ESM 514
Collaborative Interdisciplinary Research

Project Report

Environmental implications and determinants of household dietary change in the U.S. 1984 - 2016

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1 Introduction and Literature Review

Agriculture is responsible for 30% of anthropocentric greenhouse gas emissions, 70% of freshwater use, and occupies nearly half of all ice-free land available on earth (Tilman and Clark; 2014; Whitmee et al.; 2015). Both the quantity and the composition of a household's diet has significant environmental implications (Marlow et al.; 2009). A deep body of literature considers the environmental impacts of various dietary profiles (Merrigan et al.; 2015; Tilman and Clark; 2014; Macdiarmid et al.; 2012; Perignon et al.; 2017; Cosme; 2017), most of which draw a similar conclusion: it is better for the environment if people eat less meat, particularly beef.

Furthermore, global environmental damage from agriculture is set to increase significantly as the world's middle class grows (Tilman and Clark; 2014), meaning it increases and then decreases with income, though the maximum occurs at such a high income that most countries will not reach 'peak beef' in the foreseeable future (Cole and McCoskey; 2013). Research has also considered the environmental implications of countries adhering to their prescribed 'recommended diet'. These diets are primarily recommended on the grounds of nutrition and health. Behrens et al. (2017) compares the environmental impacts of average diets with nationally recommended diets for 37 countries and finds a net reduction in environmental impacts through adoption of the latter, despite increasing damages from low-income countries.

While we urgently need solutions, a global call for vegetarianism or "healthy eating" on the basis of dietary environmental profiles overlooks two critical questions regarding dietary choice: "why do people eat what they eat?" and "why has diet changed historically?". Previous research has looked at transitions in household consumption. Levinson and O'Brien (2015) uses environmental Engel curves to show that the average household consumption bundle has lower environmental impact today than it did thirty years ago. Could this be due to dietary transitions?

Other research has considered the environmental profile of dietary transitions in the context of a developing country, namely China, and found that while expenditure on food and nutritional quality has increased and diet composition has changed, the environmental impact of diet has decreased due to improvements in production efficiency (Feng et al.; 2015; He et al.; 2018). By focusing on dietary transition in the United States, we consider a more nuanced change that is less likely to be driven by a rapid increase in average income. Understanding the determinants of dietary change and the environmental implications in the American context will help ground potential interventions to change diets in the realism of consumer choice.

2 Research Questions and Significance

The goal of our study is to identify the determinants of the dietary transition and its footprint in the United States to ultimately explore its implications regarding demand-side environmental food policy.

The first question we try to answer is to what extent are the changes in the American households' dietary environmental profile driven by income-related preferences or changes in other demographic characteristics and, by changes in economy-wide trends (e.g. changes in prices, environmental policies).

Secondly, we would like to explore how the relative importance of income-related preferences, demographics and other economy-wide trends change over time. Using this over-time decomposition we will explore how historical major food-related events impacted households' dietary environmental profiles.

Finally, we will answer the question of to what extent would different policy tools impact American households' dietary environmental profile. We will do this by considering the information gathered through our analysis to incorporate more realistic demand responses into projected scenarios.

We believe answering these questions is relevant to empirically identify the factors that should be considered when thinking about interventions to promote "greener diets" in the United States. As well as providing empirical understanding regarding the extent to which different interventions can impact food consumption and its environmental implications.

3 Methodology

In essence, this research involves analysis of American households' dietary environmental profile over time. We plan to generate the profile by connecting the U.S. consumer expenditure survey conducted by the Bureau of Labor Statistics with EXIOBASE, an environmentally-extended multi-regional input-output database. The components of this process and the analytical tools we will use to interpret the results are outlined below.

3.1 Environmentally Extended Input-Output Analysis - EEIOA

Multi-Regional Input-Output (MRIO) has been increasingly applied in global environmental footprints calculation for the last decade. Among a number of MRIO databases developed so far, EXIOBASE has a clear environmental and resource focus with high levels of detail in primary production (Wood et al.; 2014). It was developed by harmonizing and detailing SUT (Supply-Use Table) for 43 countries, estimating emissions and resource extractions by industry, linking the country EE SUT (Environmental Extended Supply Use Table) via trade to an MR EE SUT, and producing an MR EE IOT from this. It can be used for the analysis of the environmental impacts associated with the final consumption of product groups.

In this paper, we will use EXIOBASE 1 and 2 versions (year 2000 and 2007 data, respectively) to calculate the emission coefficients of the U.S. food production industries, and then obtain the environmental Engel curve by combining them with U.S. household expenditure data (Levinson and O'Brien; 2015). Mapping of the food catogeries in EXIOBASE and household expenditure date needs to be done before further calculation.

3.2 Consumer Expenditure Survey

Here we use consumer expenditure survey collected by the Bureau of Labor Statistics. The household expenditure data used comes in the form of a "diary" collected from roughly 14,000 respondents each year. Each household keeps reports all purchases over a two week period alongside a myriad of demographic and other household information. Diary responses are available from 1984 - 2016. Using consumer price index (CPI) to deflate expenditures over time gives us the trends in dietary composition.

