

# Food Security, Welfare, and Sustainability in Canada -Mathematical Conceptual Foundation

Ghana Gomaa A. Mohamed<sup>1</sup>, PhD., PDFs

<sup>1</sup>Dean of Students; Global Forward Academy, USA

Correspondence: President: ECO-ENA: Economics & ECO-Engineering Associate, Inc, Canada

Received: June 27, 2023 Accepted: August 30, 2023 Online Published: October 18, 2023

doi:10.5539/jmr.v15n5p73

URL: <https://doi.org/10.5539/jmr.v15n5p73>

## Abstract

This manuscript provides a mathematical approach to measuring food security, linking it mathematically to the concept of social welfare over time to figure out the impact of food security on the transitional dynamism of social welfare. The utilized mathematical approach in this manuscript is essential as a foundation for further research on food insecurity/ security, consumer behaviour, and social welfare over time. <sup>1</sup>

**Keywords:** food insecurity, food security, consumer surplus, consumer confidence, social welfare, sustainability, survey analysis, intervention analysis, time series data, Canada

## 1. Introduction

This manuscript depends on the definition of Health Canada of the concepts of food insecurity and food security. In addition to the definition of the FAO of food security. On the other side, it depends on Weitzman's definition of social welfare. It also depends on the Canadian Household Food Security Survey Modules (HFSSM) to measure food insecurity.

This manuscript provides a mathematical approach to measuring food security, linking it mathematically to the concept of social welfare over time to figure out the impact of food security on the transitional dynamism of social welfare. The utilized mathematical approach in this manuscript is essential as a foundation for further research on food insecurity/ security, consumer behaviour, and social welfare over time.

This manuscript is structured as follows. Section II, after the introduction, provides the implicit function of food insecurity. Section III explains the explanatory variables of the food security function. Section III provides a mathematical calculation to derive the data trend of food security. Section IV presents the term social welfare and its measure. Section V introduces the intervention time series model to determine food security's impact on social welfare over time. Section VI provides the implications and the conclusion of the manuscript.

## 2. Definitions and The Food Security Function

According to Health Canada, “food insecurity is the inability to acquire or consume an adequate diet quality or sufficient quantity of food in socially acceptable ways, or the uncertainty the one will be able to do so.”

The 1996 World Food Summit provided a broad definition of food security., I.e., “Food Security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life.” (FAO, 1996).

The Food Policy Canada defines security as “All people in Canada can access a sufficient amount of safe, nutritious, and culturally diverse food.” And added that “Canada’s food system is resilient and innovative, sustains our environment and supports our economy.” (AAFC).

The Household Food Security Survey Module (HFSSM) measures food insecurity. This tool has been included in Statistics Canada’s Canadian Community Health Survey since 2004 and in the Canadian Income Survey (CIS) since

---

<sup>1</sup> This paper was discussed and deposited into the conference proceeding of the 9th annual conference of economic forum of entrepreneurship & international business. Mohamed, G., G. (2023). Food Insecurity, Food Security, Welfare, and Sustainability in Canada - A Quantifying Approach - *From Micro to Macro*. The 9th Annual Conference of Economic Forum of Entrepreneurship & International Business. **Venue:** LMH, University of Oxford, Oxford, United Kingdom. ISSN 1925-461X , ISBN: 978-1-988081-12-0: Library & Archive Canada. [https://epe.lac-bac.gc.ca/100/201/300/annual\\_conference\\_economic/v09.pdf](https://epe.lac-bac.gc.ca/100/201/300/annual_conference_economic/v09.pdf)

2019.) PROOF, 2022). The appendix provides the questionnaire for this survey.

We can assume different factors affect food. According to this survey, four types of people can be identified: a more protective person against food insecurity, a vulnerable person to food insecurity, a secure food person, and a food insecure person. On the other hand, households not identified as food insecure are considered food safe. (PROOF, 2022).

*The food insecurity function can be explained as follows.*

*Food Insecurity = f(financial factors, social & cultural factors, human behaviour, uncertain macro factors).*

The financial factors are about the household's disposable income and food prices. In other words, the financial factors could be represented by the consumer surplus, which can be explained on the macro level in the following section of this manuscript. Assuming that the gross consumption can be derived as a function of disposable income. Wealth could be added as one of the financial factors as well.

