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Using Engel Curves to Estimate Purchasing Power Parity

A Case Study of the Computation of the Exchange Rate between the Norwegian krone and the U.S. dollar

Abstract:
Standard practice of estimating purchasing power parities (PPP) involves using prices, in domestic currencies, of a common basket of goods and services, then calculating the price-equalizing exchange rate. In this article, I substitute observed consumer behavior for price data. On the assumption that an Engel curve for food reflects material standard of living, I estimate Engel curves for food for the United States and Norway. This allows us to calculate the exchange rate required for re-aligning the two curves, i.e. the incomes needed in the two countries to purchase the same standard of living. Since different relative prices or preferences for food can affect the position and slope of the curves, I also estimate the Engel curves of non-food, for which the effect is opposite. Not only does this provide a band of upper and lower bounds of PPP, it also improves upon the assumption of preference homogeneity underlying conventional PPP-computations. Using Consumer Expenditure (CES) data for 2001, I obtain estimated PPP-levels for the rate of the Norwegian krone (NOK) versus the U.S. dollar (USD) in the 5.38-7.90 range. The average rate 1977-2007 was 6.81 NOK per USD. The conventional estimates of PPP from the World Bank and OECD are 8.84 and 9.18 NOK per USD, respectively.

Keywords: Engel curve, exchange rate, material standard of living, purchasing power parity

JEL classification: C20, D10, E30, F31

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1. Introduction

Estimating purchasing power parities (PPP) is highly challenging. But because PPPs are extremely useful, the International Comparison Project (ICP), working under the auspices of the World Bank, now computes them on a regular basis. The advantages of these parities are proportional to the disadvantages of using market exchange rates. Market rates are volatile, reflect investor sentiment, and are sensitive to short-term trade mechanisms. To quote The International Bank for Reconstruction and Development/World Bank (2008),

Market exchange rates are determined by the demand for, and supply of, currencies used in international transactions. They do not necessarily reflect differences in price levels and may therefore under- or overstate the real value of an economy's output and the standard of living of its residents. In fact, the prices of many goods and services within economies are determined in partial or complete isolation from the rest of the world." (page 3).

As a consequence, international statistical agencies collaborate on collecting prices on identical baskets of goods and services, an effort that allows estimation of PPPs. But the main problem with the conventional approach is that neither baskets nor preferences are identical across countries. This article explores a possible way around this conundrum, by supplementing the price data PPPs with PPPs estimated from data on observed consumer behavior. In order to do so, I employ one of the oldest empirical regularities in economics, the Engel curve for food.

The stability and universality of the Engel curve for food invite exploitation and this empirical regularity can be put to many uses because it allows a fixed point around which to fashion comparisons. For example, Hamilton (2001) utilized, in a novel and innovative fashion, drift in Engel curves to estimate CPI-bias in domestic price data. He inspired Beatty and Røed Larsen (2005) and Røed Larsen (2007) to employ and refine the method on data from Canada and Norway. Hamilton's method is also emulated and put to use by Almås (2007) who seeks to measure potential PPP-bias in studies of international income inequality. In general, Engel curves serve a wide range of purposes. Costa (2001) uses Engel curves to estimate historical developments of real incomes. Gibson (2002) discusses uses of the Engel method in determining scale economies of household size since the estimation of equivalence scales is a major branch of Engel curve employment.

The idea of deploying Engel curves to estimate PPP-rates is simple: Analysts could be able to infer PPP-levels implicitly from explicit and actual economic decisions. It could be argued that two baskets of food need not contain identical elements as long as they serve the same end and yield the same utility level. A basket of fish, corn, and carrots, for instance, could serve the same end as a basket of meat, rice, and broccoli. This is how I propose to employ Engel curves in this article. I first assume that the proportion of a household's economic purchasing power spent on food reflects that household's material standard of living. I proceed to estimate Engel curves for food in two economies, the United States and Norway. Then I calculate the exchange rate required to re-align the two Engel curves, i.e. what exchange rate would equalize the cost of purchasing a given material standard of living in the two countries.

My contribution in combining Engel curves with PPP-estimation is twofold. First, I show that Hamilton's idea to use estimated Engel curves to correct or supplement *national* price data can also be used to correct or supplement *international* price data. Second, I develop several new techniques to address some of the shortcomings of Hamilton's method and the weaknesses in Almås' approach. As some critics have argued, food preferences may change domestically over time, causing Hamilton's method to mis-attribute preference-drift to price index bias. I recommend studying the all-encompassing other good, *non-food,* with which food exhausts total expenditure, and applying the same methodology to this aggregate good. Since food preference shifts would be reversed and opposite for non-food, observers would be able to establish upper and lower limits of the severity of the disadvantage arising from preference difference confounders. In addition to this improvement, I refine Hamilton's method to control for three other omissions. Since Røed Larsen (2007) demonstrated likely sensitivity of results from Hamilton's method to demographic composition of the household, level of material standard of living, and the chosen functional form of the parametric approach, I develop remedies to these three obstacles. That is, I introduce parametric preference-shifters and a segmentation technique, allowing for flexibility of standard of living, and employing a non-parametric approach.

I hope in this article to demonstrate the feasibility of the idea as a useful supplement to conventional PPP-estimation, especially in countries where price data are scarce or subject to manipulation, and the plausibility of the resulting PPP-estimates. Applying the methodology to 2001 data from the United States and Norway, I obtain a PPP-estimate band that ranges from 5.38 to 7.90 NOK per USD. In 2001, the annual average of the market exchange rate was 8.99 NOK per USD. By 2008, after years of decline, the market exchange rate fell to about 5 NOK per USD. In early 2009, it is hovering just below 7 NOK per USD. The mean market exchange rate for the last 30 years is 6.81 NOK per USD. While the conventional PPP-estimates of the World Bank and OECD, of 8.84 and 9.18, respectively, lie at the high end of the market exchange rate, this article's band lies almost symmetrically around the long-term average. Now although this observation is no proof of the Engel curve method's superiority, it gives at least some indication of the method's applicability.

Observers may object because PPP estimation presupposes a tradable object. A basket of goods is tradable, a standard of living is not. But contrary to the belief of some economists, the legitimacy of the construction and uses of PPPs does *not* rely on the tradability of the goods and services involved. Only when the PPPs are used to forecast future market exchange rates is it necessary to invoke the law of one price, arbitrage opportunities, and tradability. The PPP rate is first and foremost a tool to convert local, regional, or national *nominal* entities into comparable and meaningful international statistics on *real* entities. In fact, PPPs may usefully be constructed when little market exchange between the domestic and international economy takes place. The information on PPP-rates would still be useful to a variety of agents and for many purposes.

But PPPs are not very accurate. Consider the magnitude of revised numbers after the world's newspapers announced in the fall of 2007 that the Chinese economy was overvalued by 40 percent.[1] That piece of information relied on new estimates of PPPs between the renminbi and other currencies. Although many readers around the world were given a jolt, it should not have, and did not, come as a surprise to PPP experts who have long grappled with the complexities of the dimensionality-reductions involved in scaling down millions of prices to one simple factor, a scalar currency converter. A good sold in one country may or may not have an exact replica in another. It can be important to the one economy, but insignificant to the other. Oftentimes, a good does not even exist in other countries; possibly resulting in completely incomparable budget shares. And even if goods and services are comparable, preferences may be quite different. Finally, data acquisition in itself is extremely cumbersome, with incentives threatening to distort reported numbers.

Nevertheless, PPP-conversion rates are not of recent date. Rogoff (1996) says the idea was articulated as early as the sixteenth century. Fascination has not diminished since then. In fact, as Taylor and Taylor (2004) say, "The idea of PPP has become embedded in how many international economists think about the world." Few topics elicit more studies every year despite the substantial difficulties involved; see e.g. Taylor (2001). The first difficulty lies with the construction of an international price

[1] See for example the New York Times on December 9th 2007: http://www.nytimes.com/2007/12/09/opinion/09sun4.html

data set. Not only does it call for sophisticated methods; see e.g. Parsley and Wei (2007), one needs to examine *alternative* approaches likely to support or contradict the estimates. So the method presented in this article could prove useful since it is relatively cheap, quite fast, can be employed when prices are scarce, and is based on consumer behavior as a standard of living indicator. This in contrast to the conventional approach which is very expensive and resource demanding, takes a long time, involves price data of variable quality, and assumes the feasibility of observing market prices of the basket of goods and services.

