An Analysis of U.S. Dairy and Non-Dairy Milk Demand

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Dairy and Plant-Based Milk Consumption

Data Description

For this study, we utilize weekly point-of-sale scanner data of dairy and plant-based milk product sales from the second week of March 2018 to the first week of December 2022, provided by Nielsen. The sales data are collected through in-store scanners of affiliated retailers and are recorded at the Universal Product Code (UPC) level. From the product dictionary, we identified 10,453 UPCs for dairy and plant-based milk sold in retailers from the years 2018-2022. The UPCs were aggregated into two dairy milk products and four plant-based milk products, including regular dairy milk, lactose-free or reduced milk, almond milk, oat milk, coconut milk and soy milk for 248 weeks. Summary statistics are shown in Table 1.

The average weekly sales of all dairy and plant-based milk products over the 2018-2022 years are $290 million. Average weekly sales of regular dairy milk are $219 million/week, accounting for the largest share of this category at 75.6% (Figure 1). Lactose-free or reduced milk and almond milk account for 9.9% and 10.0% of expenditure/sales share each, with about $29 million/week each, while average weekly sales of oat, coconut and soy milk are $13 million/week combined, accounting for the remaining 4.6% of the expenditure share for milk products. The average weekly sales of all milk products have increased over five years, but soy milk has decreased by 15.1% from 2018 to 2022[1]. Meanwhile, the weekly sales of oat milk grew by 4150% from 2018 to 2022, showing a dramatic increase.

Regular dairy milk is less expensive than plant-based milk, averaging $0.03/oz., but lactose-free or reduced milk is more expensive than almond or soy milk, averaging $0.065/oz.

[1] The change in weekly sales in 2022 compared to 2018 is calculated using the average weekly sales for 2018 and 2022. The average weekly sales for 2018 is a 43-week average from the second week of March to the last week of December, and the average weekly sales for 2022 is a 49-week average from the first week of January to the first week of December.

from 2018-2022. Among plant-based milk products, almond and soy milk are the least expensive at $0.05/oz. and $0.052/oz., respectively. Coconut milk is the most expensive at $0.094/oz. The average weekly prices of all milk products have risen over the past five years, except for oat milk. Coconut milk has the largest increase in average weekly price over five years at 33.4%, followed by regular dairy milk at 33.1%. However, oat milk price has decreased in the same periods at 18.2%.

Table 1. Summary of descriptive statistics on expenditure, prices, and budget share

Variable	Mean	SD	Min	Max	% Change (18-22)
Average weekly sales ($1000)					
Regular dairy milk	218,533	16,435	191,345	311,201	17.0%
Lactose-free/reduced milk	28,829	5,017	21,129	41,691	60.7%
Almond milk	28,836	2,877	20,329	48,169	22.6%
Oat milk	5,176	3,868	150	11,452	4150.1%
Coconut milk	4,490	639	3,576	7,880	30.9%
Soy milk	3,817	324	3,321	5,963	-15.1%
Weekly expenditure shares					
Regular dairy milk	0.756	0.021	0.725	0.802	-6.3%
Lactose-free/reduced milk	0.099	0.010	0.081	0.116	28.7%
Almond milk	0.100	0.006	0.079	0.114	-1.8%
Oat milk	0.017	0.012	0.001	0.034	3304.4%
Coconut milk	0.015	0.001	0.014	0.019	4.8%
Soy milk	0.013	0.002	0.010	0.017	-32.0%
Average weekly price ($/oz.)[1]					
Regular dairy milk	0.030	0.003	0.026	0.038	33.1%
Lactose-free/reduced milk	0.065	0.003	0.062	0.072	10.9%
Almond milk	0.050	0.002	0.047	0.059	7.2%
Oat milk	0.077	0.009	0.067	0.105	-18.2%
Coconut milk	0.094	0.011	0.080	0.133	33.4%
Soy milk	0.052	0.003	0.048	0.065	10.2%

Note[1] Average weekly price is calculated as a weighted average using the consumed quantity as the weighted factor from each UPC in the category.
Source: Author's calculation based on the 2018-2022 weekly point-of-sale data from Nielsen.

