A meta-analysis of the response of calorie demand to income changes

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Abstract

Over the past three decades, several studies have analyzed the response of calorie intake to income with varying and inconclusive results. This paper review these studies and employs meta-analysis to examine the potential bias in the calorie-income elasticity, as well as the impact of specific study attributes on these elasticities reported in the empirical literature. A total of 40 studies which yielded 99 estimated elasticities were considered. The results show the presence of publication (reporting) selection bias in the reported elasticities. Besides, the estimates revealed evidence of positive and significant empirical effect of income on calorie intake from all the studies that goes beyond publication bias. Study attributes such as ranking of the journal, panel data used in the analysis, whether expenditure was used as proxy for income, year of primary survey, sample size, and numbers of the years of primary data were found to have significant impacts on the reported calorie-income elasticities in the literature.

Key words: Calorie-income elasticity, heterogeneity, meta-analysis

JEL classification: D12, C01

I. Introduction

The response of nutrient intakes to rising income either at the micro or macro level has some far reaching policy implications, particularly for underdeveloped economies. The significance of this relationship has contributed to a voluminous empirical literature on the topic over the past three decades. However, the extent to which nutrition responds to income changes has been widely debated in the recent literature. For example, some schools of thought argue that the response of calorie to income is close to zero and statistically significant (e.g., Behrman and Deolalikar, 1987; Bouis, 1994), while other authors have shown that the response of calorie to income is substantially greater than zero and statistically significant (e.g., Subramanian and Deaton, 1996; Gibson and Rozelle, 2002; Abdulai and Aubert, 2004). The former concluded that income mediated policies will have limited impacts on nutritional goals, while the later argue that income growth could go a long way to improve nutrition in developing countries.

Furthermore, there is another view known as revisionist in the literature. They argue that the response of calorie to income among the poor is statistically significant but small with calorie elasticities ranging between 0.30-0.40 (Deaton, 1997). Although this group identifies the role of income growth in improving nutrition, they lay emphasis on its weakness. Because high and low estimate of reported elasticities of calories broadly reinforce these views, there is little agreement about the size of these elasticities in the literature.

Given these different schools of thought, a review of the empirical literature on the calorie-income elasticity estimates reveals a significant systematic variation in the reported elasticities (see table A of the Appendix). But previous studies have shown that significant differences in elasticity estimates could be linked to differences in theoretical microeconomic choice approaches, differences in spatial and temporal dynamics, as well as differences in research design of the underlying studies (Knell and Stix 2005; Gallet 2007; Gallet 2010a). In other words, considerable heterogeneity do exists in terms of model specification (functional form, definition of explanatory variables), estimator, type of data (panel or cross-sectional or time series data), number of observations, and publication status (published or unpublished), location of the study etc across primary studies (see Stanley, 2005). In fact, Costa-Fonta *et al.* (2011) posited that the methods employed by primary researchers varied over time with available data such as cross-section, time series and panel data.

The differences in estimated results from similar studies have prompted several authors to undertake studies to investigate the source of variation in the reported estimates. Example of such studies include: Espey, (1998) on price elasticity of demand for gasoline, Dalhuisen *et al.* (2003) on price and income elasticity of demand for residential water, Gallet and List (2003) on income elasticity of demand for cigarette, Knell and Stix (2005) on income elasticity of money demand, Gallet (2007) on price and income elasticity of demand for alcohol, Gallet (2010 a and b) on price and income elasticity of demand for meat and Costa-Fonta *et al.,* (2011) on income elasticity of demand for healthcare expenditure.

Despite the significance of the calorie-income relationship, to the best of our knowledge no study has attempted to analyse the sensitivity of the estimated elasticities to potential publication bias and study attributes. Of course this could be very useful in advancing understanding of calorie-income nexus by researcher across the globe.Our paper therefore contributes to this literature by examining the variation of estimated calorie-income elasticities to study attributes and sensitivity to publication bias. The study-specific attributes considered include the type of publication outlet used (i.e., in journal or conference proceeding/working papers etc), quality of publication outlet (i.e., publication in top ranking journals), type of data used (i.e., panel, time series or cross sectional data and size of data etc), econometric modeling and specification used, and the location of the primary studies. To implement this empirically, we employed meta-regression analysis (MRA) which allows researchers to test the sensitivity of the estimated elasticities to the study-specific characteristics in an attempt to provide a guide to policy analyst on which study characteristics should be considered in the future research. Thus, MRA is a regression analysis of existing studies where the dependent variable is estimated calorie income elasticity and the explanatory variables are the type of data, model specification, econometric method and other characteristics and scope of the primary studies.

The rest of the paper is structured as follows. The next section provides detailed description of the meta-dataset used for the analysis. In section three, an overview of meta-analysis and model specification are provided. Section four, presents the empirical results, while conclusions are provided in section five.

II. The Meta-Dataset

The data employed in the present study consist of primary studies compiled from different sources that include economic database such as Web of Science, and Google Scholar. The studies are mainly from Journal articles, research reports, and working and discussion papers. We used a number of criteria to select the primary literature needed for the study. In order to be included, an article has to report standard error or t-value of the estimated calorie-income elasticities. Thereafter, sample size and the year of the survey in the primary studies are also essential. Thus, a total of 40 studies were selected for the analysis. Since, retrieved studies reported multiple elasticities due to subgroup of sample population or different econometric specification, a total of 99 observations from 40 studies were considered for the empirical analysis. The list of the 40 case studies employed for the meta-analysis with full citation is presented immediately after the conclusion of this paper. Likewise, detailed information regarding the authors, year of publication, the publication outlet for the primary study, reported calorie-income elasticities, and the associated standard error from the study are presented in Table A of the appendix. [1]

Presented in table 1 are the summary statistics of some of the study attributes by the reported calorie-income elasticity. The mean calorie-income elasticity across the sample is 0.3122, which falls within the revisionist range and range from 0.004 to 0.97. A closer look at the summary statistics across Asia and Africa, two key regions that have received much attention in the last decade, shows that an average calorie-income elasticity of about 0. 28 and 0.35 were obtained for these regions, respectively. The implication of this is that both estimates fall within the revisionist range. However, a *t-test* of difference between the two means suggests there is no significant difference between the two estimates.