Thus, the key assumption I make is that Engel's Law holds, understood as a monotonous mapping from food share to material standard of living, or at least that a given food share in one country plays the same economic role as in another country. The Engel curve method does not stand or fall on the foodstuffs being identical, only that food in one country serves the same purpose as food in another country and that consumers share sufficiently similar preferences for comparison of Engel curves to make sense. As in Hamilton's work, I find the distinction between food and non-food attractive because the treatment is straightforward, and can be modeled with plausible separability between food and non-food. Indeed, as Hamilton says, food is convenient because its elasticity is clearly below unity so demand curves are nicely behaved and downward-sloping, it is perishable so one can assume expenditures are close to consumption without too many flow-stock issues, and the Working-Leser Almost Ideal Demand System functional form has been widely investigated. As in Hamilton's usage, the idea here bears close resemblance to Jorgenson and Slesnick (1997), who used estimated demand systems to back out standards of living and treated food as a separate main category in the demand system.

The article proceeds as follows. In the next section, I introduce the theoretical reasons for employing Engel curves to estimate PPPs and then I describe my data sources. Section four presents the empirical results and in section five I discuss the severity of the shortcomings. Section six concludes and offers policy implications.

2. Theory and Empirical Techniques

Today, the work horse of Engel curve estimation is the baseline model known as the modified AIDS-model. This article joins this tradition and takes as its point of departure the AIDS-model, given in equation (1):

$$(1) \qquad \omega_{h,r} = \alpha + \gamma\left(\ln\left(P_{f,r}\right) - \ln\left(P_{n,r}\right)\right) + \beta\left(\ln\left(Y_{h,r}\right)\right) + \sum_{j} \theta_j D_{j,h,r} + u_{h,r}, \; h \in H, r \in R, j \in J ,$$

in which food's share of income (or total expenditure) is denoted by ω, observed prices by P, income by Y, and demographical characteristics of households by D from a set J. Subscripts h, r, j, f, and n refer to household, country, characteristic of household, food, and non-food. The error term u captures omitted structure and stochastic elements. It is assumed to behave classically; so that its distribution has zero mean and constant variance. Food is defined as food consumed at home, food consumed away from home, or both. The basket of food contains non-alcoholic beverages. The income variable I is income before taxes, but I have also experimented with income after tax, and I report the results below. The dependent variable is the ratio of food outlays to income before tax. Household characteristics are assumed captured by variables controlling for household size and composition, the importance of which is demonstrated by Logan (2008). Engel curve estimates of CPI biases, he shows, may themselves be biased over time unless they account properly for demographic composition and size.

Since this article studies cross-sections, time-varying demographic effects are not an issue, but composition and size of the household are still key to proper modelling. I use two dimensions, and span them by the variables "number of adults" and "number of children" in the household. These characteristics are included to allow for differences in preferences for different types of households (single-person households and 2-adult 2-children households are likely to experience different demands of food and thus food shares). In essence, these characteristics function as shift parameters to re-position the Engel curve for different types of household. In order to check the robustness on this choice of modelling, I have added a segmentation technique, with which I perform non-parametric regressions. Segmentation before the regression means that I avoid having to identify the appropriate functional form of demographic size and composition effects, and instead may estimate, non-parametrically, Engel curves for each demographic type of household.

Econometrically, I estimate a regression, for each country separately, a modified AIDS-demand specification. I obtain two Engel curves, one for Norway and one for the United States. The idea is that households share a household utility production function and that only the monetary unit, the domestic currency, is different. The factor that would re-align the two curves may be an approximation of purchasing power parity. What follows below are some qualifications, moderations, and embellishments of this idea. Allow first some details of the econometrical model. I regress the food-share of income before taxes onto the logarithm of income before taxes, the squared logarithm of income before taxes, the number of children, and the number of adults, as given in equation (2):

$$(2) \qquad (F_h/I_h) = a + b(\ln(I_h)) + c(\ln(I_h))^2 + dC_h + eA_h + r_h, \ h \in H ,$$

in which F_h is the observed food expenditure of household h, I_h is income before tax of household h, C_h is the number of children in household h, and A_h is the number of adults in household h. The error term r_h is modelled to behave classically. Notice one important point. I have suppressed the relative price of food to non-food in equation (1), which follows from the decision to run a separate regression for each country. Since I take the relative price of food to be common to all households in an economic area, i.e. a country, including the price would involve reduced rank matrices due to linear dependence between variables, since the country relative price would only be a re-scaling of the intercept. However, relative price effects between the two countries should, nevertheless, be accounted for since households in the two countries probably face a different relative price of food compared to the other, non-food, good. Thus, the relative price of food could be a plausible candidate for a classic confounder. If food is relatively cheaper in one country, the different position of the Engel curve could be due to *both* the exchange rate between the monetary units *and* the relative price of food. But accounting for the relative price of food would simply give us another instance of the problem facing the conventional PPP-computations, i.e. constructing and compressing price data. Having to replicate the conventional PPP-method before supplementing it, would not save time or add knowledge; nor would it make sense. I suggest the following remedy. When the relative price of food in one country is cheap then the relative price of non-food must be expensive – and vice versa. Thus, the effects on the slope and position of the Engel curves are opposite for food and non-food. To control for the effect caused by a possible difference in the relative price of food to non-food, I compute an exact replica of equation (2) for non-food. This produces a range within which the purchasing power parity lies and incorporates a control for potential preference heterogeneity in the two countries.

Choosing the determinant in the regression and the denominator in the dependent variable's share is a challenge. There are three candidates: income before taxes, income after taxes, and total expenditure. None come without disadvantages. For example, the variable income before taxes includes the proportion of the income the household plans to save. It is non-obvious how this would affect the results, and I discuss the issue below. Saving, I suggest, is associated with the inter-temporal profile of utility extraction, not the cost of a material standard of living in the present, so heterogeneous saving behavior should lead to different positions along one Engel curve, not different Engel curves. Total expenditure is another candidate. It is, however, a well-known problem in the Engel curve literature and demand estimation using errors-in-variable models that total expenditure is endogenous and that including it as a determinant is likely to cause serious simultaneity problems; see Kay, Keen, and Morris (1984) and Røed Larsen (2009). The numerator in the share, i.e. food expenditure, comes with measurement errors that also, by the definition, will end up in total expenditure. That being so the determinant total expenditure will have a non-zero covariance with the error term, creating a bias in the estimate of its coefficient. Analysts can solve this problem using 2SLS methods with exogenous instruments, though the trade-off would be a narrowing of one's choice of parametric form.

Using income after taxes as a determinant is no remedy, because U.S. and Norwegian tax rates differ, as of course do income after tax incomes. Tax in effect is a charge on the consumption of public goods; since it contributes to material standards of living, it cannot be ignored. I perform robustness checks and experiment with after tax income in order to determine the disturbance potential of the different tax rates. As this brief outline of the choice of determinants suggests, the least disadvantageous determinant is income before taxes. It has three major advantages: it is a plausible explanatory variable, it is exogenous and it is insensitive to tax rate differences.