Among plant-based milk products, five-year average of almond milk expenditure accounts for the largest share at 68.1%. The share of diary-alternative expenditure on oat milk accounted for 12.2% for 2018-2022, although as indicated the share has risen over time.

Meanwhile, coconut milk has a 10.6% share of the plant-based market. Soy milk, which accounts for a larger quantity of sales (in oz.) than coconut milk, accounts for a smaller share of plant-based sales, 9%, because soymilk is less expensive per ounce than is oat milk. The share of expenditure on plant-based milk increased from 12.9 in 2018 to 15.4% in 2022 (Figure 2). Among plant-based milk, the share of oat milk expenditure increased sharply from 0.7% to 21.0% over five-years.

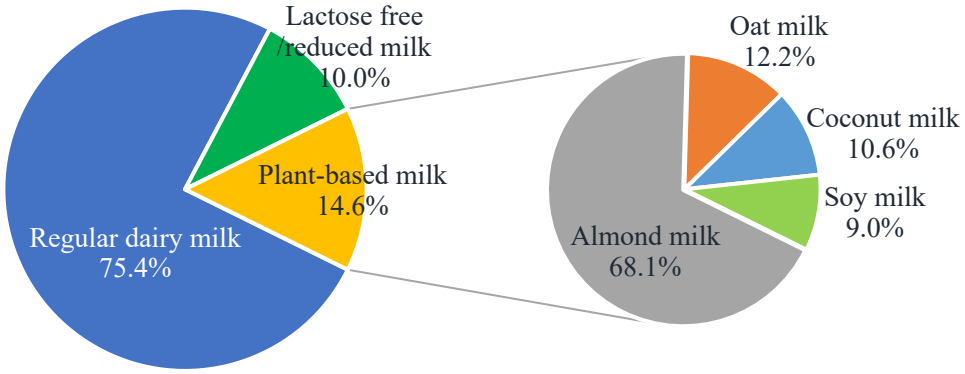


Figure 1. Average weekly expenditure shares of milk products (2018-2022 average)