[Table 1 Here]

3.0 Meta-analysis: An overview and model specification

3.1 *Meta-Analysis: An overview*

Following the pioneer work of Glass (1976), meta-analysis has become the standard method of searching for general patterns in a body of existing specific research results. It provides the same methodological rigor to a qualitative literature review. According to Gallet (2010b), unlike qualitative reviews that can be sensitive to the subjective decision of reviewers, through emphasis on certain study attributes over others, meta-analysis has become an increasingly popular method in quantitative literature review. It offers a methodological improvement and provides a technique for reducing subjectivity bias.

[1] The detail references of the case studies used for meta-analysis could be obtained from the lead author.

The author concludes that by doing so, the subjective decision of the reviewer is replaced by statistical test. This, however, sheds light on the relative statistical importance of study characteristics that influence reported effect size (or treatment effect) to draw policy conclusions.

One important use of meta-analysis is to identify the existence of publication bias, which emerges when there is an explicit or implicit preference by authors, reviewers, and journal editors for statistically significant results, resulting in studies that yield relatively small and statistical insignificant results remaining unpublished (Stanley, 2005).

Meta–analysis is usually performed with the use of descriptive statistics or regression techniques, or a combination of both. The regression technique is known as meta-regression analysis (MRA), which has become popular among the meta-analyst. The increasing popularity of MRA is closely associated with the fact that it can be used to filter out publication bias, as well as to model the sources of differences in the estimated study effects. MRA involves regressing effect size on variables that control for study specific attributes.

Although, meta-analysis is very popular in the medical, pharmaceutical and marketing research, it is gaining increasing significance in applied economics literature. In applied economics literature, the effect size is usually measured as an elasticity estimate, a partial correlation coefficient, or a regression coefficient that is thought to measure some important underlying economic phenomenon (Stanley 2001).

Given the wide range of results in economic research, examples of a standard effect size in the literature include income or price elasticities of demand (see earlier references), effect of aid on economic growth (Mekasha and Tarp, 2011), technical efficiency (Bravo-

Ureta *et al.,* 2007; Ogundari and Brümmer, 2011), total factor productivity growth (Tian and Yu, 2012), income inequality and economic growth (de Dominicis *et al.*, 2008), prospect cohort studies of alcohol marketing and adolescent drinking (Nelson, 2011), effect of currency unions on trade (Havranek, 2010), economic freedom and economic growth (Doucouliagos, 2005), willingness to pay for farm animal welfare and preservation of multifunctional agriculture by Lagerkvist and Hess, (2011) and Johnson and Duke (2009), respectively, causes of asymmetry price transmission (Perdiguero, 2010; Bakucs et al., 2012; Amikuzuno and Ogundari, 2012) and the language effect in international trade (Egger and Lassmann, 2012).

The present study extends these meta-analysis studies in the applied economics literature to include effect size of calorie-income elasticity. This is essential because knowledge on how the calorie income elasticity varies across study specific attributes could give additional insight into the characteristics that require attention in modeling calorie-income nexus in the literature.

3.1.1 *Test for homogeneity in the effect size*

Because meta-analysis relies on a wide range of studies with varying focus and methodologies, heterogeneity has always been an issue of concern in the population effect size.[2] Hence, the first step in meta-analysis is to investigate the existence of heterogeneity in the population effect size, using the Q-test. Algebraically, the Q-test of the null hypothesis of homogeneity in the effect size has the following form: [3]

$$Q = \sum_{j=1}^{N} w_j \left(T_j - T\right)^2 \qquad 1$$

[2] Effect size here is referred to estimated calorie-income elasticities from the primary studies

[3] *Q*-test of heterogeneity is available via *meta* routine in STATA which require specification of both the size effect and its standard error.

where T_j is the estimate of the effect size from the primary studies; T is the weighted average of T_j and w_j is equivalent to the inverse variance of the standard error of the effect size under scrutiny (Sutton *et al.,* 2000).

Under the null hypothesis of homogeneity in the population effect size (i.e., no differences in the effect sizes), Q-statistic is distributed as chi-square ($Q-test \sim \chi^2$), with degrees of freedom ($d.f$) equal to the number of studies (observation) minus one (i.e., $d.f = N-1$). Hence, the null hypothesis (H_0) of Q-statistic suggests that the studies under scrutiny have common effect size as against alternative hypothesis of heterogeneity effect. If the Q-statistic exceeds the critical value of the χ^2 distribution, the H_0 of homogeneity of the underlying population treatment effect is rejected. This implies that meta-regression analysis (MRA) is needed to identify the study attributes that best explains the systematic variation in the population treatment effect, T_j.

3.1.2 *Funnel Asymmetry Test (FAT) and Precision Effect Test (PET)*

As mentioned earlier, one important use of meta-analysis is to identify the existence of publication bias that emerges when there is an explicit or implicit preference by the authors, reviewers, and journal editors for statistically significant results causing studies that yield relatively small and or insignificant results to remain unpublished (Stanley, 2005). According to Card and Krueger (1995), there are three sources of publication selection (reporting) bias in the literature; 1) reviewers and editors may be predisposed to accept papers consistent with the conventional view, 2) researchers may use the presence of a conventionally expected result as a model selection test, and 3) everyone may possess a predisposition to treat statistically significant results more favorably.

According to Stanley (2005), the existence of publication bias in the literature may outweigh the real effect size under investigation, causing the distribution of the reported effect size to be skewed.[4] He concludes that publication bias may make empirical effects seem much larger than they actually are.