In Engel curve estimation, functional form needs to be considered. Engel curves are best modelled as non-linear; see Banks et al. (1997). Alternatives to a linear set-up, such as quadratic forms and semi-parametric estimation, are explored in Lewbel (1998). Blundell et al. (2003) examine non-parametric estimation. There is a promising demonstration of semi-nonparametric instrumental variable estimation in Blundell et al. (2007). These studies underline the importance of functional specification. This article offers a combined approach. After estimating the Engel curves parametrically, using a quadratic logarithmic form in order to incorporate curvature, I estimate the Engel curves non-parametrically, using a local regression technique. Since income before taxes is exogenous, it is an excellent determinant in non-parametric estimation processes. I start my non-parametric estimation by noting that the relationship between the food share of income before tax and income before tax, is generally given by a non-specified relationship g() in equation (3):

(3) $$\omega_{f,h} = g\left(p, I_h, D_h\right) + \mu_h,$$

in which $g(.)$ is an unspecified function, potentially non-monotonous, and the classically behaved error term μ is uncorrelated with income before tax, I. As before, D denotes preference shifters such as demographic variables that control for size and composition, p denotes relative prices, and ω_f now refers to food's share of income before tax. I estimate the function $g(.)$ in equation (3) non-parametrically by using a local regression technique. The local regression method fits a linear weighted regression line in a local neighborhood for each I_h.[2] The linear regression weight assigned to an included observation I_i around I_h, for which the local line is fit, is given by equation (4):

$$W(I_i, I_h, b_i) = K_0(x) = K_0\left(\frac{I_i - I_h}{b_i}\right), \; i \in I, h \in H, x \in X \,, \tag{4}$$

where I_i is member of the bandwidth set around I_h, where b_i specifies the range of bandwidth, and where $K_0(x)$ is a smooth weighting function. The variable x is an intermediary variable and element in the real-number set X. The neighborhood set I is a subset of the set H containing all household observations. This article uses the Tri-Cube function for $K_0(x)$, as given in equation (5):

$$K_0(x) = \begin{cases} \left(1-|x|^3\right)^3, & \text{for } |x| \le 1, \\ 0 & \text{otherwise.} \end{cases} \tag{5}$$

3. Data

I use information on consumer expenditures from the United States and Norway. The U.S. data were compiled by the Bureau of Labor Statistics; see Bureau of Labor Statistics (2002); the Norwegian by Statistics Norway.[3]

a. The Norwegian Data

Statistics Norway contact 1/26 of their household sample every fortnight and ask households to keep a complete diary of all expenditures for a 14-day period. The households are subsequently interviewed for information on demographic variables, housing arrangements and attributes, and other variables of interest. A data set can provide information on, for instance, household size and composition, age of

[2] The neighborhood is chosen so that it contains a percentage of all available observations in the sample. These observations are weighted by a smooth, decreasing function of their distance for each center $I_{,h}$.

[3] Statistics Norway has constructed a special internet site in English on CES, sampling, weights, and latest developments. Use: http://www.ssb.no/english/subjects/05/02/forbruk_en/.

household members, region of residence, vocation of main income earner, number of hours worked by main income earner, and ownership of selected household durables such as cars, boats, refrigerators, washing machines, stoves, television sets, video recorders, and microwave ovens. Sample sizes are typically around 1200 households per year. The sampling scheme is a two-stage stratified random sample of the universe of Norwegian households. Response rates vary around 60 percent. On reception of the information, statisticians encode the information on household spending per item recorded in the accounting books into pre-assigned groups. Expenditures are annualized (by multiplying with 26). Standard aggregation levels are 9, 37, 150 and 488 commodity groups. The demographic data include variables on number of children under 7, 16, and 20. For my purposes, the variable "No. of Children in household" is the number of children under 16. I use information from 999 households all told, after omitting some due to missing values, truncation, and data cleansing.

After gaining the approval of the authorities, Statistics Norway link Consumer Expenditure Surveys data sets with data sets from income registers. These income registers are not surveys, but complete and exhaustive full-count registers held by the Norwegian tax authorities ("Skattedirektoratet"; the Norwegian equivalent of the IRS) and national insurance authorities ("Rikstrygdeverket"). They cover all Norwegian residents. I was able to access several income variables from this combined resource, e.g. income before taxes and income after taxes. Income data maintain a high standard. In Norway, employers are required by law to file information on employees, for example pay and salary, with the authorities. It is neither based on individual memory nor given at a person's discretion. The data for this study were sourced directly from the income registers.

b. U.S. data

The U.S. consumer expenditure data were obtained from the Bureau of Labor Statistics as described in U. S. Dept. of Labor, Bureau of Labor Statistics, 2002[4], (documentation available online at http://www.bls.gov) for the four quarters of 2001 and the first quarter of 2002. I use the interview component of the CES system. The data were downloaded from the ICPSR-site at the University of Michigan, Ann Arbor (available online at http://www.icpsr.umich.edu), which are in the public domain, and can be accessed to cross-check the results, and examine sensitivity to specifications. My data comprise 5 datasets of the fmly-type and are named as follows: da3674.fmly011, da3674.fmly012, da3674.fmly013, da3674.fmly014, and da3674.fmly021.

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[4] The full bibliographic reference, for file, producer, and distributor, is: U.S. Dept. of Labor, Bureau of Labor Statistics. Consumer expenditure survey, 2001: Interview survey and detailed expenditure file [Computer file]. Washington, DC: U.S. Dept. of Labor, Bureau of Labor Statistics [producer], 2002. Ann Arbor, MI: Inter-university Consortium for Political and Social Research [distributor], 2003.

The interview component of the CES-system consists of data on major items of expenses, household characteristics, and income in a continuous flow of surveys. Each consumer unit is interviewed every three months over a 15-month period, and each reports expenditures for the past three months prior to the interview. These expenditures are recorded as they were undertaken, and are not annualized (p. 99, op.cit.). It is estimated that the interview covers 90 to 95 percent of expenditures, but first quarter interview expenditure data are not reported (p. 321) because they are collected for bounding purposes only. However, the next four quarters, i. e. from the second through the fifth interview, of expenditure data are reported and available. Each quarter sample is designed to be representative of the United States population, and the response rate of the 2001 survey was 78 percent (p. 326). The results in this article are based on the reports from the five-quarter period starting with January 2001 and ending with March 2002, but are limited to expenditures reported in the calendar year 2001 only. Because of the rotating sampling scheme, some households report more often than others. BLS derives corrective weights that restore population properties. I use income before taxes as defined by BLS (p 66), but include analyses with income after taxes.

Reported expenditures for all reporting households are transformed to an annual basis by dividing by number of reporting months and multiplying by 12. I did not weigh households by length of observation period, but I did truncate by requiring at least 6 months of observed expenditures. Moreover, some of the expenditures reported by early observation households, e.g. households whose second interview was in the first quarter of 2001, where undertaken in the fourth quarter of 2000. When that was the case, I omitted the 2000 data. Conversely, some households were interviewed in the first quarter of 2002, in which case I omitted expenditures for that quarter. Some variables, including income and demographics, vary over the observation period. I use the latest available. Notice children are defined as household members under 18. The variable “Adults” is defined as family size minus number of children.

After rejecting households for missing values, truncation, and data cleansing, I was left with a total of 5,391 households.

c. Comparing U.S. and Norwegian data

The U.S. and Norwegian classification systems are different; see Bureau of Labor Statistics (2002), p. 100) for the content of total expenditures in the U.S. data. Total U.S. expenditures are categorized into food (including non-alcoholic beverages and food away from home), alcoholic beverages, housing, apparel, transportation, health care, entertainment, personal care, reading, education, tobacco, miscellaneous, cash contributions, and personal insurance. Norway divides total expenditures into food (excluding beverages and food away from home); beverages (both non-alcoholic and alcoholic) and tobacco; clothing and footwear; rent, fuel, and power; furniture and household equipment; health care; recreation and education; and other goods and services. Thus, for the headline comparison I used the U.S. definition of food, including non-alcoholic beverages and food away from home. The comparable Norwegian variable food was extended by adding non-alcoholic beverages and food away from home from sub-categories under other categories. In the discussion, I include sensitivity analyses on alternative definitions of food, most notably by excluding food away from home. Table 1 below tabulates the summary statistics of households in the two country samples.

Table 1. Summary Statistics of Variables and Distribution. United States (in USD) and Norway (in NOK). 2001

Variable	10th Percentile	50th Percentile	Mean	90th Percentile
Norway N = 999 obs.				
Food[1]	21,625	52,441	56,579	93,130
Income before taxes	243, 263	502,227	528,051	817,676
No. of children	0	1	1.06	3
No. of adults	1	2	2.10	3
United States N = 5, 391 obs.				
Food	2,590	5,319	5,926	9,856
Income before taxes	20,400	47,400	59,150	142,600
No. of children	0	0	0.76	2
No. of adults	1	2	2.02	3

[1] Food is defined as food-at-home (including non-alcoholic beverages) and food-away-from home.