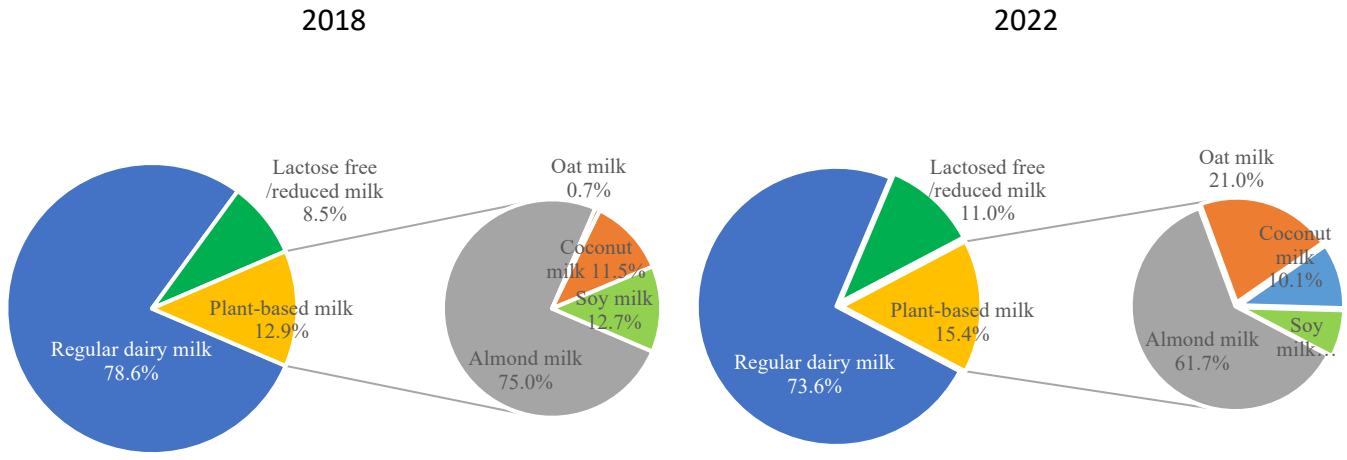


Figure 2. Average weekly expenditure shares of milk products of 2018 and 2022

Dairy Milk and Plant-Based Milk Consumption Trend

Consumption of dairy milk and plant-based milk products from 2018-2022 is shown in Figure 3. Overall, the quantity of dairy and plant-based milk consumed decreased 1.7% each year on average between 2018 and 2022. The decline is driven by a decrease in consumption of regular dairy milk, which accounts for the majority of ounces consumed at 85.9%. From 2018 to 2022, milk consumption decreased by 6.6%, led by an 11.9% decline in consumption of regular dairy milk.

In early 2020, as Coronavirus (COVID-19) spread around the world, consumers' food consumption patterns temporarily changed. In mid-March 2020, many states in the United States begin to implement business shutdowns and stay-at-home orders went into place. As a result, consumers to sharply increased their grocery food purchases. Expenditure in the third week of March 2020 was $421 million, which was 60% higher than the same period in 2019. Total ounces purchased increased 44.7% during this period.

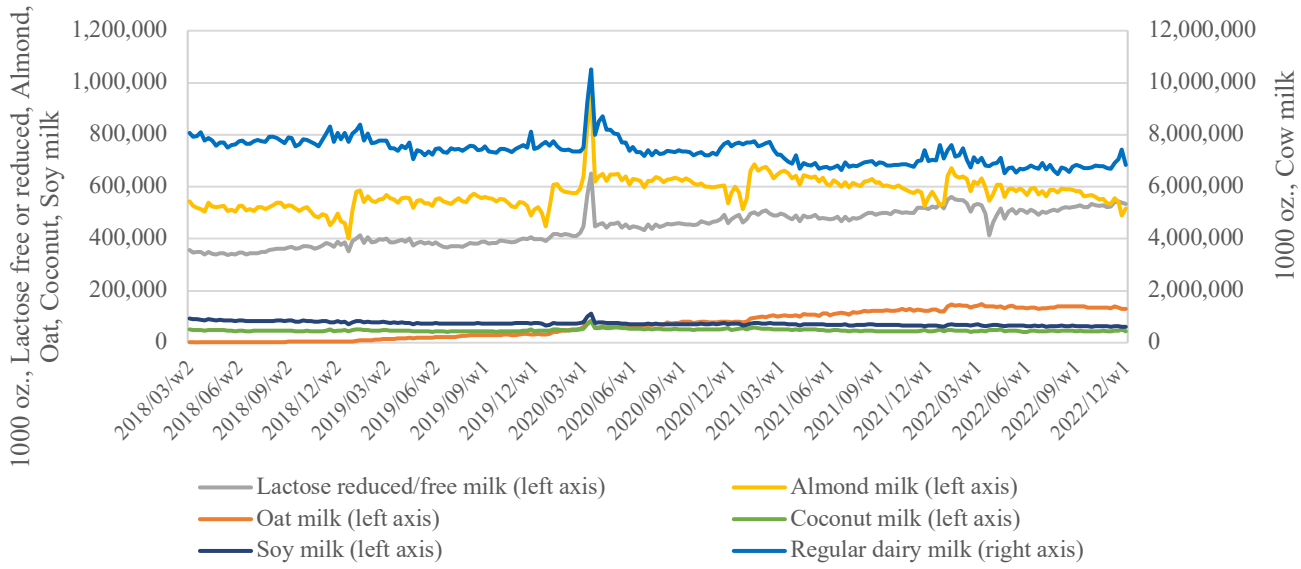


Figure 3. Weekly consumption quantity (1000 oz.) of dairy and plant-based products

Dairy milk consumption decreased slightly over the past five years, but plant-based milk consumption has steadily increased. Figure 4 shows the trend in quantity of four plant-based milk products purchased during 2018-2022. Increases in consumption of almond and oat milk drover the overall increase in plant-based milk consumption. Among plant-based milk products, oat milk has increased at a compound annual growth rate of 167.4%, primarily as a result of the proliferation of new oat milk products in this category over five years.

