World Development 110 (2018) 192–204

Contents lists available at ScienceDirect

World Development

journal homepage: www.elsevier.com/locate/worlddev

Assessing the nonlinearity of the calorie-income relationship: An estimation strategy – With new insights on nutritional transition in Vietnam

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ARTICLE INFO

Article history:
Accepted 19 May 2018

Keywords:
Calorie-income relationship
Generalized additive model
Decomposition methods
Nutritional transition
Vietnam

ABSTRACT

Assessing the nonlinearity of the calorie-income relationship is a crucial issue when evaluating policies aimed at fighting against malnutrition. A natural choice would be to adopt a fully nonparametric specification of the relationship in order to let the data reveal its nonlinearity. But, we would be faced with the problem of the curse of dimensionality due to the presence of many control variables in addition to income. Here, we first propose to estimate generalized additive models where only income is supposed to enter nonlinearly in the specification. Second, we use a recent cross-validation procedure in order to choose among various competing specifications including the parametric double-log specification widely used in the literature in addition to GAM specifications. This methodology is implemented for each of the six waves of the Vietnam Household Living Standard Survey from 2004 to 2014. The calorie-income relationship is nonlinear whatever the wave. A strong response of calorie intake to an increase in income for poorest households is highlighted, showing that there is still room for income-based policies to fight against malnutrition. A byproduct of this methodology is the decomposition of the evolution of average calorie intake between the two waves in the part due to population change and that coming from the change in calorie-income relationship, shedding new light on the nutritional transition in Vietnam.

1. Introduction

Policies aimed at reducing starvation and redressing nutritional deficiencies remain among the most widely accepted policies in the world as emphasized by Banerjee (2016). These policies can take many different forms, from subsidized prices of basic foodstuffs to cash transfers, and their effectiveness depends on the existence of a sensitivity of food demand to income variation and its magnitude. Numerous papers in development and health economics deal with the issue of estimating the relationship between food demand measured in calories and household income, and lead to controversial results. Recently, Ogundari and Abdulai (2013), Santeramo and Shabnamb (2015), and Zhou and Yu (2015) provide surveys of this literature, and summarize the main issues that have been encountered. Thus, following Ravallion (1990), the literature generally agrees that the calorie-income relationship is nonlinear. Its general shape is popularly assumed to change with income dynamics. Calorie intake increases rapidly as income increases for consumers with low income. These consumers spend most of their additional income on food, and calorie intake therefore grows rapidly with income. Calorie intake increases then with income growth up to a threshold, called subsistence level. Beyond this threshold, calorie intake increases only slowly or even decreases, the marginal utility of additional calories going down significantly and finally staying relatively low. Many empirical studies tackle this issue by estimating the classical double-log specification where the log-income parameter possesses a direct interpretation as calorie-income elasticity and nonlinearity is captured by adding the square of log-income. 86 of the 99 elasticities recorded by Ogundari and Abdulai (2013) were thus obtained by estimating this parametric specification. Following Gibson and Rozelle (2002), only few papers use semiparametric specifications to deal

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https://doi.org/10.1016/j.worlddev.2018.05.030
0305-750X/

with the nonlinearity of the calorie-income relationship (Nie & Sousa-Poza, 2016; Tian & Yu, 2015).

This paper aims at contributing to the literature on estimating the calorie-income relationship. It proposes to mobilize recent developments in semiparametric estimation (Wood, 2017) and model selection (Racine & Parmeter, 2014) to revisit the nonlinearity problem mentioned above. The objective is to find a functional form that best describes the relationship between calorie intake and income from cross-sectional data. A natural choice would be to adopt a fully nonparametric specification of the relationship. Since the estimate of the relationship involves many control variables (age, education, region ...) in addition to income, we would be faced with the problem of the curse of dimensionality (Stone, 1980). The accuracy of our nonparametric estimates would be low even if we were lucky enough to have large samples. Semiparametric specifications then make it possible to seek a balance between the problem of the curse of dimensionality and the choice of totally nonparametric specifications to measure the impact of certain variables such as income in our case. We choose to estimate various semiparametric additive specifications in which the control variables are included in the parametric part of the model, and income is supposed to impact calorie intake through a smooth function of unknown form. A similar choice has also been done by Gibson and Rozelle (2002), Tian and Yu (2015), and Nie and Sousa-Poza (2016). Here, we consider general semiparametric specifications belonging to the family of generalized additive models, or GAM (Wood, 2017). The conditional distribution of calorie intake given income and various control variables is thus chosen in a list of conventional statistical distributions, and the conditional expectation of calorie intake given income and various control variables is expressed as the sum of linear functions of the control variables and a smooth function of income, up to a monotone transformation or link function. For instance, the papers cited just above actually use GAM specifications where the conditional distribution is the classical normal distribution and the link function the identity function.