4. Empirical Results

Tables 2 and 3 present this article's main findings. I estimate an Engel curve for food for both the United States and Norway by regressing a household's food-proportion of income before taxes onto a second order polynomial of logarithm of household income before taxes, the number of children in the household, and the number of adults. Notice the U.S. regression yields an adjusted R-squared of 0.42, a high level of explanatory power in a cross-sectional study, and one that is consistent with the hypothesis that Engel curves for food reveal valuable information on household behavior and for which preference heterogeneity may not be an insoluble challenge. For Norway, the variation in determinants explains 28 percent of the variation in food's share of income before taxes. The estimated coefficients are statistically significant and economically important. The negative estimate of the coefficient of the logarithm of income before taxes indicates the inverse relationship between food's proportion and income, and the positive estimate of coefficient of the squared logarithm of income demonstrates the curvature of the Engel relationship. Observe also the estimated coefficients of number of adults are larger than the coefficients of number of children, consistent with the ex ante hypothesis that adults consume more food than children.

I use the estimated Engel curves from Table 2 to compute the association between levels of income before taxes and levels of material standards of living, measured as food's proportion of income before taxes. I use the income levels to compute PPP-estimates and tabulate the estimates in Table 3. For example, in the United States, an income before taxes of 36,500 dollars is associated with a 15-percent food share for a family of two adults and one child. In comparison, 290,500 Norwegian kroner (NOK) are needed to achieve the same material standard of living. This means that a Norwegian household needs 7.96 times more units of their domestic currency to purchase the same material standard of living; the estimated purchasing power parity is therefore 7.96 NOK per USD. For a more luxurious standard, e.g. for 8-percent standard, the estimated PPP-rate is 7.33 NOK per USD.

For an American single-person household an income before taxes of 42,800 U.S. dollars is associated with a material standard of living commensurate with a 10-percent food share. The similar association for Norwegian single-person households occurs at NOK 310,500. This gives an estimated PPP for the 10-percent standard single-person-household of 7.25 NOK per USD.

Table 2. Estimating Engel Curves for Food: Food's[1] Share of Income[2] before Tax on Determinants, United States and Norway, 2001

Variable	U.S. 2001	Norway, 2001[3]
Constant	4.201 (20.4)	4.701 (4.7)
Log(Inc. b. tax)	-0.682 (-18.0)	-0.635 (-4.2)
Log(Inc. b. tax)^2	0.0277 (15.9)	0.0213 (3.6)
No. of Children	0.0132 (17.1)	0.0205 (12.2)
No. of Adults	0.0217 (20.7)	0.0229 (7.6)
R^2 Adj.	0.4194	0.282
No. of observations:	5,391	999

[1] U.S. food is defined as food at home (which includes non-alcoholic beverages) + food away from home (which includes non-alcoholic beverages). Norwegian food is defined as food at home + sub-category food away from home + sub-category non-alcoholic beverages.

[2]U. S. CES data truncated at $15,000 and $300,000. Only households reporting expenditures for at least 6 months in 2001 were included. (Before truncation the data comprised 17,690 observations over 5 quarters.) Norwegian CES data truncated at NOK 135,000 and 2,700,000. All households reported for a 14-day period in 2001. All expenditures were annualized.

[3]Multicollinearity explains the relatively low t-values. An alternative specification, without the squared log(inc.b.tax) element, yielded a regression line (with t-values in brackets): 1.094 (18.6) – 0.0798 (-16.8) * Log(inc.b.tax) + 0.0199 (11.8)* No. of Children + 0.0221 (7.2)* No. of Adults. This line had an adjusted R-sq. of 0.273. Thus, the second order polynomial, does not improve upon a linear specification, but is used in the table because it compares easily to the U.S. estimates, where the second order polynomial was preferable to a specification with only the first order log(inc.b.taxes) element.

Table 3. PPP Computations Based on Re-alignment of Engel Curves. U.S. vs Norway. Family of 3 (2 adults, 1 child) and Single-Person Household. 2001

Living Standard (Inverse of food share)	Norwegian Income Required, in NOK	U.S. Income Required, in USD	Estimated E_{PPP} = NOK income/USD income
Family of 3 (2 Adults, 1 Child)			
0.08	691,500	94,400	7.33
0.10	516,000	66,500	7.76
0.12	401,500	50,800	7.90
0.15	290,500	36,500	7.96
0.20	183,500	23,400	7.84
Single Person Household			
0.08	386,500	54,100	7.14
0.10	310,500	42,800	7.25
0.12	254,500	34,800	7.31
0.15	194,000	26,500	7.32

The accuracy of this estimation is sensitive to a potential difference in the relative price for food-to-non-food in Norway and in the United States. It is also sensitive to a potential difference in households' preference for food. While the latter cannot easily be empirically accounted for, the former could have been dealt with by estimating the price of a given basket of food in terms of a given basket of non-food in the two countries. But this would simply replicate the conventional PPP-approach, the very activity I seek to supplement. Instead of replicating the conventional PPP, it is possible to exploit the completeness of the demand system and the plausible separability of the two categories. The good categories of Food and Non-Food exhaust total expenditures, so if the relative price of food to non-food is lower in the U.S. than in Norway, the relative price of non-food to food must necessarily be higher. Similarly, if American households have greater preferences for food over non-food than Norwegian households, it stands to reason that American households must have less preferences for non-food than Norwegian households. Because of the completeness of food and non-food, we can examine the Engel curves for non-food and inspect the ramifications of a reversal of the price-effect and an opposite preference-effect.

Table 4 lists the results of an estimation of Engel curves for non-food for the United States and Norway. There is evidence of a non-negligible effect from prices and/or preferences. Some observers may find it puzzling to see a downward-sloping Engel curve for food alongside a downward-sloping Engel curve for non-food. After all, if households' food-share of total expenditures decreases as their income increases, households' non-food share of total expenditures should increase. That is correct. But recall, I do not use budget shares as dependent variables and I do not use total expenditure as a determinant. For theoretical reasons related to the endogeneity of total expenditure in errors-in-variable models, I use income before taxes. Income before taxes is allocated to taxes, savings, and expenditures. One should not be perturbed to see the estimated curves decline with income before taxes since tax proportions tend to increase with income.

In Table 5, I list the pairs of association between proportion of non-food and income before tax for both countries, and find that Norwegian households behave such that a given standard appears be achieved at a relatively low multiple of U.S. incomes before taxes. For example, for an American family of three an income before taxes of USD 53,100 is associated with a material standard of living commensurate with a 70-percent non-food share. In Norway, the association for this household type occurs at NOK 286,000, yielding an estimated PPP of 5.38 NOK per USD.

Table 4. Estimating Engel Curves for Non-Food: Non-Food's[1] Share of Income before Tax on Determinants, United States and Norway, 2001

Variable	U.S. 2001	Norway, 2001[3]
Constant	15.129 (9.6)	16.535 (2.5)
Log(Inc. b. tax)	-2.385 (-8.2)	-2.226 (-2.2)
Log(Inc. b. tax)^2	0.0962 (7.2)	0.0764 (2.0)
No. of Children	0.0259 (4.4)	0.0541 (4.9)
No. of Adults	0.0530 (6.6)	0.00922 (0.5)
R^2 Adj.	0.131	0.0812
No. of observations:	5,391	999

[1] See notes of Table 2 for definitions and remarks.

Table 5. PPP Computations Based on Re-alignment of Engel Curves for Non-Food[1]. U.S. vs Norway. Family of 3 (2 adults, 1 child) and Single-Person Household. 2001