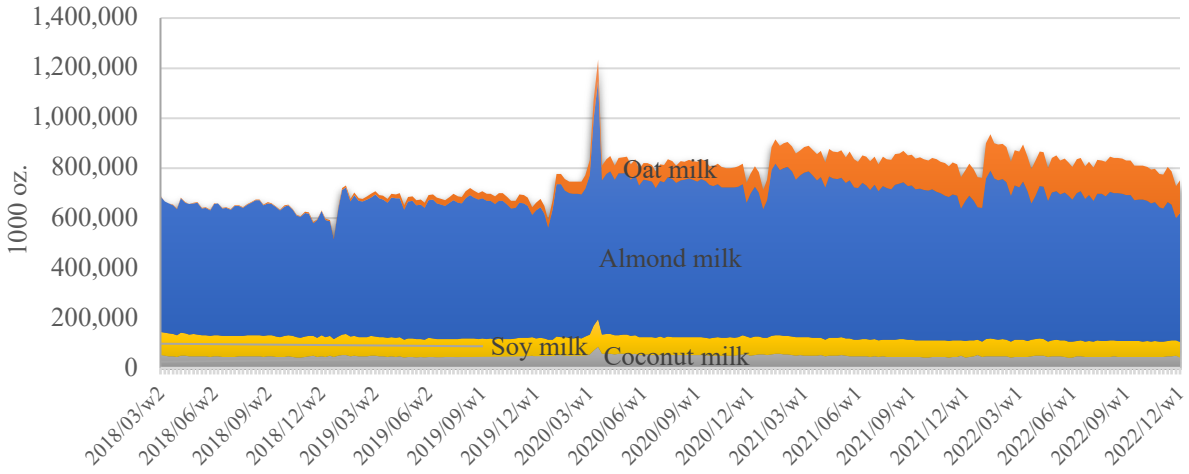


Figure 4. Weekly consumption quantity (1000 oz.) of plant-based milk products

Soy Milk consumption trends

Soy milk expenditures by product characteristics are shown in Table 2. The expenditure on overall soy milk consistently fell from 2018 to2022. Average weekly expenditure on soy milk was $3,817 million/weed over this five-year period, and expenditure decreased by 15.1% in 2022 compared to 2018. The decline in soy milk consumption accelerated after 2020. There are two main drivers: rising prices and new competition from oat milk. Figure 5 shows soy milk prices over the past five years. Consumers spend more on non-organic than organic, more on large-sized packages than small-sized packages and spend more on sweetened vs. unsweetened soy milk. As for the flavor, consumers spend more on plain vs. vanilla flavors (Figure 6).