The standard approach used to examine the presence of publication (reporting) bias in meta-analysis is funnel plot. Funnel plot is a visual graphical image that illustrates the relationship between reported treatment effect from primary studies and a measure of precision such as sample size (*n*), standard error (*SE*) or inverse of SE, and degree of freedom (*df*). However, Stanley (2005) notes that funnel plots are always vulnerable to subjective interpretation. Hence, Egger *et al.,* (1997) proposed the use of funnel asymmetry test (FAT) of the meta-regression analysis (MRA) approach known as FAT-MRA. A FAT-MRA model, which accounts for heterogeneity and covariates representing omitted selection variables related to publication bias can be specified as (Stanley and Doucouliagos (2007):

$$effect_i = \underset{Bias}{\beta_0} + \underset{precision}{\beta_1 \; SE_i} + \sum_{k=1}^{K} \pi_k X_{k,i} + \sum_{m=1}^{M} \psi_m Z_{m,i} + \varepsilon_i \qquad 2$$

where $effect_i$ is the standard effect size from the primary studies such as the reported calorie-income elasticity in the present study, SE_i is the correspondent standard error of the effect size, X_k is the vector of covariate that explain the heterogeneity associated with genuine empirical effect beyond publication bias in the effect size; Z_m is the vector of covariates that captures the heterogeneity associated with the propensity to get

[4] The term study effect, size effect and treatment effect are used synonymously, are refer to the magnitude of reported calorie-income elasticities estimated in the primary studies.

estimates published, β_0, β_1, π_k and ψ_k are the parameters to be estimated and ε_i is the usual random error in the regression.

The significance of β_1 is indication of publication bias in the selected literature, which is quite similar to the principle behind the funnel asymmetry plot discussed earlier. As noted by Nelson (2011), if specification and estimates of equation 2 are selected based on the significance of the main covariates (SE), publication (reporting) selection bias will vary directly with the standard error (SE). That is, large number of studies with lower SE values are associated generally with significance of β_1, thus indicating publication bias.

Because parameters of equation 2 are inherently heteroskedastic, largely due to the specification of the equation, Stanley (2005) suggested that it is appropriate to divide the equation by the standard error while re-writing the equation as shown below:

$$t\text{-}value_i = \underbrace{\beta_0\left(\frac{1}{SE_i}\right)+\sum_{k=1}^{K}\pi_k\left(X_{k,i}/SE_i\right)}_{Genuine\ empirical\ effect}+\underbrace{\beta_1+\sum_{m=1}^{M}\psi_m Z_{m,i}}_{Publication\ Bias}+\tau_i \quad [5] \qquad (3)$$

where, the dependent variable is the *t-statistic* (i.e., $t\text{-}value_i = \frac{effect_i}{SE_i}$), the independent variable $\frac{1}{SE_i}$ is the inverse of the standard error (SE) of the effect size, $\tau_i = \frac{\varepsilon_i}{SE_i}$ is the random error in the regression and β_0, β_1, π_k and ψ_k are as defined earlier.

By construction, equation 3 allows us to carry out Funnel Asymmetric Test (FAT) for publication selection bias, because asymmetry of the funnel plot is evidence of publication selection bias (Egger *et al.* 1997). Thus, the null hypothesis of FAT is $H_0 : \beta_1 = 0$. When H_0 is rejected, we have evidence of publication selection bias (or

[5] It is important to note that variable X_k are divided by standard error (SE) to correct for heteroskedasticity and variable Z_m is not. And by new specification, publication selection bias is capture by combination of Z_m, and parameter β_1. Likewise, genuine empirical effect is captured by the combinations of variable X_k and parameter β_0.

evidence of small study effect). The larger the deviation of β_1 from zero the higher the asymmetry and hence bias in the effect size reported in the primary studies.

Also equation 3 can be used to identify the existence of genuine empirical effect beyond publication selection bias in the effect size. This process is called Precision Effect Test-PET in the meta-analysis of studies (Stanley, 2005). The null hypothesis of PET is $H_0 : \beta_0 = 0$. The sign and significance of β_0 measures the direction of an empirical effect of the treatment effect or common effect size under scrutiny in the meta-analysis of studies (Stanley, 2008). When $\beta_0 \neq 0$ implies that the empirical effect of the treatment effect (or effect size) is not an artifact of publication selection bias in the cited studies.[6] Equation 2 is referred to as FAT-PET-MRA bivariate specification in the literature. However, assuming a non-zero (significant empirical effect) underlying the effect size $(\beta_0 \neq 0)$ coupled with the absence of publication bias $(\beta_1 = 0)$, small studies are expected to have high SE and *t-values* very closed to zero while large studies will have low SE and *t-values* that are significantly different from zero. Consequently, the t-statistics are expected to scatter around the regression line. But failure of equation 3 to pass through the origin implies publication bias or presence of small study effect in the sample.

Equation 2 is equivalent to a Weighted Least Square (WLS) regression of the effect size on its standard error with inverse variance of the standard error and variance of standard error of the effect size as weight, respectively (Stanley, 2008).

[6] It is important to note also that the measure of precision could also be replaced by the square root of the sample size or that of the degree of freedom to reduce bias in the FAT-PET-MRA model due to lower power which may be compensated by using a lower significance level, say 10% (Egger et *al.,* 1997).

One of the significant extensions of the FAT-PET model is the Meta-Significance Test (MST) and Precision Effect Estimate with Standard Error (PEESE). These tests are often carried to validate the results of the FAT-PET model. The tests are extensively discussed in Stanley (2005) and Stanley and Doucouliago (2007).