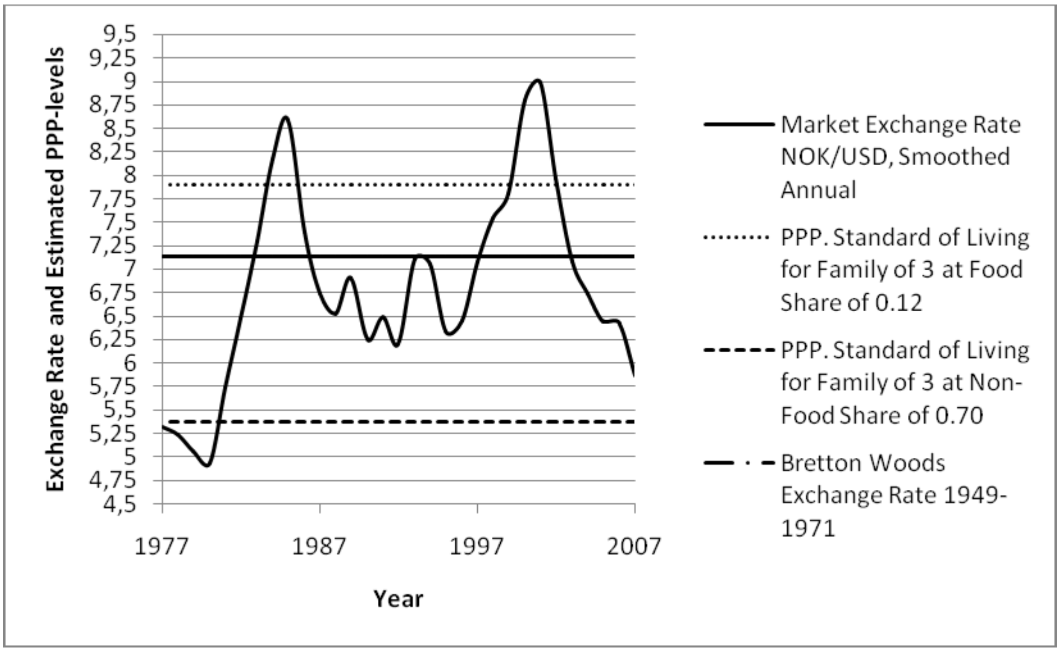
Living Standard (Inverse of food share)	Norwegian Income Required, in NOK	U.S. Income Required, in USD	Estimated E_{PPP} = NOK amount/$ amount
Family of 3 (2 Adults, 1 Child)			
0.55	507,000	102,100	4.97
0.60	410,000	78,600	5.22
0.70	286,000	53,100	5.38
0.80	211,000	38,800	5.44
Single Person Household			
0.60	324,000	57,100	5.67
0.70	235,000	41,300	5.69
0.80	177,500	31,400	5.65

[1] Non-food is defined as total expenditures subtracted by food.

This two-step approach of utilizing food and non-food at the same time allows us to construct an interval containing price and preference effects, and is a useful supplement to conventional PPP-computations, the butt of constant criticism for the homogeneous-preference assumption underlying any and all choices of weights.

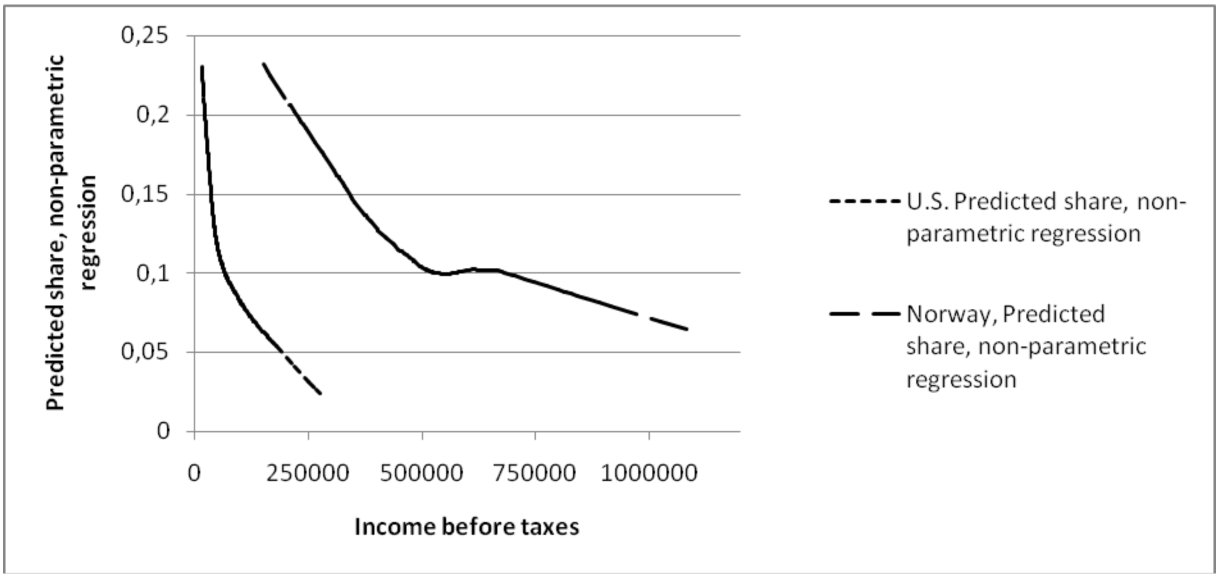
In Figure 1, I plot upper and lower bound for my PPP-estimates. The upper bound of 7.90 NOK per USD results from the computation of a 12-percent food-share standard of living for households with two adults and one child. The lower bound of 5.38 NOK per USD is obtained using a 70-percent non-food-share standard of living for the same household type. In order to create a check on the validity of this interval, I plot the market exchange rates for the last 30 years. As we observe, the market rate remains largely within the interval. Intriguingly, the Bretton Woods fixed exchange rate of 7.14 NOK per USD throughout the period 1949-1971 also falls well within the band and around the middle. This I interpret in two ways. First, since market exchange rate deviations from PPP typically reduce within a period of some time; see Rogoff (1996); constructing Engel curve PPP-bands may have predictive power. Imagine, for example, observing the market exchange rate is outside of an estimated band. More likely than not it would return to levels within the band relatively shortly. Second, but perhaps more importantly, it strengthens the plausibility in the supposition that Engel curve PPP-estimates are feasible. Since the band encompasses market exchange rates over time, and we know that currency deviations typically halve in three to five years, the fit between my estimated band and historical market rates speaks to the method's usefulness.

Figure 1. Market Exchange Rates and Band of Estimated PPP-levels Using the Engel Curve Re-alignment Method. Food and Non-Food. Family of 3. U.S. dollar versus Norwegian krone. 1977-2007



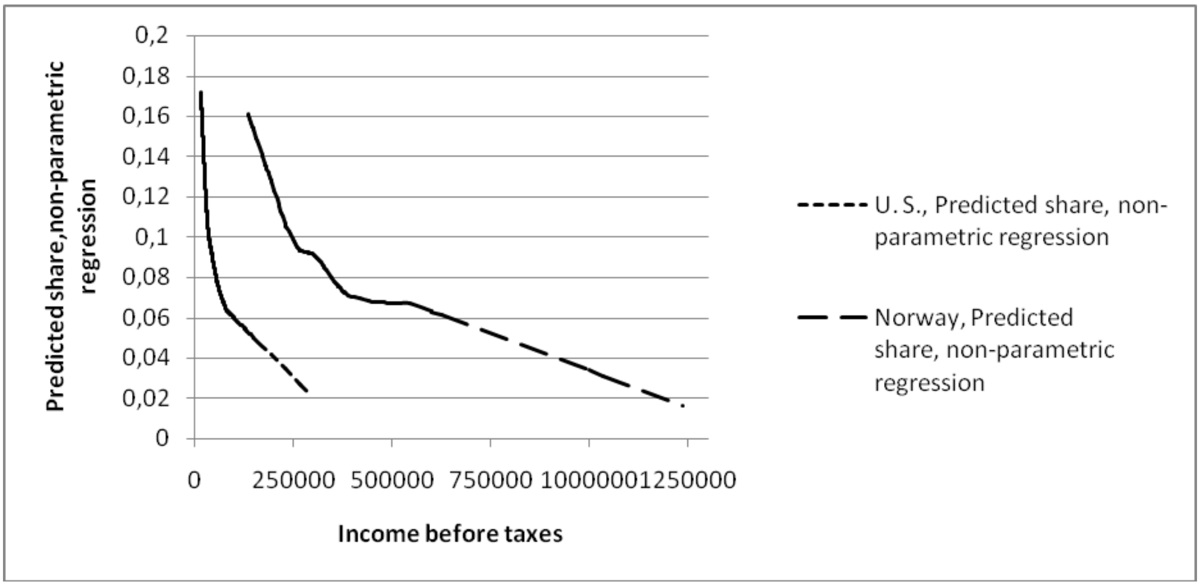
How restrictive is the parameterization of the Engel curves? Even if the adjusted R-squared levels were substantial, significant kinks and twists in the relationship between food share and income could escape the parametric model. Empirical economists would be especially concerned at what happens at the lower and higher end of the income spectrum. Moreover, the literature has carried a long and intense discussion on the shape of Engel curves. In order to examine the sensitivity to modeling choices, I perform non-parametric regressions. Since these regressions rely on the technique of fitting local linear regression lines to each point along the first axis, and thus involve constructing a relationship between the two variables proportion of food and income before taxes, I utilize a two-stage method, in which I first segment for demographic type in order to avoid confounding effects from household size and composition, then compute the non-parametric regressions. In Figure 2, I depict the results from utilizing the non-parametric technique on households of two adults and one child. Figure 3 shows non-parametric Engel curves for single-person households.