The social and cultural factors are cultural diversity, family kinship, community cooperation, age, gender, education, isolation, and bleakness. The social and cultural factors can be measured via a survey to determine the number of populations that suffer from negative social and cultural integration. To simplify, it can be measured by the number of immigrants in Canada every year, assuming that; immigrants take time for social and cultural integration. The data trend is available in this case.

Human behaviour toward food assistance programs is about positive behaviour toward food assistance programs or negative behaviour toward food assistance programs. "A cognitive game approach can cognitively explain this behaviour." To neutralize, we can consider only positive behaviour toward social assistance. The consumer confidence index in Canada could measure this. The data trend is available in this case.

The uncertain macro-factors are about food supply chain blocks, crises, etc. This is considered a random term. To simplify, let's assume that the random term is a white noise disturbance term.

The above function can then be rewritten as follows.

$$FI = f(X1, X2, X3, e).$$

Where; FI refers to food insecurity, X1 refers to the consumer surplus term, X2 refers to the social/ cultural integration term, X3 refers to the consumer confidence index, and e refers to the uncertainty.

### 3. How to Measure the Consumer Surplus on the Macro-Level. From Micro to Macro

The consumer surplus is measured by the difference between what they are willing to pay and what they are actually paying. From a macroeconomic perspective, we can take the CPI as a proxy of what the consumers are actually paying in the economy, while the entire area under the aggregate demand is what the consumers are willing to pay. In different words, the consumer surplus is theoretically feasible within the area located under the demand and above the price. (Mohamed & Javid (2014)).

If we consider on the macro level that the entire demand is the gross nominal private consumption, then; the consumer surplus on the macro level can be determined mathematically as follows:

*The consumer surplus = ln (nominal gross consumption) - ln(CPI); this equals the real gross consumption. Therefore, the real gross consumption in the economy can be considered a proxy of the consumer surplus. (Mohamed & Javid (2014)). The trend data of the real gross consumption is available.*

This entire section depends on the same author's analysis in her paper with Saima Javid (2014); however, here, we can consider the GDP of the natural resources, not the entire GDP of the economy. The trend data is available in Canada as well. For more explanations, Px refers to the price of a good X; QD<sub>x</sub> refers to the quantity demanded of a good X, P is the price of this good and D is the demand for this good. Y is the real GDP of the natural resources, the CPI is the consumer price index, and AD is the aggregate demand.

### 4. How to Estimate the Trend Data of Food Security

In this section, we explain how to estimate the trend data of food security. We can do so in two steps;

Step 1 by using the results of the Household Food Security Survey Module (HFSSM) in Canada. We then estimate the explained model in the previous section. After selecting the best-fit model, we forecast it to figure out the data trend of food insecurity. - We can control all econometric problems here. The estimated food insecurity function over time is as follows:

$$FI_t = a + bX1t + cX2t + cX3t + et.$$

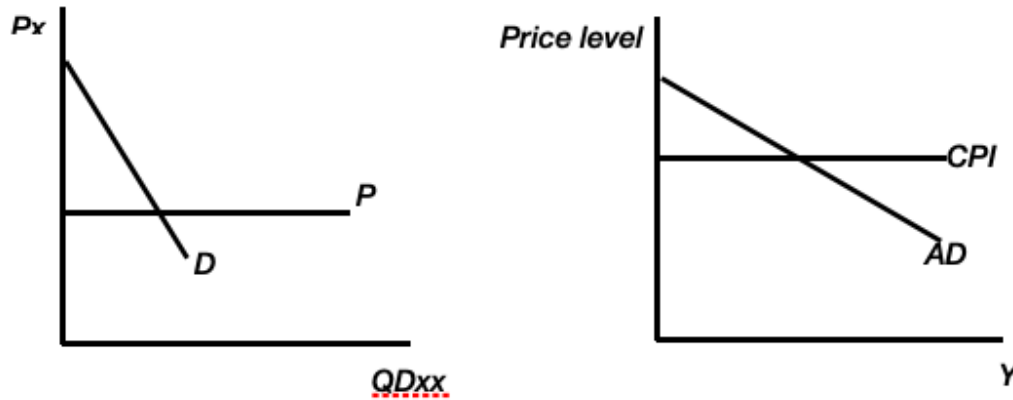
Step 2: generating the data of the food insecurity from the previous model directly as follows:

Recall;  $FI = f(X1, X2, X3)$ , considering the macro uncertainty is zero. By taking the total differentiation of this function, thus.,

$$dFI = dX1. (\partial FI / \partial X1) + dX2.(\partial FI / \partial X2) + dX3.(\partial FI / \partial X3).$$

By minimizing food insecurity, the  $FI$ , as a policy, then.,

$$dFI = dX1. (\partial FI / \partial X1) + dX2.(\partial FI / \partial X2) + dX3.(\partial FI / \partial X3) = 0.$$



Where the  $(\partial FI / \partial X1)$  is the sensitivity of the change of food insecurity to the change of the financial factors, the  $(\partial FI / \partial X2)$  is the sensitivity of the change of food insecurity to the change of the social/ cultural factors, and the  $(\partial FI / \partial X3)$  is the sensitivity of the change of the food insecurity to the change of the human behaviour variable.

Mathematically speaking, we link the coefficients a, b, and d mathematically to the partial differentiation terms. - We then can calculate the data trend of the food insecurity variable.

### 5. How to Measure Social Welfare Over Time - Macro-Sustainability

According to t Weitzman (2001), “the difference in inter-temporal welfare between two points in time of the same economy can be exactly measured by the difference in real national income plus a consumer surplus term.”

Recalling Weitzman’s statement and our macro-explanation of the consumer surplus term, then;

*The intertemporal welfare between two points in time t & t-1 = (the real national income + the real gross consumption)t - (the real national income + the real gross consumption)t-1.*

Now, we have a quantitative variable that reflects the welfare over time. (Mohamed & Javid (2014)).

This entire section depends on the same author’s analysis in her paper with Saima Javid (2014); however, here, we can consider the GDP of the natural resources, not the entire GDP of the economy.

Accordingly, the trend data of social welfare over time can be easily derived from the relevant trend data in Canada.

### 6. The Impact of Food Security on Social Welfare Over Time - Sustainability

With two quantitative variables, i.e., food security and welfare, we can then figure out the transitional dynamic impact of food security on social welfare by utilizing an intervention time series model as follows:

$$Wt = a0 + A(L) W(t-1) + c0 FSt + B(L) + \epsilon t.$$

Where; the  $W$  refers to social welfare,  $FS$  refers to the food security which is the intervention variables, and  $a0$  is the constant term. The  $A(L)$  and the  $B(L)$  are polynomials in the lag operator, and the  $\epsilon t$  is the disturbance term.

After doing all relevant data checks, we run the ARMA with the intervention variable up to ARMA (3,3) until selecting the best-fit model. By forecasting the model, we can figure out the transitional dynamism of the impact of food security on social welfare over time. (Mohamed & Irandoust (2023)).

### 7. Conclusion and Implications

This manuscript provided a quantitative approach to measuring the variable of food security, hence providing trend data to figure out the transitional impact of food security on social welfare over time. Yet, this manuscript should be extended to provide data analysis for Canada as the country case study taken in this manuscript.

**References**

- Deaton, B. J., & Scholz, A. (2022). Food security, food insecurity, and Canada's national food policy: Meaning, measures, and assessment. *Outlook on Agriculture*, 51(3), 303-312.
- Mohamed, G. G. A., & Irandoust, M. (2022). A Dynamic Analysis of Financial Interruption on a Small Open Economy: A Case Study on South Africa. *Asian Economic and Financial Review*, 12(5), 317-328. <https://doi.org/10.55493/5002.v12i5.4487>
- Mohamed, G. G., & Saima, J. (2014). The Impact of Foreign Direct Investment on Dynamic Net Social Welfare in Saudi Arabia - A quantifying macroeconomic approach- Time Series Analysis. *International Journal of Academic Research in Economics and Management Sciences*, 3(4), 1-8.
- Mohamed, G., G. (2023). Food Insecurity, Food Security, Welfare, and Sustainability in Canada - A Quantifying Approach - *From Micro to Macro*. The 9th Annual Conference of Economic Forum of Entrepreneurship & International Business. Venue: LMH, University of Oxford, Oxford, United Kingdom. ISSN 1925-461X, ISBN: 978-1-988081-12-0: Library & Archive Canada.

PROOF research work on food insecurity in Canada, University of Toronto.

**Copyrights**

Copyright for this article is retained by the author(s), with first publication rights granted to the journal.

This is an open-access article distributed under the terms and conditions of the Creative Commons Attribution license (<http://creativecommons.org/licenses/by/4.0/>).