws have their place and new phenomena can be explored. In doing so, "the theories give meaning to the law, for a mere empirical regularity conveys only limited credibility and cannot be extrapolated with much confidence. In their turn, the laws give significance to the theories that can account for them. In particular, the establishment of empirical laws enables us to avoid the *ceteris paribus* assumption that has long been the bane of economic theory" (Houthakker, 1967 [1992], p. 219).

To what extent has Engel's work, and particularly the empirical regularities he discovered, informed post-nineteenth-century economic research?

In the twentieth century, many empirical studies were devoted to developing functional forms for Engel curves that better fit the data. The classical treatment is that of Prais and Houthakker (1955) who investigated several functional forms, concluding that a semi-logarithmic form is most suited to necessities and that a double logarithmic form better fits expenditures data on luxuries. Both the estimation method and the measure of fit are based on least squares regression. More complex and flexible forms have been explored in the literature, such as the sigmoid, or S-shaped, Engel curves proposed by Aitchison and Brown (1955). In recent decades, further advances in this task have been accomplished via nonparametric analysis. First, the issue of nonlinearity has been directly tackled by the kernel (nonparametric) regression methods. Second, control for measurement errors and for other covariates (such as demographic effects) has been incorporated in the estimation of Engel curves. Third, progress has been made in methods for comparing different regression functions (Deaton, 1986; Lewbel, 2008, and references therein).

In terms of linking Engel curves to microeconomic theory, much progress has been made in reconciling functional specifications with standard assumptions about utility maximization. Early contributions included Antonelli (1886) who showed that individuals must have linear parallel Engel curves in order for a market demand function to be derivable from a market utility function. Gorman (1961) developed the so-called "Gorman polar form," a useful functional form for indirect utility functions that assumes linear and affine Engel curves. Gorman (1981) proved that a system of Engel curves must have a matrix of coefficients with rank three (or less) in order to be consistent with utility maximization. Moreover, the structure of Engel curves has been exploited to construct demand systems in which prices are incorporated in the model. Thus, the "almost ideal demand system" of Deaton and Muellbauer (1980b) is based on expenditure-share Engel curves that are linear in the logarithm of total expenditure. Banks, Blundell, and Lewbel (1997) generalize this model, assessing nonparametrically the shape of Engel curves and proposing a quadratic logarithmic expenditure shares system.

Despite such progress, some important questions remain unanswered. Satisfactory theoretical underpinnings that explain the wide scatter of household expenditure data seem still lacking. The variability of consumption patterns across households has been duly noted in the literature. Houthakker (1952) argued that this variability cannot be explained by income and prices alone. Deaton and Muellbauer (1980b, p. 323) also suggested that "influences other than current prices and current total expenditure must be systematically modeled if even the broad pattern of demand is to be explained in a theoretically coherent and empirically robust way." Lewbel (2008) recognizes that Engel curves and demand systems "still fail to explain most of the observed variation in individual consumption behavior."

To some extent, Engel's focus on the consumers' wants suggests that a deeper understanding of the motivations driving expenditure decisions may provide a proper foundation for answering this question. Various authors have argued that goods and services related to particular wants display distinctive

income–expenditure patterns: for example, goods and services related to the want for status (Frank, 1999) as well as the want for arousal (Scitovsky, 1976). These studies suggest that as household income rises some motivations become more prominent in household expenditure as the more basic wants that dominate consumption patterns at low-income levels, such as hunger, eventually become satiated at higher income levels (Witt, 2001). Such changes in the underlying wants that drive consumption may go some way in accounting for the shape as well as variability in Engel curves.[6] Unfortunately, this work has rarely been developed to a stage where the implications for Engel curves have been drawn out. Thus, it may be tempting to conclude, as Houthakker (1967 [1992]) did, that any proper explanation of variation observed in Engel curves requires researchers to go "far outside economics."

Indeed, Houthakker (1967 [1992]) himself offered an intriguing explanation for the variance of Engel curves which suggests that this variance will not ever be fully explained by regression analysis. Rebutting the notion that consumption decisions are strongly influenced by advertising, Houthakker conjectured that household welfare partially depends on the discretion it enjoys in allocating expenditure amongst goods. Houthakker (p. 222) argued that this discretion is reflected in the variability of expenditure observed across households of equal size and income level: "We expect to find more variation in small households than in large households at the same income level because in large households 'needs' in some sense are more important in determining what can be bought." In other words, the higher the income and the smaller the household, the lower is expenditure on necessities and the more discretion households have in spending, leading to more variability in expenditure patterns. In this sense, Houthakker offered a twist to Engel's (1857) hypothesis about how household's expenditure on necessities relates to the state of household welfare. Engel argued that household welfare depends on how little is spent in percentage on the households' most basic want. Houthakker takes this one step further by positing that household welfare is also observable in the variation of expenditure patterns that emerges as households spend less on basic necessities. Consequently, Houthakker (p. 220) holds that the observed diversity in household expenditure patterns can be used as evidence against the argument that consumers are "merely slaves" to advertising and social pressures.

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[6] Other equally important strategies also include improving household expenditure surveys in order to reduce sample bias (which is especially problematic with regard to households at high income levels) and accounting for possible violations in the law of one price.

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