3.2. *The MRA: explaining the sources of heterogeneity in the population effect size*

A general model of explaining sources of heterogeneity in meta-analysis of the studies is the use of regression techniques known as meta-regression analysis (MRA). A typical MRA is specified below:

$$elasticity_{ij} = \alpha + \sum_{k=1}^{K} \beta_k X_{k,ij} + \mu_{ij}\,;\ \mu_{ij} \sim N\left(0, \sigma_\mu\right) \qquad 4$$

where, the *i-th* calorie income elasticity ($elasticity_{it}$) from the *j-th* literature serves as dependent variable and α is an intercept common across *j-th* studies; X_k is a vector of the identified study attributes; α and β_k are parameters to be estimated, μ_{ij} is assumed to be normally distributed with zero mean and constant variance. The hypothesized X_k variables include $D\_JOURNAL$ representing articles published in journal (articles published in conferences, working papers and research reports were dropped as a reference); $D\_RANKING$ representing articles published in journals with impact factor; D_PANEL and $D\_TIME\ SERIES$ representing articles that used panel and time series data, respectively (articles published with cross sectional data were dropped as a reference); D_IVREG representing articles that employed instrumental variable regression (articles that did not use instrumental variable to control for possible endogeneity problem in the expenditure often taken as proxy for household income were dropped as a reference); $D\_DOUBLE-LOG$ representing articles that employed double log functional form (articles with other functional forms such as exponential and semi functional forms were dropped as a reference); $D\_EXPENDITURE$ representing articles that used expenditure as proxy for income; $DATAYEAR$ is the mean year of data that a primary study uses; $SAMPLE\ SIZE$ is the logarithm of the sample size and $REGRESSOR$ is the logarithm of the size of variable inputs or regressors from the primary study; $NO.OF\ YEARS$ is the number of years in the primary data; D_ASIA, D_AFRICA, $D\_NAMERICA$, $D\_SAMERICA$, and $D\_OCEANIA$ representing articles published in Asia, Africa, North America, South America and Oceania (articles published in Europe were dropped as a reference).

The econometric procedure appropriate for modeling sources of variation (heterogeneity) in the effect size, particularly to lessen publication bias in MRA is to use weighted average of the measure of precision of the effect size (such as the inverse of the variance of the standard error of the estimated effect size) that discount small sample studies as noted by Stanley (2008). In view of this, we followed Stanley (2008) framework to estimate the parameters of equation 4 using Weighted OLS model (WLS), with the inverse of the variance of the standard error of the estimated calorie-income elasticity in the primary studies as the weight.[7]

The use of each estimate's variance as the weight minimizes the resulting variance of the weighted average. Besides, unlike OLS which gives equal weight to each observation, weighted OLS also corrects for some outliers and measurement errors by giving less weight to such outliers to ensure that potentially more reliable estimates are not confounded by observations subject to a larger variance.

[7] Recently, Lagerkvist and Hess (2011) employed weighted OLS to explaining the heterogeneity in the meta-analysis of consumer willingness to pay for farm animal welfare.

4.0 Results and Discussion

As a preliminary test in meta-analysis of studies based on section 3.1.1, the Q-test of homogeneity in the effect size was computed for the reported calorie-income elasticities. With a Q-statistic of 43,000 (*p-value* of 0.000), the null hypothesis of homogeneity in the elasticities was rejected, implying significant heterogeneity in the sample. This finding suggests that no single elasticity or common elasticity mean would be representative of the estimated elasticity in the selected primary studies.

Another equally important step is to investigate the presence of publication bias and genuine empirical effect in the reported calorie-elasticity estimates. In this case, we employed the funnel asymmetric and precision effect tests of meta-regression analysis (FAT-PET-MRA) model specification (Eqn. 3) to test for the presence of publication bias in selected literature in the sample. The results are presented in table 2. The estimate for publication bias β_1 is positive and significantly different from zero, suggesting that publication bias (FAT) is a problem in the reported calorie-income elasticities from the reviewed studies used in the present analysis. Of interest is the result of the precision effect test (PET) which is the coefficient of the β_0 parameter. This coefficient is also positive and statistically significant, suggesting the presence of positive and statistically significant effect of income on calorie intake from the primary studies.

From the Z-variables in table 2, which represent variables capable of influencing the propensity of a study being published, we found evidence that studies carried out in Asia (D_ASIA) and those published in journals (D_JOURNAL) are more likely to exhibit potential publication bias.

[Table 2 Here]

Table 3 presents the results of the model specification for the meta-significance test of meta-regression analysis (MST-MRA) for both the logarithm of degree of freedom (*df*) and sample size (*n*).[8] The test is essential as a further evidence of a clear authentic empirical effect of income on calorie intake that goes beyond publication bias in the literature available for the study. Thus, the results show a positive and statistically significant coefficient for δ_1 in all the specifications, indicating a positive and significant impact of income on calorie from the studies under consideration in the present analysis. In other words, this finding underpins the authenticity of the positive and significant effect of income on calorie intake as observed in the FAT-MRA results.

However, when $0 < \delta_1 < 0.5$ (i.e., from Table 3), it shows the presence of both genuine empirical effect and publication bias. Given this, the present study shows that the estimated parameters δ_1 vary from about 0.24 to about 0.30 across the columns. These findings support the presence of genuine empirical effect of income (i.e., positive) on calorie intake, as well as publication bias across the selected literature.

[Table 3 Here]

Table 4 presents the result of estimated calorie-income elasticities that have been corrected for publication bias. Therefore, the coefficient of precision (1/SE) estimated as 0.3125 represents the magnitude of the calorie-income elasticity from the primary studies corrected for publication bias. The estimate reveal that the corrected calorie-income elasticity estimates of 0.3125 of table 4 is not significantly different from the average estimate of 0.3122 from table 1. This suggests that about 31% change in calorie intake is associated with 1% change in income from all the sampled studies. That is,

[8] For the MST-MRA test, the logarithm of sample size(n) or degree of freedom (df) could be used as measure of precision.

calorie intake increases slower than income from the sample, which is consistent with Engel's law.

[Table 4 Here]

Because earlier Q-test showed evidence of heterogeneity in the effect size, an effective way of identifying the sources of the systematic variation in the reported calorie-income elasticities across the primary studies is to use previously discussed meta-regression technique (MRA). Table 5 therefore presents the results the WLS -MRA for the present study.

Our empirical findings revealed that reported calorie-income elasticity from the primary studies appears less elastic for articles published in journals (D_JOURNAL) compared to articles in working/discussion papers/research reports. However, the estimate was found to be statistically insignificant. We also observed that articles published in top ranking journals (D_RANKING) report higher elasticities compared to articles in non-ranking journals and studies in working/discussion papers.