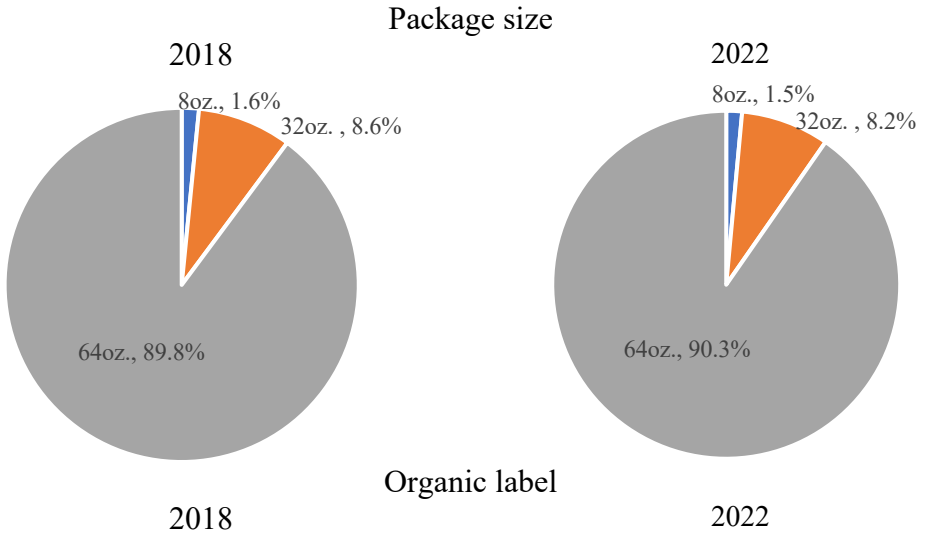
Table 2. Soymilk expenditure by product characteristic

Variable	Mean	SD	Min	Max	% Change (18-22)	
					Expenditure	Share
Soy milk	3,817 (100.0)	324	3,321	5,963	-15.1%	-
Package size						
16oz.	59 (1.5)	17	36	106	-41.21%	-30.3%
32oz.	330 (8.6)	91	228	889	-21.5%	-6.5%
64oz.	3,428 (89.8)	271	2,903	4,984	-14.9%	1.4%
Organic label						
Organic	1,594 (41.8)	117	1,338	2,667	-3.9%	14.7%
Non-organic	2,223(58.2)	247	1,882	3,296	-23.9%	-9.2%
Sweetness						
Sweet	2,776 (72.7)	379	2,194	4,396	-29.8%	-16.4%
Unsweet	1,041 (27.3)	154	702	1,567	33.3%	58.7%
Flavor						
Regular	1,079 (28.3)	98	845	1,621	12.8%	33.7%
Vanilla	1,042 (27.3)	253	715	1,747	-46.7%	-36.5%
Chocolate	182 (4.8)	72	64	357	-68.2%	-61.2%
Remaining	1,5151 (39.7)	130	1,301	2,388	4.0%	23.8%

Note: The parentheses indicate the share of product expenditure for each characteristic in all soymilk expenditures. Author's calculation is based on the 2018-2022 weekly point-of-sale data from Nielsen

According to the change in the weekly expenditure share by characteristic from 2018-2022s, along with the rise in soy milk prices, there has been a reduction in the expenditure share of small-sized package soy milk, which is more expensive per ounce than large-sized packages. On the other hand, the share of large-sized packages increased by 1.4% over five-years (Figure 6). The share of organic soy milk relative to non-organic increased 14.7% during the same period. More than 70% of consumer spending is directed toward sweetened soy milk, but the share of unsweetened soy milk increased 58.72% from 2018 to 2022. This is also evident in the flavor preference, where the share of vanilla and chocolate expenditure is decreasing, while the share of plain soy milk expenditure is increasing. This change in consumption patterns implies a growing interest in consumers in healthy eating habits.

Figure 5. Soymilk weekly consumption quantity (1000 oz.) and average price ($/oz.)