Figure 2. Non-parametric Regression. Tri-cube Function. Foodshare on Income before Taxes. Family of 3 (2 Adults, 1 Child). United States and Norway. 2001



Notes: The non-parametric regression line for households of 2 adults and 1 child in the United States included 467 observations. It had 17 fitting points and the smoothing parameter was 0.60. Points in local neighborhood: 280. Residual sum of squares: 1.314. Equivalent number of parameters: 3.99. The non-parametric regression line for households of 2 adults and 1 child in Norway included 101 observations. It had 14 fitting points and the smoothing parameter was 0.60. Points in local neighborhood: 60. Residual sum of squares: 0.324. Equivalent number of parameters: 3.79.

Figure 3. Non-parametric Regression. Tri-cube Function. Foodshare on Income before Taxes. Singles. United States and Norway. 2001



Notes: The non-parametric regression line for households of 1 adult in the United States included 1098 observations. It had 17 fitting points and the smoothing parameter was 0.60. Points in local neighborhood: 658. Residual sum of squares: 3.379. Equivalent number of parameters: 4.35. The non-parametric regression line for households of 1 adult in Norway included 108 observations. It had 17 fitting points and the smoothing parameter was 0.60. Points in local neighborhood: 64. Residual sum of squares: 0.549. Equivalent number of parameters: 4.36.

Visual inspection reveals that the choice of parametric model with substantial curvature is warranted. The curves are clearly non-linear, with strong curvature occurring at high standards of living, i.e. low shares and high incomes. I proceed to employ the non-parametric curves to estimate PPPs and find the combination of segmentation and non-parametric regression to lead to wider PPP-bands. For households of two adults and one child, the computed PPP at 15-percent food-share standard is 9.43 NOK per USD. For singles the computed PPP at a 7-percent food-share standard is 5.98 NOK per USD. I suggest the following interpretation of this finding. Making parametric choices allows one to deploy larger funds of data at the same time, combining income and demographics in one regression analysis instead of separating income and demographics. Parameterization may compress information into fewer scalars and narrow the band around the most interesting demographic types, but at the cost of smoothing out interesting kinks (e.g. at the 10-percent share for 3-person households and at the 7-percent share for singles) and differences between population segments in how they optimize purchases given prices.

Table 6. PPP-estimates from other sources

Source	Time Frame	Method	PPP-estimate
The Economist	April 25 2002	Big Mac Index[a]	14.06
OECD[b]	2001	Representative Basket[c]	9.18
BLS[d]	1999	Representative Basket[e]	9.25
World Bank[f]	2005	Boad Basket[g]	8.84

[a] The prices quoted for Big Macs in April 2002 were USD 2.49 in the United States and NOK 35.00 in Norway.
[b] Available online: http://www.oecd.org/std/ppp.
[c] Representative basket of consumer goods and services.
[d] Bureau of Labor Statistics. Current data available online: http://www.bls.gov/fls .
[e] See BLS (2003): Comparative Real Gross Domestic Product Per Capita and Per Employed Person. Fourteen Countries. 1960-2002.July 29th 2003. BLS: Office of Productivity and Technology.
[f] International Comparison Program. See World Bank online for details on methodology and scope: http://www.world . For general outline and technical details see International Bank for Reconstruction and Development/The World Bank (2008): Global Purchasing Power Parities and Real Expenditures. 2005 International Comparison Program, Washington D.C: The World Bank. Available online: http://siteresources.worldbank.org/ICPINT/Resources/icp-final.pdf . The USD-NOK estimate can be found on page 26 under Tables of Results from the 2005 round, see: http://siteresources.worldbank.org/ICPINT/Resources/icp-final-tables.pdf .
[g] The ICP seeks to produce PPPs that take into account prices for a broad range of goods and services, not only consumer goods and services, but also capital and government expenditures.

Table 6 lists other estimates of PPP from the same time period. For example, The Economist's Big Mac Index estimates the PPP between the USD and NOK at 14.06 since a Big Mac was priced at USD 2.49 in the U.S. and NOK 35.00 in Norway. Even if the Big Mac Index is not meant as a scholarly estimate of PPPs, the difference between its estimate and mine may point to some of the advantages of the Engel curve approach. A Big Mac purchased in America is virtually the same as one purchased in Norway. However, the context is quite different. In oil rich and labor scarce Norway, buying a Big Mac is to buy what is truly expensive in Norway, manual labor. The Norwegian unemployment rate has been exceptionally low for decades, and any commodity involving significant labor input is very expensive. In fact, the Norwegian price of a Big Mac is among the highest in the world. The labor hours are partial elements of the delivery of a Big Mac, when it is seen as a package of attributes rather than a physical item. However, the number of minutes an average industrial worker needs to clock up in order to afford a Big Mac, i.e. the real price, is not very high in Norway, because wages are high. The Balassa-Samuelson effect that followed the expanding oil industry of the 70s has worked itself into *both* prices and wages. While this is not taken into account when one compares Big Macs or baskets, it is partly reflected in an Engel curve food share since the numerator consists of prices and the denominator of income. Potentially, then, the Engel curve approach may be especially useful in determining PPPs between countries with booming sectors.

Notice also, for the Big Mac Index to be accurate as a means of forecasting currency, there would have to be tradability and arbitrage. Of course, the Big Mac is not traded across borders and there are no arbitrageurs to take advantage of price differences. Thus, what the Big Mac Index really does is to indicate where labor is expensive. Thus, it should surprise nobody that the Norwegian krone has been massively overvalued for years, according to the Big Mac Index, for which one can blame the persistence of the Balassa-Samuelson effect. At the same time, it shows the usefulness of the Engel curve approach since it incorporates the Balassa-Samuelson effect in a ratio that involves both prices and incomes. To see how this may be advantageous, compare the estimated PPP-band from the Engel curve approach with PPP-estimates sourced elsewhere. My band ranges from 5.38 to 7.90 NOK per USD. By comparison, PPP estimates from OECD, Bureau of Labor Statistics, and the World Bank range from 8.84 to 9.25 NOK per USD, clearly above my band and clearly above the average of the market exchange rate in the last 30 years. This average is 6.81 NOK per USD, somewhat above the Bretton Woods rate of 7.14, possibly hinting at a Balassa-Samuelson real appreciation effect.

However, we should be asking how and why the conventional estimates lie at the very high end of plausible estimates. The point is subtle, and to understand the mechanisms behind it, consider an example. Imagine a big country, Big Place, where a basket of goods sells at price p_b. The manual labor required to produce it costs w_b. Now imagine a small country, Small Place, where the basket of goods sells at p_s, which is much larger than p_b since manual labor costs w_s are much higher than w_b. This difference in manual labor costs has to do with the opportunity costs of labor. The wages in Small Place are high because labor alternatively could have and would have been deployed in a key industry like the oil industry. The PPP computation now involves a choice: is the international value of the basket actually p_b in Small Place because it is physically identical to the Big Place basket or does the Small Place basket include something that the Big Place basket does not, namely scarce manual services in an economic environment where the foregone labor production is valuable? In concrete numbers, if a worker produces a service “meal delivery” valued \$10 dollars elsewhere, but which involves a foregone industrial service valued at \$20 elsewhere, is the value of the worker’s production \$10 or \$20?

5. Discussion

The Engel curve PPP approach relies on maintained assumptions, which it cannot test. The key assumption is that an x-percent food share in the United States involves a material standard of living which is comparable to, if not identical to, the material standard of living associated with x-percent food share in Norway. It is a plausible assumption, even if it may be contentious. Its plausibility is related to which economies are compared, to cultural similarities and comparable income levels. The United States and Norway are good in terms of such comparability. The existence of some relation between the proportion of income spent on food and material standard of living is consistent with the burgeoning theoretical and empirical literature on the topic of Engel curves.

