Essays on Aggregation in Macroeconomics

Abstract

Macroeconomics is a field of study that seeks to understand the behavior of the economy as a whole. Nonetheless, the economy is complex, with various goods, households, and firms exhibiting heterogeneity, making it difficult to capture a full picture of the economy. Consequently, the process of aggregating such heterogeneity is a fundamental aspect of macroeconomics as it enables a comprehensive analysis of the economy.

One challenge of heterogeneity in macroeconomics is the diversity of goods in the economy. Goods can vary in character, function, purpose, and other dimensions, making it difficult to aggregate their price and quantity into a single measure.

Recent advances in theoretical and empirical methods have led to new aggregation techniques that can capture the heterogeneity of goods. For instance, the seminal study by Diewert (1976) proposes the concept of a superlative index, which allows measuring the cost of living under a flexible utility function. This research is pivotal as it allows for the economically meaningful inclusion of substitution between heterogeneous goods in the price index. This study has also significantly impacted official statistics, leading to the adoption of the superlative index, specifically the Fisher index, in calculating the Gross Domestic Product (GDP) deflator in the US and Canada.

Another promising research field is the utilization of new data sources. For example, Broda and Weinstein (2010) utilize household scanner data to estimate the impact of product turnover on the cost of living index. This innovative approach is particularly important as it allows for the incorporation of new features into traditional aggregates, which help provide a more accurate and comprehensive picture of economic activity.

This thesis focuses on three studies on heterogeneity and aggregation, exploring how the aggregation of goods affects our understanding of key macroeconomic variables. By providing insights into the importance of incorporating heterogeneity in macroeconomic analysis, this thesis aims to contribute to the advancement of the field.

Chapter 2: The Effect of Aging on the Age-Wage Profile in Japan

Chapter 2 is based on a published study by Inoue (2022). In recent years, the Japanese economy has experienced a phenomenon known as the "flattening of age-wage profile," in which the wage gap between older and younger workers has dramatically shrunk. If such a phenomenon is interpreted by a simple model which assumes a competitive labor market and homogeneous labor, these changes in wage difference stem from a change in worker's productivity. This study

seeks to provide a different interpretation of this change in age-wage profiles by challenging the assumption of homogeneous labor in such a simple model.

This study argues that the aging of the workforce is an important factor causing the flattening of the age-wage profile of the Japanese economy. Assuming imperfect substitution between older and younger workers, I derive the labor demand function from the firm's optimization problem. I estimate the elasticity of substitution between different aged workers, and quantify the effect of aging on the age-wage profile. I find that aging of the workforce can explain more than 80% of the change in the age-wage profile from 2000 to 2019.

While not explicitly discussed in Chapter 2, aging is linked to research topics about prices, which are examined in Chapters 3 and 4. As demonstrated by Aguiar and Hurst (2007), Unayama and Keida (2011), and Abe and Shiotani (2014), price levels exhibit heterogeneity across different age groups, suggesting that aging may influence the price level of the entire economy by changing the composition of the age group. Further evidence of heterogeneity has been documented by Diamond et al. (2020) for inflation rates and inflation expectations. As demographic aging becomes more pronounced in numerous countries, delving into the relationship between an aging population and prices will be an increasingly significant area of future research.

Chapter 3: Price Index Numbers under Large-Scale Demand Shocks: The Japanese Experience of the COVID-19 Pandemic

Chapter 3 is based on Abe et al. (2022), a joint work with Naohito Abe and Hideyasu Sato. The consumer price index is often designed to measure the cost of living. One of the problems in measuring the cost of living is that it is necessary to assume a constant utility function and no shocks to demand. To solve this problem, a recent development by Redding and Weinstein (2020) proposes a method to measure the cost of living index by allowing time-varying parameters of the utility function, but there is not enough empirical analysis using this method.

Using a recently developed index number formula that is exact for the constant elasticity of substitution utility function with variable preferences, we quantify the degree of demand shock caused by the pandemic. Specifically, we investigate the prices and quantities of face masks when the COVID-19 pandemic was particularly serious to understand the impact of demand shocks on the cost of living index (COLI). The empirical analysis revealed that shifts in preferences during the pandemic were so significant that the COLI with variable tastes became vastly different from the standard superlative indexes. While the prices of face masks decreased in the Fisher index in May 2020 by 0.76% per week, the COLI increased by 1.92% per week.

This increase in the COLI relative to the Fisher index is interpreted to reflect the actual

change in the purchasing behavior of households for masks during the COVID-19 pandemic. Essentially, the COLI used in this research is assumed to decrease (increase) as the dispersion of preferences for each mask increases (decreases). The rise in COLI for May 2020 indicates a decrease in the dispersion of preferences. This is consistent with the actual economic situation. In fact, during the COVID-19 pandemic, households placed less importance on the brand or packaging of masks, prioritizing their functionality instead. Households purchased whatever masks were available in the stores. This change in mask preferences is captured by COLI, which showed a greater increase than the Fisher index.

Chapter 4: The Effect of Seasonality on Elementary Index

Chapter 4 is based on a working paper by Inoue (2023). To create annual indicators in real terms (e.g., real gross domestic product, real consumption, etc.), statistical authorities calculate the annual prices and quantities of each commodity for the inputs of an index formula. One of the challenges in creating commodity-level prices and quantities is dealing with seasonal goods. The annual price and quantity of seasonal goods are typically calculated using unit prices from the monthly quantity-weighted average prices (also known as the unit value price index), and a summation of monthly quantities. However, the studies of the index number theory have revealed that this aggregation technique is appropriate for homogeneous goods but not for heterogeneous goods (Silver, 2010). Therefore, this study seeks to investigate whether seasonal goods are consumed as homogeneous goods throughout the year or as heterogeneous goods in different seasons.

By estimating the Constant Elasticity of Substitution (CES) utility function with monthly commodity level data, I show that a significant number of fresh foods are non-homogeneous commodities throughout the year. This non-homogeneity can result in up to a 15% difference in the annual commodity-level aggregated quantity between the simple summation of the monthly quantity and the quantity aggregated using the CES utility function. Non-homogeneity results in significant long-term differences in quantity changes, with up to a 20% point difference between the relative simple summation quantity and the Fisher quantity index over a 40-year period. Additionally, my findings indicate that these differences at the commodity level affect higher-level aggregations, such as the annual aggregated price and quantity indicators for fresh foods and real consumption.

Non-homogeneity affects the aggregate results through two factors. First, the utility of consumption changes with seasons. The estimated results of the CES utility functions show that the preference weights are uneven for almost all goods. This means that the same amount of

consumption in different seasons results in different levels of utility. Possible reasons for these uneven weights include changes in quality, such as taste and nutritional value, and in consumer value, influenced by seasonal traditions and customs. Another contributing factor is the imperfection of temporal substitution. The estimation results of the CES utility functions indicate that substitution between different months is imperfect for many goods. This implies that households prefer more balanced consumption and consider seasonal fluctuations inconvenient. This inconvenience of seasonal fluctuations lowers the aggregates of the CES utility function. These two factors create a discrepancy between the aggregates of the CES utility function and the simple summation.

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