The results also show that elasticities of studies that employed panel data (D_PANEL) and time series data (D_TIMESERIES) were significantly higher than those using cross-sectional data. Furthermore, the findings indicate that reported elasticities of sampled articles that used total expenditure (D_EXPENDITURE) as proxy for household income are significantly higher than studies that directly used household income in the empirical analysis. We also found that the reported elasticities decreased significantly as the year of the data in the primary study (DATAYEAR) and Number of years of primary data (NO.OFYEARS) increases. The result of D_EXPENDITURE lends support to the argument that households generally underestimate their incomes which in turns makes total expenditure a reliable proxy for the household income in the literature as noted by Deaton (1997). Also the result of DATAYEAR is an indication that reported elasticities from the sampled studies decreased significantly over the years.

Also, we found that the elasticities increased as the number of observations (SAMPLESIZE) and the number of explanatory variables used in the regression equation (REGRESSOR) from the primary study increased as well. The later was found to be statistically insignificant. The significance of the SAMPLESIZE attests to the fact that studies with large samples deliver systematically different elasticities that are higher than those with smaller sample sizes.

The estimates further reveal that the reported elasticities appear higher, but not significant for studies with double-log specification (D_DOUBLE-LOG), compared with studies that used other functional forms such as exponential and semi-log functional forms. Similarly, we observed that the reported elasticity appears higher but not significant for studies that employed instrumental variable regression (D_IVREG) specification, compared to studies that did not take into account via instrumental regression, endogeneity in the total expenditure often taken as a proxy for household income.

Estimates for the regional effects reveal that studies on Asia (D_ASIA), Africa (D_AFRICA), and North America (D_NAMERICA) are lower in magnitude relative to studies from Europe (reference). However, the coefficients are not significantly different from zero, with the exception of D_NAMERICA. The estimated coefficients for studies from South America (D_SAMEIRICA) and Oceania (D_OCEANIA) appear to be higher in magnitude than those from Europe (reference), with the coefficient of D_SAMEIRICA being significantly different from zero. Thus, while the studies in Asia, Africa and North America show that calorie intake responds at a lower rate compared to studies on Europe, those on South America and Oceania show higher response than from Europe.

[Table 5 Here]

V. Conclusions

The paper employed a meta-analysis approach to examine the potential bias in the calorie-income elasticity studies published in previous studies. In particular, we examine how specific attributes of studies found in the empirical literature impact on the estimated calorie-income elasticities. We employed a total of 40 studies which yielded 99 estimated elasticities because some studies reported more than one estimate.

An initial Q-test employed to examine homogeneity among the reported elasticities rejected the null hypothesis, suggesting the existence of significant variation in the reported calorie-income elasticities in the cited studies.

Our finding also showed evidence of publication (reporting) selection bias. Furthermore, we found evidence that studies carried out in Asia (D_ASIA) and those published on journals (D_JOURNAL) are more likely to exhibit potential publication bias. Also the estimates revealed evidence of positive and significant empirical effect of income on calorie intake from all the studies that go beyond publication bias. An average calorie-income elasticity estimate of about 0.31, which has been corrected for publication bias, was obtained from the analysis.

The results of the meta-regression analysis which linked the systematic differences (heterogeneity) in the reported calorie-elasticity to a set of study–specific attributes identified important factors that are associated with the variation. Specifically, we found evidence that publication characteristics such as studies published in top ranking journals tend to report higher elasticities. This observation underscores the quality of the journal as important factor influencing the tendency to report higher elasticity estimates. Also, reported calorie elasticity appeared to be higher when characteristics of the data used by the primary researcher are panel data, time series data, and the use of expenditure as proxy for income. Besides, we found that reported elasticities decreased as the year of survey in the primary study and number of years of primary data increases. Likewise, we found evidence that sample size, number of the years of primary data, and the region (particularly studies carried out in the North and south American in reference to studies in Europe) significantly influence the differences in the reported calorie-income elasticities.

In conclusion, the findings of this study could be explored by policy analyst to provide additional insight into characteristics that require attention in modeling calorie-income nexus in the literature. For example, the sensitivity of reported calorie-income elasticities to characteristics such as; the use of panel data, the use of expenditure as a proxy for household income, and the use of large sample size as observed in the present study is a potential insight into why varying and inconclusive results characterized analysis of calorie- income elasticities by previous studies. Thus, policy analysts could explore this finding to provide reliable calorie-income elasticities for policymaking.

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Table 1: Summary statistics of the elasticity by study specific characteristics

Category	Variables	Number of Observation	Mean of calorie-income elasticity
Pooled	Reported Calorie-Income Elasticity	99	0.3122 (0.0004-0.97)
Publication:	Journal articles (D_JOURNAL)	74	0.3023 (0.0004-0.70)
	Working/Discussion papers/ Research report (*reference*)	25	0.3418 (0.0280-0.97)
	Articles in top ranking journals (D_RANKING)	57	0.3234 (0.0300-0.70)
Data:	Articles with Panel Data (D_PANEL)	23	0.2778 (0.0360-0.55)
	Articles with Time series data (D_TIME SERIES)	04	0.2570 (0.1620-0.35)
	Articles with Cross-sectional data (*reference*)	72	0.3263 (0.0004-0.97)
	Articles with expenditure as proxy for income (D_EXPENDITURE)	64	0.3829 (0.0004-0.97)
	Article with actual income (*reference*)	35	0.1829 (0.0010-0.53)
Specification:	Double –Log functional form (D_DOUBLE-LOG)	86	0.3000 (0.0004-0.97)
	Other functional forms e.g., semi and exponential(*reference*)	13	0.3931 (0.0300-0.70)
Method:	Instrumental variable Regression method (D_ IVREG)	33	0.2782 (0.0190-0.97)
	Articles that did not employed instrument (*reference*)	66	0.3293 (0.0004-0.97)
Region:	Asia (D_ASIA)	41	0.2837 (0.0200-0.97)
	Africa (D_AFRICA)	29	0.3540 (0.0004-0.70)
	North America (D_NAMERICA)	05	0.2726 (0.0200-0.67)
	South America (D_SAMERICA)	07	0.2947 (0.1400-0.58)
	Oceania (D_OCEANIA)	10	0.2815 (0.0100-0.97)
	Europe (*reference*)	07	0.3927 (0.2400-0.54)