The idea conceptualizes an important insight: the proportion of a person's time spent on sustenance says something about that person's standard of living. The need for calories and desire for food are innate in humans and universal, and there may be a biological basis for the stability and universality of the Engel curves. However, let me not overstate the case, since there exists many sources to differences in the household production function that may be socially amenable and sociologically constructed. Cultural differences matter. Variety in the physical environment is another source of heterogeneity. Thus, the assumption that food's proportion may be used to compare material standards of living becomes less plausible the more different the economies are.

Let me avoid a doctrinaire defense of the Engel curve approach, and instead appeal to some level of pragmatism and practicality. The assumption of a link between food-share and standard of living is a disadvantage of the method. But it is a disadvantage it *shares* with conventional PPP estimates. A conventional PPP estimate is derived from the prices of identical baskets across different economies. But there may be no conventionally quoted prices in a given developing country and the baskets available here may not be available elsewhere and vice versa. In fact, in the absence of markets and prices, the Engel curve approach may prove to be more, not less, useful. Observers could measure the proportion of economic activity spent on sustenance and for students of development economics the Engel curve approach enables a comparison of sorts, which is impossible with pure price data. Thus, the fact that a method has limitations is not the most severe criticism, since every method has. The question is rather whether there are obvious improvement points or the alternative is superior or inferior. I would suggest a compromise: the Engel curve approach may usefully assist and supplement the conventional basket PPP approach.

There are, however, a few issues to explore. Consider first using food's share of income after tax instead.

Table 7. Estimating Engel Curves for Food: Food's Share of Income after Tax on Determinants, United States and Norway, 2001

Variable	U.S. 2001	Norway, 2001[3]
Constant	51.241 (85.8)	2.678 (1.6)
Log(Inc. b. tax)	-9.371 (-83.9)	-0.316 (-1.2)
Log(Inc. b. tax)^2	0.427 (81.7)	0.00871 (0.8)
No. of Children	0.0207 (4.9)	0.0204 (9.0)
No. of Adults	0.0496 (8.6)	0.0324 (8.0)
R^2 Adj.	0.595	0.150
No. of observations:	5,391	999

Note: Same truncation as in Table 2, i.e. income before taxes used as truncation variable.

As we see from Table 7, the Engel curve for food also emerges with clear empirical regularity when the analyst uses after-tax income. However, after tax income is not an optimal variable for our purpose. The tax systems in Norway and the United States differ in scope and scale; the Norwegian tax system is one of the most progressive in the world. It offers a wide array of deductibles and uses a marginal tax rate that increases steeply with income. We observe from Table 7 that the adjusted R^2 in Norway drops to 0.15, while the American actually increases to 0.6. Even though they are not immediately comparable to those of Table 2, since the dependent variable is different, it is interesting to note the increase in the difference between explanatory power in the U.S. and Norway when this income-variable is used. We also observe a change in the statistical significance of the estimated coefficients. I cannot legitimately claim that I can fully explain such a dramatic change in significance and explanatory power, but the interpretation I can offer, especially for the low adjusted R-squared for Norway, is that the Norwegian tax system reduces some of the correspondence in the relationship between material standard of living and income. In Norway, taxes pay for universal health care, pensions, generous unemployment coverage, and a very extensive program in the event of mental and physical disability. Kindergartens, schools, and universities are essentially free, and charge only symbolic attendance fees, much below costs. Since American households pay for many of these services out of own pocket and income, voluntarily, analysts cannot legitimately use after tax income to compute PPPs.

Observers would also want to discuss the concept of food. It could be argued that while food consumed at home is designed to cover caloric needs and nourishment, food consumed away from home may be used for several other purposes. Food consumed away from home includes an element of social participation. If households' production function of utility is a nested tree, and if food at home is separable from food away from home, the production function may utilize food-away-from-home much more differently than it utilizes food-at-home. After all, food and nourishment are basic biological needs, sociality, on the other hand, is socially constructed, more prone to heterogeneity across societies. I cannot offer a rigorous way out of this problem. If we inspect the data, we see from Table 8 that the exclusion of food-away-from-home does not seem to affect the structural findings substantially. Both explanatory power and statistical significance are at more or less the same levels as Table 2.

Table 8. Estimating Engel Curves for Food: Home Food-at-Home's Share of Income before Tax on Determinants, United States and Norway, 2001

Variable	U.S. 2001	Norway, 2001[3]
Constant	3.366 (22.2)	3.901 (4.73)
Log(Inc. b. tax)	-0.593 (-19.6)	-0.519 (-4.1)
Log(Inc. b. tax)^2	0.0240 (17.3)	0.0170 (3.5)
No. of Children	0.0136 (22.1)	0.0207 (14.8)
No. of Adults	0.0217 (26.1)	0.0254 (10.1)
R^2 Adj.	0.481	0.348
No. of observations:	5,391	999

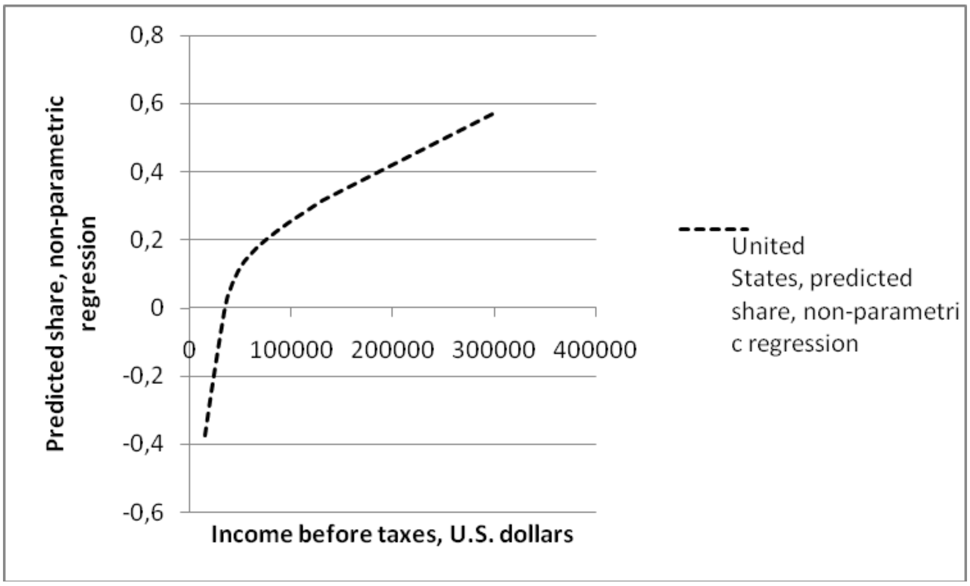
Note: Same truncation as in Table 2, i.e. income before taxes used as truncation variable. Food home is defined as food consumed at home including non-alcoholic beverages.

The role played by *saving* needs analysis. At first blush, analysts would be tempted to call saving an obstacle. However, saving need not necessarily or seriously disturb the proposed methodology. Let me explain why not. Essentially, saving determines *when* utility is extracted, not the *cost* of constructing it. Material standard of living is constructed in a household production function by the consumption of goods and services today, and if a household decides to build up a savings cache, it is presumably because it has decided to postpone and delay utility extraction until tomorrow. In a cross-section, some households are savers and delay the extracted utility. Other households dis-save, and obtain credit or spend savings, and push forward utility. The savers and dis-savers may balance each other out.

Moreover, even if the savers and dis-savers are asymmetrically distributed in a sample or across two countries, different savings behavior may still not necessarily nor seriously affect our upper-and-lower PPP-bounds. One may be tempted initially to think that if the propensity to save is a function of income, and if the function is different between the two countries, it would tilt and/or re-position the Engel curves and potentially change the PPP band. However, the answer is not that a difference in the function of propensity to save would alter the Engel curves, but rather that it would alter the distribution of households *along* the Engel curves. Households would, if savings behavior was different, be positioned differently on the curves, but the curves themselves should and would be stable.