Several potential options are possible to describe the relationship between calorie intake and income: not only semiparametric GAM specifications as suggested above, but also the classical parametric double-log specification, and we must choose among them. We use a cross-validation procedure recently proposed by Racine and Parmeter (2014), namely "revealed performance test" or RPT, to choose among these various competing parametric and semiparametric specifications. This procedure is a data-driven method for testing whether or not two competing specifications are equivalent in terms of their expected true errors, i.e., their expected performances on unseen data coming from the same data generating process. The RPT procedure is quite flexible with regard to the types of models that can be compared (nested versus non-nested, parametric versus nonparametric, ...) and is applicable in cross-sectional and time-series settings. This procedure can thus be applied to model selection as shown in Kiefer and Racine (2017).

Empirical analysis focuses on Vietnam. Indeed, although Vietnam has experienced a strong economic development that turned this poor country in the 1980s into a lower middle income country currently, Vietnam faces the double burden of malnutrition. This double burden of malnutrition is characterized by the coexistence of undernutrition along with overweight and obesity, or diet-related noncommunicable diseases, within individuals, households and populations, and across the life course (Nguyen & Hoang, 2018). Policies to fight against malnutrition are already relevant in Vietnam. The Vietnamese government has recently defined a comprehensive strategy to improve the nutritional situation of the Vietnamese population (Ministry of Health, 2012). The characterization of the shape of the calorie-income relationship is therefore relevant in order to assess the appropriateness of public policies affecting incomes of poor Vietnamese households.

The empirical analysis is based on six waves of the Vietnam Household Living Standard Survey, or VHLSS: 2004, 2006, 2008, 2010, 2012, and 2014. Expenditure data of each survey are transformed into nutritional data using energy conversion factors of food kilograms into kilocalories that are specific to Vietnam (National Institute of Nutrition, 2007). These data are used to characterize the shape of the calorie-income relationship for each wave of VHLSS, using the methodology presented above. The shapes of the chosen estimated calorie-income relationships are consistent with what was expected. Calorie intake increases as income increases.This growth is strong up to an income threshold from which it noticeably reduces. This result shows that there is still room for income-based policies to fight against malnutrition in Vietnam.

A by-product of the previous work is the analysis of the evolution of the calorie-income relationship over the studied period. The aim is to provide new insights into the nutrition transition in Vietnam. It then needs to be stressed that this analysis is not easy because the calorie-income relationship is estimated from different cross-sectional samples whose structure has evolved over time to remain representative of the population of Vietnamese households. Nevertheless, estimates of the relationship between calorie intake and income for each VHLSS wave can be used to decompose the difference between average calorie intakes between two waves in two effects: the effect of change in the surveyed populations between the two waves, and that due to changes in eating habits as reflected by the differences between the estimates of the calorie-income relationship for these two waves. This is the usual objective of decomposition methods in economics initiated by Oaxaca (1973) and Blinder (1973) and surveyed by Fortin, Lemieux, and Firpo (2011). We modify the approach proposed by Machado and Mata (2005) and Nguyen, Albrecht, Vroman, and Westbrook (2007) by applying it to the case of a difference between mean values and by incorporating the previously chosen parametric or semiparametric estimates of the relationship under investigation.

The results of the decomposition show that both effects contributed positively to the increase in average calorie intake over the studied period. Nevertheless, the effect of changes in eating habits, as reflected by changes in the estimated relationship between calorie intake and income, is a little higher than the effect due to changes in the structure of the population (mainly increasing urbanization and decreasing household size), the first effect remaining fairly stable while the latter is slowly increasing over the period.

The paper is organized as follows. Section 2 gives a picture of the nutritional situation of the Vietnamese population. Section 3 presents the methodology used in this paper. Section 4 is devoted to the presentation of the VHLSS data and to the approach chosen when converting expenditure data into quantities of calories. Results are presented and discussed in Section 5. Special attention is devoted to the potential endogeneity of the measure of income we have chosen, i.e. total expenditure. Section 6 concludes.

2. Nutritional issues in Vietnam

Vietnam's development record over the past 30 years is remarkable. Economic and political reforms under Doi Moi, launched in 1986, have spurred rapid economic growth and development and transformed Vietnam from one of the world's poorest nations to a lower middle-income country. According to World Bank, per capita Gross National Income rose from 435 to 1691 constant 2010 US dollars between 1989 and 2016. Moreover, the poverty rate