Table 2: FAT & PET-MRA result for publication bias and genuine effect test

Variables (Parameters)	**Estimates**
1/SE (Empirical effect-β_0)	**6.2162** (2.7472)**
X-variables:	
D_EXPENDITURE/SE	**0.2811***(0.0486)**
D_DOUBLE-LOG/SE	0.0238 (0.0667)
DATAYEAR/SE	**-0.0031** (0.0014)**
Z-variable:	
D_JOURNAL	**-2.3805* (1.2942)**
D_RANKING	1.3600 (1.0834)
NO. OF YEARS	0.0239 (0.3314)
D_PANEL	-2.1801 (1.5333)
D_TIME SERIES	-0.9253 (11.388)
SAMPLE SIZE	-0.4443 (0.3836)
REGRESSOR	-0.4549 (0.5595)
D_IVREG	0.8337 (0.8652)
D_ASIA	**2.2701* (1.1922)**
D_AFRICA	-0.1321 (0.8569)
D_NAMERICA	-2.0215 (5.2021)
D_SAMERICA	-2.2527 (1.9434)
D_OCEANIA	-0.4659 (1.5658)
Constant (Publication Bias-β_1)	**5.6591** (2.7695)**
R^2	0.7408

*Estimates in parentheses are the standard error; *, **,and *** represent levels of significance at 10%, 5%, 1%, respectively*

Table 3: MST-MRA result for authentic effect test

Variables	(Parameters)	I Coeff. (Std.Err)	II Coeff. (Std.Err)
Constant	(δ_0)	20.5789 (14.0345)	20.6298 (14.0511)
LOG (df)	(δ_1-Genuine effect)	**0.2385** (0.0995)**	-
LOG (n)	(δ_1-Genuine effect)	-	**0.2412**(0.1018)**
D_JOURNAL		0.3169 (0.4121)	0.3102 (0.4121)
D_RANKING		0.0099 (0.3719)	0.0151 (0.3719)
D_PANEL		-0.1959 (0.3083)	-0.1997 (0.3084)
D_TIME SERIES		1.1609 (3.4208)	1.0956 (3.4184)
D_EXPENDITURE		1.3532*** (0.2757)	1.3556*** (0.2761)
DATAYEAR		-0.0107 (0.0072)	-0.0107 (0.0072)
REGRESSOR		-0.1642 (0.1024)	-0.1702* (0.1035)
NO. OF YEARS		-0.0209 (0.0976)	-0.0194 (0.0976)
D_DOUBLE-LOG		0.3670 (0.3817)	0.3702 (0.3818)
D_IVREG		-0.1988 (0.2329)	-0.1971 (0.2331)
D_ASIA		0.3113 (0.3128)	0.3194 (0.3128)
D_AFRICA		-0.1104 (0.3436)	-0.1079 (0.3442)
D_NAMERICA		-0.4036 (0.5032)	-0.4029 (0.5039)
D_SAMERICA		-0.2795 (0.4255)	-0.2884 (0.4257)
D_OCEANIA		-0.1775 (0.3806)	-0.1779 (0.3809)
R^2		0.4689	0.4681

*Estimates in parentheses are the standard error; *, **,and *** represent levels of significance at 10%, 5%, 1%, respectively.*

Table 4: PEESE-MRA-estimated calorie-income elasticity corrected for publication bias

Variables	Coefficient	Std. Err	t-value	P-value
1/SE	0.3125***	0.02267	13.79	0.000
SE	-0.0480	0.6330	00.08	0.940

*Note: SE stands for the standard error of the estimated calorie –income elasticity in the primary study; *, **, and *** represent levels of significance at 10%, 5%, 1%, respectively*

Table 5: Meta-regression analysis (MRA) of the calorie-income elasticity

Category	Variables	Description of the variables	WLS Estimates
Publication:	D_JOURNAL	Equal to 1 if the article was published in journal	-0. 1054 (0.0737)
	D_RANKING	Equal to 1 if the article was published in top ranking journal	0.1172* (0.0765)
Data:	D_PANEL	Equal to 1 if the article used panel data	0.0969***(0.0349)
	D_TIME SERIES	Equal to 1 if the article used time series data	3.2459*** (0.6449)
	D_EXPENDITURE	Equal to 1 if the article used expenditure as proxy for income	0.0750***(0.0300)
	DATAYEAR	Average year of the data that a primary study uses	-0.0023** (0.0009)
	SAMPLE SIZE	Logarithm of the sample size from the primary study	0.0449*** (0.0167)
	REGRESSOR	Logarithm of the number of regressors from the primary study	0.0161 (0.0172)
	NO. OF YEARS	Number of years of primary data	-0.0902***(0.0159)
Specification	D_DOUBLE-LOG	Equal to 1 if the article used double log functional form	0.0659 (0.0669)
Method:	D_IVREG	Equal to 1 if the article used Instrumental Variable Regression	0.0142 (0.0355)
Region:	D_ASIA	Equal to 1 if the study was carried out in Asia	-0.0988 (0.0620)
	D_AFRICA	Equal to 1 if the study was carried out in Africa	-0.0651 (0.0737)
	D_NAMERICA	Equal to 1 if the study was carried out in North America	-0.1016* (0.0522)
	D_SAMERICA	Equal to 1 if the study was carried out in South America	0.1438* (0.0740)
	D_OCEANIA	Equal to 1 if the study was carried out in Oceania	0.0156 (0.0372)
	CONSTANT	The Intercept	4.4695** (1.9052)
	Adjusted R^2		0.8591
	F-statistics (16,82)		31.26
	Prob.>F		0.001

*Note: The WLS is weighted by the inverse of the reported calorie elasticity variance for each of the observation; estimates in parentheses are the standard error; *, **,and *** represent levels of significance at 10%, 5%, 1%, respectively.*