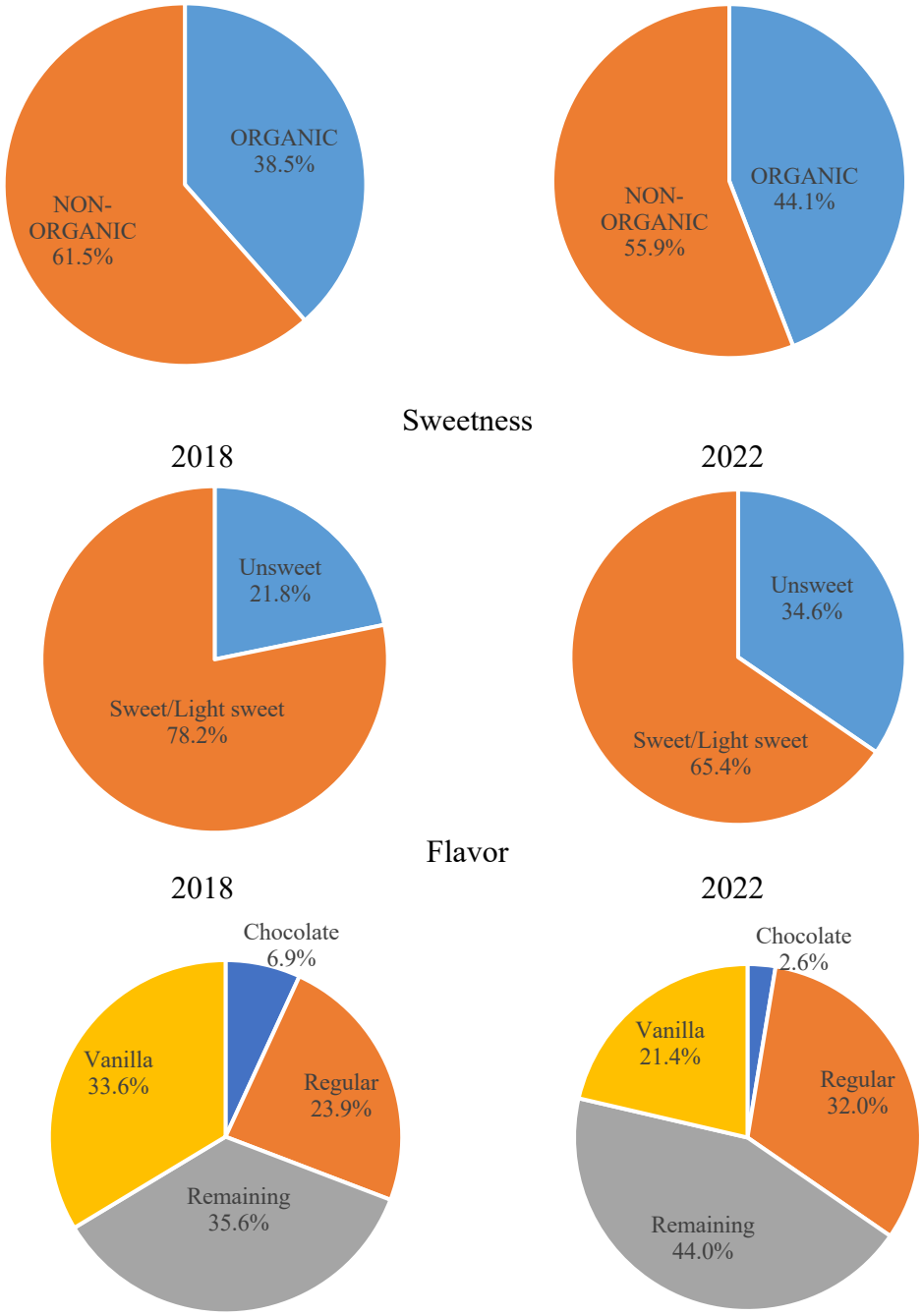


Figure 6. Soymilk expenditure share by characteristic (2018-2022)

Estimation of Milk Demand

Plant-based milk alternatives are becoming increasingly popular with consumers. Concerns about animal welfare, environmental sustainability and personal health are referred to

as the major reasons for consumers' choice of plant-based milk instead of dairy milk. On the other hand, as dairy milk consumption has steadily declined, the milk industry stakeholders, including milk producers, are raising interest in whether the consumption of plant-based milk is playing a role as a substitute for milk consumption. Given the change in consumers' expenditure of milk products that have occurred recently, we identify the relationship between dairy and plant-based milk products. An Almost Ideal Demand System (AIDS) is used for estimating elasticities that characterize U.S. retail demand in 2022 for milk varieties; regular dairy milk, lactose-free or reduced milk, almond milk, oat milk, coconut milk and soy milk. Data used in this analysis is national weekly scanner data for the calendar year 2022 available from Nielsen.