Concatenation of the above results with the EXIOBASE emission data allows us to build a

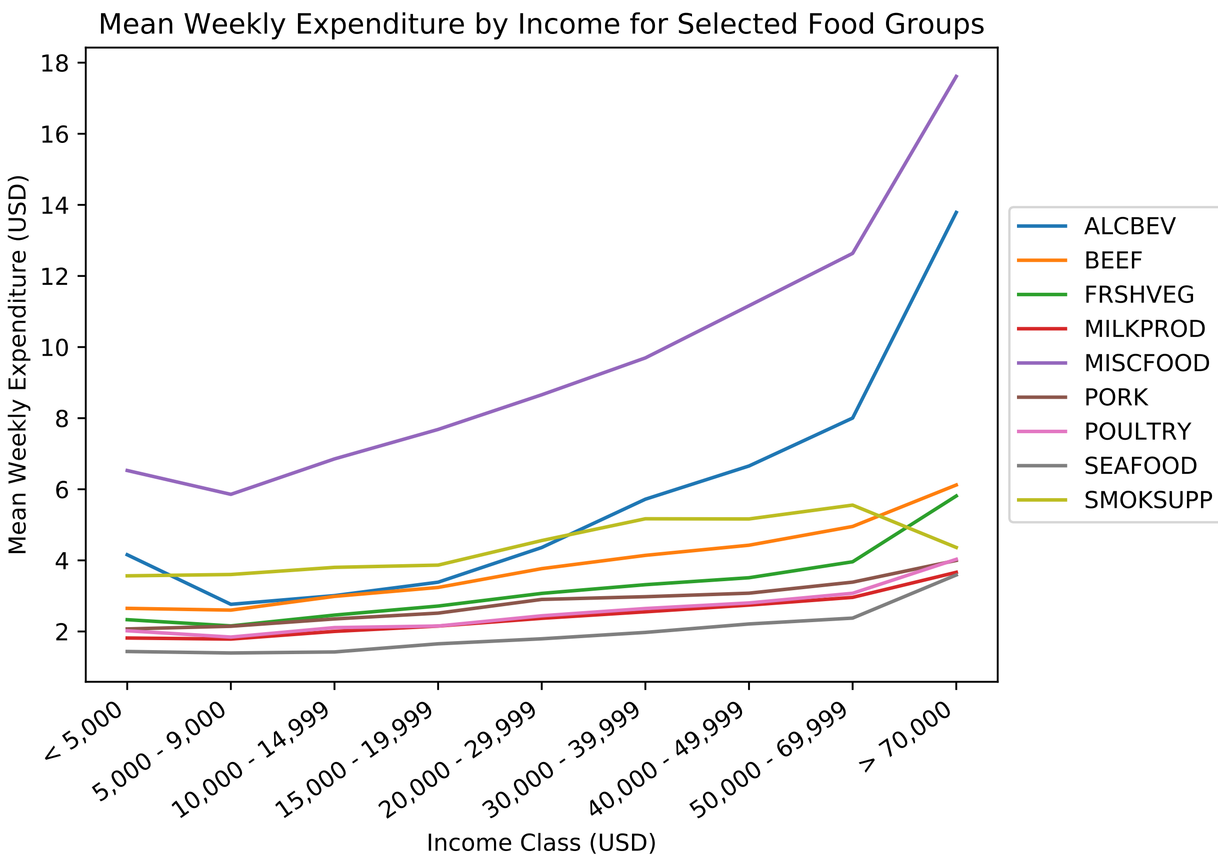

Figure 1: Mean expenditure on selected food groups from the CPI data plotted against reported income. Income data in the CPI is imputed due to low response rates.

complete environmental profile of a households' dietary consumption. Once household dietary environmental profiles have been generated we can use statistical methods to determine what household characteristics determine dietary composition.

3.3 Econometric Specification

The econometric specification follows Levinson and O'Brien (2015) is very straightforward. Let E_{it} be an environmental outcome for person i at time t, Y_{it} be their income, and X_{it} be a vector of controls. The specification is then

$$E_{it} = \alpha + \beta_1 Y_{it} + \beta_2 Y_{it}^2 + \gamma X_{it} + e_{it}$$

This specification traces out a single Engel Curve for all time periods. In contrast, Levinson and O'Brien fit separate Engel curves for each year to see how the relationship changes over time (we may adopt this approach as well).

3.4 Policy Analysis

The policy analysis section of this paper has two components:

a) A historical trend analysis of food expenditures and emissions against significant food-related events.

b) A predictive analysis of the influence of different policy tools on food expenditure and emissions.

The first analysis is currently conceptualized as a qualitative exercise. We will identify significant policy changes or external shocks over the period of our data. Identification will be based on the frequency with which the particular policy change or shock is mentioned in the literature and media. Policy change for example would include government mandated initiatives such as labeling programs, issuance of nutritional guidelines, taxes on agriculture or food processing that had an impact on food price and so on. External shocks would include events such as epidemics caused by sources of food (e.g. Bovine spongiform encephalopathy or Mad Cow disease) and the resulting change in demand for that food source. We will juxtapose these policies and events with our expenditure and emissions analysis to qualitatively identify whether policies and shocks lead to changes in consumption patterns. We propose this exercise as one way to learn about the behavioral impacts of food policy measures. We will also explore statistical methods for conducting this analysis once we have prepared our basic datasets of expenditures and emissions.

The second analysis is a quantitative exercise built on our model of food expenditure, prices and emissions. We will shortlist a set of potential policy measures such as i) tax on a particular food item (such as beef); ii) tax on a basket of high emissions food items and iii) general carbon taxes. While similar analyses have been performed before, the impact on expenditure and behavioral change is under studied.

4 Next Steps

We plan on completing the following tasks over the next 6 months:

a) Decomposition of expenditure on food over the period of our data.

b) Inclusion of prices into our model from CPI data.

c) Complete matching of industry types across different databases (EXIOBASE, CEX).

d) Conversion of all data to a common units and to a constant baseline year of analysis.

e) Coding and combining datasets by industry type in R.

f) Qualitative analysis of food related policies and shocks.

g) Development of EECs for the range of our data.

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