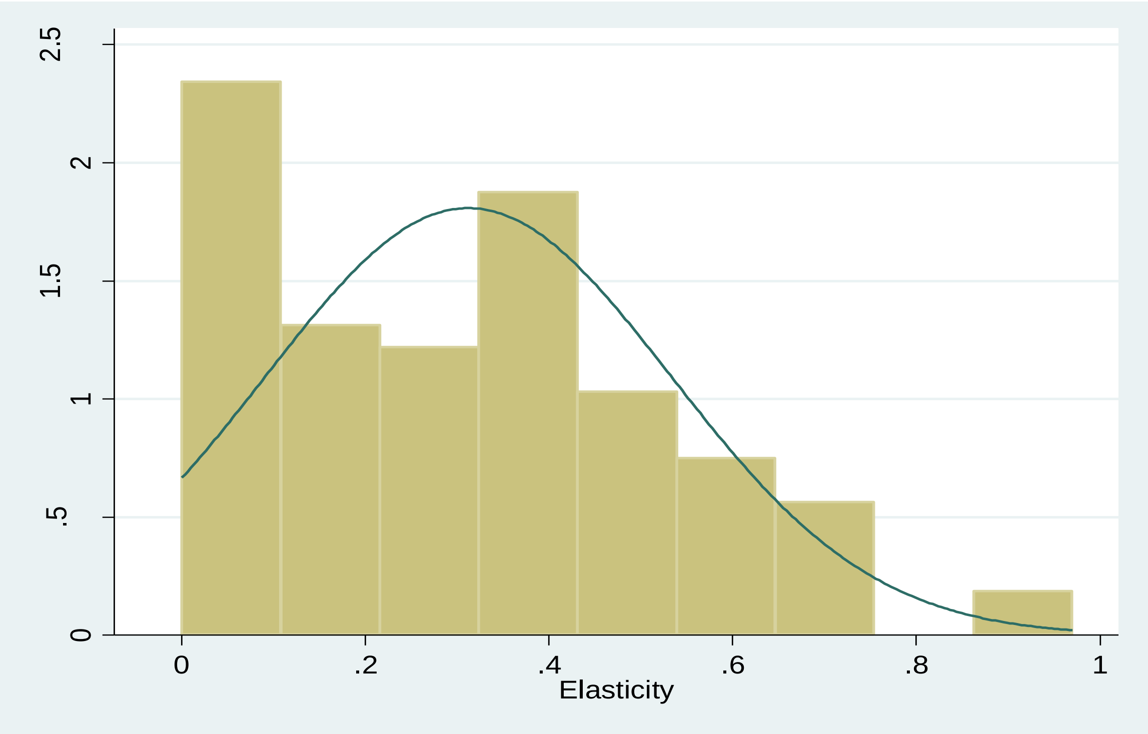

Figure 1: Distribution of the retrieved calorie-income elasticities

Appendix

Table A: Summary statistics of the studies for the meta-analysis

Authors	Year	Country	Publication Outlet	Elasticity	SD Error
Logan.T.D	2009	UK	The Journal of Economic History	0.674	0.038
Logan.T.D	2009	USA	The Journal of Economic History	0.543	0.011
Logan.T.D	2009	Bangladesh	The Journal of Economic History	0.244	0.070
Logan.T.D	2009	Bangladesh	The Journal of Economic History	0.351	0.069
Al-Mulhim	1991	Saudi Arabia	Journal King Saud University	0.140	0.233
Bocoum & Dury	2009	Mali (Rural)	Working paper	0.221	0.095
Bocoum & Dury	2009	Mali (Urban)	Working paper	0.112	0.051
Jha *et al.,*	2006	India	Working paper	0.065	0.013
Babatunde *et al.,*	2010	Nigeria	Journal of agricultural sciences	0.019	0.006
Babatunde *et al.,*	2010	Nigeria	Journal of agricultural sciences	0.010	0.002
Aromolaran	2004	Nigeria	Food policy	0.194	0.078
Aromolaran	2004	Nigeria	Food policy	0.041	0.012
Ayalew	2000	Ethiopia	Working paper	0.139	0.036
Ayalew	2000	Ethiopia	Working paper	0.164	0.043
Ayalew	2000	Ethiopia	Working paper	0.037	0.069
Abdulai & Auber	2004	Tanzania	Food policy	0.529	0.018
Abdulai & Auber	2004	Tanzania	Food policy	0.448	0.046
Orewa & Iyangbe	2009	Nigeria	Middle East Journal of Scientific Research	0.260	0.591
Orewa & Iyangbe	2009	Nigeria	Middle East Journal of Scientific Research	0.001	0.020
Sinha	2005	India	Working paper	0.391	0.007
Sinha	2005	India	Working paper	0.575	0.009
Gibson & Rozelle	2002	Papua New Guinea	Journal of Development studies	0.420	0.017
Gibson & Rozelle	2002	Papua New Guinea	Journal of Development studies	0.330	0.018
Gibson & Rozelle	2002	Papua New Guinea	Journal of Development studies	0.380	0.023
Gibson & Rozelle	2002	Papua New Guinea	Journal of Development studies	0.380	0.028
Gibson & Rozelle	2002	Papua New Guinea	Journal of Development studies	0.310	0.019
Gibson & Rozelle	2002	Papua New Guinea	Journal of Development studies	0.200	0.020
Gibson & Rozelle	2002	Papua New Guinea	Journal of Development studies	0.200	0.026
Gibson & Rozelle	2002	Papua New Guinea	Journal of Development studies	0.180	0.033
Bouis	1994	Kenya	Journal of Development Economics	0.430	0.024
Bouis	1994	Kenya	Journal of Development Economics	0.370	0.093
Bouis	1994	Philipian	Journal of Development Economics	0.550	0.013
Bouis	1994	Philipian	Journal of Development Economics	0.520	0.022
Ecker & Qaim	2010	Rwanda	African Journal of Agriculture & Resources Economics	0.646	0.051
Ecker & Qaim	2010	Uganda	African Journal of Agriculture & Resources Economics	0.680	0.046
Ecker & Qaim	2010	Tanzania	African Journal of Agriculture & Resources Economics	0.587	0.043
Behrman & Wolfe	1984	Nicaragua	Journal of Development Economics	0.100	0.030
Pan *et al.,*	2009	Nepal	Journal of family Economic issue	0.210	0.010
Bouis & Haddad	1992	Philipian	Journal of Development Economics	0.120	0.010
Bouis & Haddad	1992	Philipian	Journal of Development Economics	0.080	0.030
Bouis & Haddad	1992	Philipian	Journal of Development Economics	0.140	0.030
Bouis & Haddad	1992	Philipian	Journal of Development Economics	0.090	0.030