Table 3 presents elasticity estimates from our AIDS model. Given our interest in the soy milk market among dairy milk alternatives, we focus on these categories with a particular focus on cross-price elasticity estimates. Soy milk and oat milk demand are estimated here to be inelastic with a 1% increase in price corresponding with a 0.26 and 0.56 reduction in quantity demanded, respectively. Own-price elasticity of regular dairy milk and coconut milk demand estimate are -0.95 and -1.13 close to one. Own-price elasticity of almond milk and lactose-free or reduced milk demand estimates are -1.99 and 1.39, more elastic than other milk products. The impact of 1% changes in regular dairy milk prices on soy milk is a 0.53 reduction in demand, suggesting that regular dairy milk and soy milk are not substitute relationship. The cross-price elasticity of demand for soy milk to the price change of lactose-free or reduced milk and almond milk are 0.41 and 0.32 indicating soy milk is a substitute for them.

Table 3. Marshallian price elasticity and expenditure elasticity of milk product

	Price of:						Expenditure elasticity
Quantity of:	Regular dairy	Lactose-free/reduced	Almond	Oat	Coconut	Soy	

Regular dairy	**-0.946**	-0.073	0.046	-0.027	-0.021	-0.010	1.032
Lactose-free/reduced	-0.056	**-1.387**	0.581	0.175	0.031	0.039	1.120
Almond	0.446	0.693	**-1.988**	-0.097	-0.002	0.037	0.906
Oat	-0.108	0.677	-0.216	**-0.567**	0.050	-0.173	0.337
Coconut	-0.747	0.268	0.006	0.093	**-1.129**	-0.186	0.696
Soy	-0.525	0.413	0.320	-0.517	-0.260	**-0.257**	0.825

References

1. Angus Deaton and John Muellbauer. 1980. “An Almost Ideal Demand System” The American Economic Review. 70(3), 312-326

Appendix: AIDS Model for Estimation of Demand Elasticities

The Almost Ideal Demand System (AIDS), introduced by Deaton and Muellbauer (1980a) would be exploited in this study. In this demand system, by imposing adding-up, symmetry and homogeneity restrictions, the budge share of different categories of product are linearly related to the logarithms of the total expenditure on them and relative prices. The budget share equation in AIDS model is given as:

(1) $w_i = \alpha_i + \sum_j \gamma_{ij} \log p_j + \beta_i \log\left\{\frac{M}{P}\right\}$,

where ***M*** is the total expenditure in each retail product, and ***P*** is the stone price index as a linear proxy, provided by

(2) $\log P = \sum_j w_j \, log p_j$.

Imposing restrictions on the parameters, equation (1) represent the system of demand equations: The first adding-up restriction implies that all budget shares are sum to one, changes in cost share responding to one price change add up to zero, and changes in the total expenditure won't affect cost shares.

(3) $\sum_i \alpha_i = 1, \sum_i \gamma_{ij} = 0, \sum_i \beta_i = 0.$

Second restriction imposed is homogeneity, indicating that the proportional change in prices would not change the cost shares.

(4) $\sum_{ij} \gamma_{ij} = 0.$

The third restriction is Slutsky symmetry.

(5) $\sum_{ij} \gamma_{ij} = \gamma_{ji}.$

With restrictions (3) – (5) hold, equation (1) satisfies homogeneity of degree zero in prices and total expenditure, and Slutsky symmetry. In the linearized AIDS model, the price elasticity could be calculated as

(6) $\varepsilon_{ij} = \frac{\gamma_{ij} - \beta_i w_j}{w_i} - \delta_{ij}, \begin{cases} \delta_{ij} = 1, & if\ i = j \\ \delta_{ij} = 0, & if\ i \neq j \end{cases}$.

And the income elasticity could be computed as

(7) $\varepsilon_{ij} = \frac{\beta_i}{w_i} + 1.$