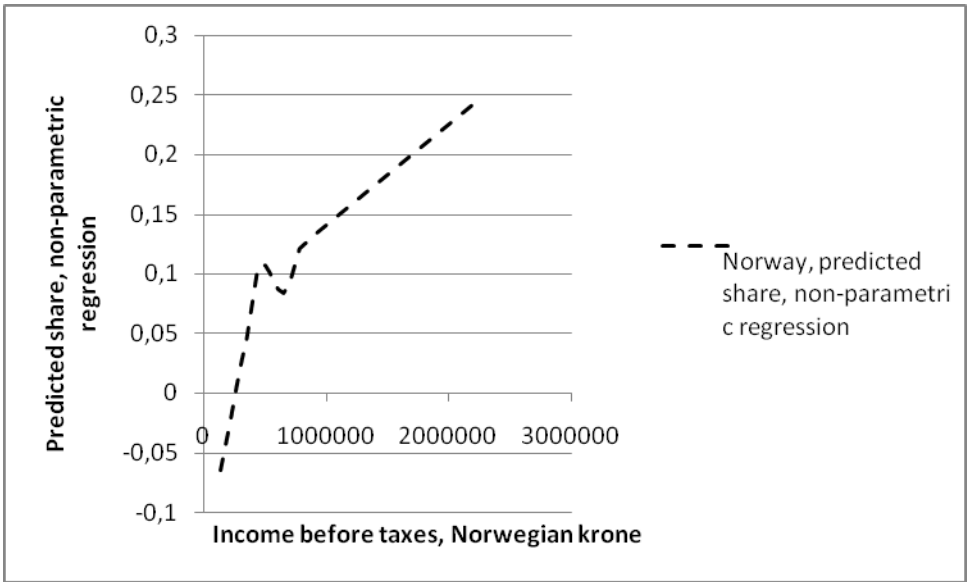
To see why, consider the following stylized example. Assume that an American household A allocates x-percent of its income before taxes to food and y-percent of income before taxes to non-food. It saves the proportion s. It attains a material standard of living MSL. A Norwegian household B seeks to attain the same standard of living MSL, i.e., as evidenced by the x-percent food share and the y-percent non-food share, and it spends an amount F on food and N on non-food to do so. But it may need to spend relatively more to achieve the food share (e.g. because food is expensive) and relatively less to achieve the non-food share (because non-food is cheap). If the Norwegian real interest rate had, hypothetically, increased, it would have changed the relative price of today's consumption measured by how much more of tomorrow's consumption it displaces. Household B might have decided to save more, i.e. to postpone some utility for tomorrow, because this optimizes the inter-temporal discounted utility streams. But that change does *not* necessarily mean our upper and lower bounds would have to change. Presumably, household B decides to *lower* its material standard today from MSL to MSL minus epsilon in order to increase it tomorrow, so it moves down to a standard of living commensurate with an x+i food share and a y+j non-food share by spending F-f on food and N-n on non-food. Another household C downgrades its standards, too, so that it now enjoys an x-food share and y-non-food share and spends F on food and N on non-food. Thus, the households find new positions on the stable Engel curves. The relative cost of inter-temporal utility has changed, but the relative cost of the material standard today between the two countries has not changed. I plot, by non-parametric regression of saving's share of income before taxes onto income before taxes, for the two countries in Figures 4a and 4b.

Figure 4a. Non-parametric Regression. Tri-cube Function. Saving's Share Regressed on Income before Taxes. United States. 2001



Note: Saving is defined as income after tax subtracted by total expenditure. The non-parametric regression line for households in the United States included 5391 observations. It had 17 fitting points and the smoothing parameter was 0.60. Points in local neighborhood: 3234. Residual sum of squares: 1480.62. Equivalent number of parameters: 4.02.

Figure 4b. Non-parametric Regression. Tri-cube Function. Saving's Share Regressed on Income before Taxes. Norway. 2001



Note: Saving is defined as income after tax subtracted by total expenditure. The non-parametric regression line for households in Norway included 999 observations. It had 17 fitting points and the smoothing parameter was 0.60. Points in local neighborhood: 599. Residual sum of squares: 171.41. Equivalent number of parameters: 4.16.

However, it is an empirical question how households behave and whether they separate inter-temporal optimization from the perception of present costs. If households for some reason behave otherwise when interest rates change, then interest rates would affect Engel curves empirically, i.e. displace the Engel curves. One such source could be a confounding effect between saving and interest payments on loans, and thus the price of consuming owner-occupied housing. A large interference would weaken the robustness of this article's methodology. However, Røed Larsen (2008b) shows that the Engel elasticity for housing is fairly stable over time and not very sensitive to changes in interest rates. In addition, Figures 4a and 4b show that saving, defined as income after tax minus total expenditures, as a proportion of income before taxes is a fairly monotonously increasing function of income before tax. In fact, inspecting the graphs more closely, we see for example that the savings rate is zero when a U.S. household has around USD 34,800 in income before taxes. In Norway, zero saving is associated with household income before taxes at around NOK 257,000. Thus, using the savings-income curve, the implied PPP-rate is 7.39 NOK per USD at this savings rate, well within and consistent with my announced PPP-band.

One possible avenue for future research would be to use a larger basket of necessities, not only food. We could still construct the PPP-band by examining a non-necessity good, which would control for price-and-preference effects. For example, one could group food, energy, basic clothes, shelter, elementary transportation, and other necessary items together. A larger basket might be more robust against different household production functions in different societies, but I have only had access to American and Norwegian data, and have not attempted to examine this possibility.

6. Concluding Remarks and Policy Implications

This article computes the purchasing power parity exchange rate between Norwegian krone and U.S. dollar by utilizing consumer behavior revealed by Engel curves. While conventional PPP-methods compare prices on presumably identical baskets of goods and services, the Engel curve method compares the purchase of assumed identical levels of material standard of living. This standard is measured as the proportion of income before taxes spent on food. It turns out that a household with two adults and one child in the United States that spends 10 percent of its income before taxes on food typically enjoys an income before taxes of USD 66,500. In Norway, regression analysis reveals that the similar association between food proportion and income before taxes is observed to occur when the income before taxes is NOK 516,000. Assuming that the Engel curve discloses the cost of material standard of living, the PPP-estimate is 7.76 NOK per USD because the Norwegian price for this standard was 7.76 times higher in nominal, domestic currency terms than the American price.

This Engel curve approach to PPP estimation comes with several advantages and one major and some minor disadvantages. The minor disadvantages were addressed by Hamilton (2001) and they are related to the maintained assumptions on separability and other technical issues. The major disadvantage is the necessity of assuming similarity, or at least comparability, between a 10 percent food proportion in the United States and the same in Norway. But the may not be similar or even comparable. Which being the case, it would speak against the Engel curve approach. On the other hand, the art of empirical economics includes balancing the desire for theoretical accuracy with the need for pragmatic approximation. After all, the Engel curve is an empirical regularity that has been found in all economies at all times. Its potential for making international comparisons can be great. And a method should not be judged only in terms of its ideal counterpart, but of its existing competitor. The conventional PPP method relies on equally strong assumptions: that preferences are universal and the goods and services in a basket are identical everywhere. The former is needed to construct meaningful weights and the latter for practical comparison of prices.

The advantage of the Engel curve method is its anchorage in consumer behavior, not acquired prices. It lends credibility to the findings. It is quick, cheap, and practical when price data are scarce, difficult to acquire or impractical to use. Small groups of analysts can use it, it does not require the resources of gigantic international bodies. It can be used when price data cannot be obtained or only with difficulty. The results are intriguing. While the conventional PPP approach employed by the World Bank and OECD yields estimates of 8.84 and 9.18 NOK per USD, the Engel curve approach yields a band of 5.38-7.90 NOK per USD, with a mid-point of 6.64 NOK per USD. Comparing these numbers with 30 years of market exchange rates, the conventional estimates lie at the very high end of the spectrum while the Engel curve band contains most of market amplitudes and appears correctly centered around the mid-point of the fluctuations. This, of course, does not necessarily increase its credibility, if the purpose for constructing PPPs is different from trying to understand the market, but it lends some support to the method all the same. The average market rate 1977-2007 was 6.81 NOK per USD. In the Bretton Woods period from 1949 to 1971, the exchange rate was 7.14 NOK per USD.

The Balassa-Samuelson effect of real appreciation in oil exporting economies probably lies behind the discrepancy between conventional methods and the Engel curve method. Maybe the difficulty of handling rising labor costs in booming economies presses the conventional estimates upwards. If so, the Engel curve approach may be a valuable supplement to the conventional estimates because it utilizes prices and income figures in a proportion while the conventional tools only look at prices. Thus, when some of the challenges have been overcome, the Engel curve approach could become a tool for background analysis for policymaking in international organizations and an instrument for market rate forecasting.

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