Authors	Year	Country	Publication outlet	Elasticity	SD Error
Bouis & Haddad	1992	Philipian	Journal of Development Economics	0.030	0.010
Bouis & Haddad	1992	Philipian	Journal of Development Economics	0.090	0.020
Bhargava	1991	India	Journal of statistic Social Association	0.066	0.032
Behrman & Deolaikar	1990	India	The Journal of Human resources	0.040	0.050
Ravallion	1990	Indonesia	Economic Development & Cultural change	0.254	0.097
Subramanian & Deaton	1996	India (Pooled OLS)	Journal of Political Economy	0.366	0.013
Subramanian & Deaton	1996	India (within est.)	Journal of Political Economy	0.341	0.013
Ward & Sanders (Caninde-1973)	1980	Brazil	Economic Development & Cultural change	0.450	0.063
Ward & Sanders (Caninde-1973)	1980	Brazil	Economic Development & Cultural change	0.530	0.087
Ward & Sanders(Caninde-1975)	1980	Brazil	Economic Development & Cultural change	0.410	0.072
Ward & Sanders(Caninde-1975)	1980	Brazil	Economic Development & Cultural change	0.520	0.118
Ward & Sanders(Fortaleza-1975)	1980	Brazil	Economic Development & Cultural change	0.240	0.030
Ward & Sanders(Fortaleza-1975)	1980	Brazil	Economic Development & Cultural change	0.330	0.044
Ngwenya	2008	Vietnam (widows)	Discussion paper	0.480	0.015
Ngwenya	2008	Vietnam (widowers)	Discussion paper	0.520	0.032
Ngwenya	2008	Vietnam (non-widowed)	Discussion paper	0.410	0.005
Kumar & Hotchkiss	1988	Nepal	Resaerch report	0.510	0.049
Tiffin & Dawson	2002	Zimbabwe	Journal of Agricultural Economics	0.309	0.080
Tiffin & Dawson	2002	Zimbabwe	Journal of Agricultural Economics	0.347	0.090
Mushtaq et al	2007	Pakistan	Pakistan Journal of Nutrition	0.210	0.100
Gaiha *et al.,*	2010	India	Working paper	0.431	0.013
Gaiha *et al.,*	2010	India	Working paper	0.354	0.010
Gaiha *et al.,*	2010	India	Working paper	0.401	0.008
Gaiha *et al.,*	2010	India	Working paper	0.388	0.008
Stillman & Thomas	2008	Russia	The Economic Journal	0.093	0.005
Stillman & Thomas	2008	Russia	The Economic Journal	0.036	0.006
Stillman & Thomas	2008	Russia	The Economic Journal	0.091	0.004
Stillman & Thomas	2008	Russia	The Economic Journal	0.085	0.006
Hoang	2009	Vietnam	Working paper	0.910	0.090
Hoang	2009	Vietnam	Working paper	0.970	0.115
Djebbarri	2005	Mexico	Working paper	0.319	0.080
Djebbarri	2005	Mexico	Working paper	0.277	0.060
Djebbarri	2005	Mexico	Working paper	0.278	0.050
Ojogho	2010	Nigeria	Agricultural Journal	$0.043 x 10^{-2}$	$0.002 x 10^{-2}$
Kochar	2005	india	Economic Development & Cultural change	0.240	0.010
Pitt et al (pooled)	1990	Bangladesh	American Economic Association	0.064	0.031
Pitt et al (male-head)	1990	Bangladesh	American Economic Association	0.084	0.042
Pitt et al(female-head)	1990	Bangladesh	American Economic Association	0.096	0.046
Reyes & Himatay	2010	Philipian	J.ISSAAS	0.061	0.021
Jha et al (rural Abdhra Pradesh)	2010	India	Journal of Asian Economics	0.020	0.010
Jha et al (rural Maharashtra)	2010	India	Journal of Asian Economics	0.420	0.100
Jha et al (rural Rajasthan)	2010	India	Journal of Asian Economics	0.240	0.090
Greek & Thorbecke (central)	1986	Kenya	Journal of Development Economics	0.630	0.036
Greek & Thorbecke(coast)	1986	Kenya	Journal of Development Economics	0.700	0.069

Authors	**Year**	**Country**	**Publication outlet**	**Elasticity**	**SD Error**
Greek & Thorbecke(eastern)	1986	Kenya	Journal of Development Economics	0.650	0.039
Greek & Thorbecke(Nyanza)	1986	Kenya	Journal of Development Economics	0.640	0.031
Greek & Thorbecke(Rift valley)	1986	Kenya	Journal of Development Economics	0.650	0.066
Greek & Thorbecke(Western)	1986	Kenya	Journal of Development Economics	0.660	0.040
Greek & Thorbecke(ALL)	1986	Kenya	Journal of Development Economics	0.630	0.017
Jensen & Miller (Hunah)	2008	China	Working paper	0.031	0.011
Jensen & Miller(Gansu)	2008	China	Working paper	0.028	0.014
Gibson & Kim(OLS version)	2011	Papua New Guinea	Working paper	0.138	0.026
Gibson & Kim(EIREG version)	2011	Papua New Guinea	Working paper	0.396	0.156
Liaskos & Lazaridis	2003	Greece	Agricultural Economics Review	0.270	0.041
Babatunde	2008	Nigeria	European Journal of Social Sciences	0.162	0.059
Skoufias *et al.,*	2011	Mexico	Applied Economics	0.470	0.012
Skoufias *et al.,*	2011	Mexico	Applied Economics	0.465	0.012