The Effect of Growing Inequality on Consumer Demand for Necessities: An Empirical Study in Taiwan

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This paper primarily focuses on the effects of growing income inequality on the demand for living necessities. In order to analyze the effects, we will construct a demand curve by using the bivariate probability distribution method. By using the properties of the newly constructed demand curve, we can find that the growing income inequality will decrease the quantity demanded of living necessities. And we suggest some strategies to improve the unfavorable situation.

1. Introduction

In the 1990s, the income inequality tends to widen in some countries. We can see this trend from the following researches. Levy and Murnane(1992) have studied U.S. earnings levels and earnings inequality, and then proposed their explanations for the recent trends; Karoly and Burtless(1995) have also studied the demographic change of rising inequality in earnings, 1959-1989; Atkinson, Rainwater and Smeeding(1995) have made a comparison with inequality in OECD countries.

In this paper we will try to present the effects of growing income inequality on the demand for living necessities. In order to analyze the effects, we will develop a new method to construct a demand curve. With the properties of the demand curve, the effects can easily be observed.

Alfred Marshall(1890) has used equal marginal utility principle analysis method to form an individual demand curve. Some economists have used another approach, "indifference curve" analysis, to form the individual demand curve. However, the methods mentioned above are too abstract, and in practice it is difficult to estimate a market demand curve for a good by using these methods. Instead of using the two methods, many scholars use historical statistical data and apply econometric methods to form a specific good demand curve in empirical research. For example, Kayser(2000) use statistical data to estimate the gasoline demand; Gerdtham, Johannesson, Lundberg and Isacson (1999) estimate the demand for health. Slade(1991); Pei and Tilton(1999) estimate metal demand.

However, these above empirical studies must use observed historical data to meet the demand for a specific good. But under some circumstances, neither historical data nor proper data for a new product or a new style product might be observed, and it will be difficult to estimate the demand curve for a new product which has no historical data. Therefore, according to the definition of the quantity demanded of a good, which is the amount of the good that consumers are willing and able to purchase at certain price during the specific period, we try to apply bivariate probability distribution method to construct a market demand curve. And using the properties of the newly constructed demand curve, we can find the effects of growing income inequality on the demand for the living necessities.

2. Demand Curve Construction: Using Bivariate Probability Distribution Approach

There is a maximum subject value in a consumer's mind for any specific good. For example, in a consumer's mind, a Benz car may be worth \$500,000. Therefore, if the price of the Benz car is \$500,000 or below, he/she may be willing to purchase the Benz car, and we call the price of \$500,000 is the willing price of the consumer. But whether the consumer really buys the car depends not only on the willing price but also on his affordability.

To illustrate the approach by the above statement, we will assume that there are some consumers in a certain area. We can ask each of the consumers to list his/her affordable highest price, x, and willing price, y, for a specific good by using market survey method. Then we can get all those price combinations of the consumers in the area.

For example, suppose there is a consumer in the area, and he/she has the ability to buy the good at the price of \$100, but he/she is willing to pay \$75 for the good. Therefore, he/she will buy the good only if the price is \$75 or below. On the contrary, there is another consumer in the area, and he/she only has the ability to buy the good at the price of \$60, even though he/she thinks the good is worth \$70. He/She can't buy the good due to budget constraint. If the price drops to \$60 or below, he/she may have the ability to buy it. Therefore the highest trade price for an individual who actually pays will be the lower one chosen from the affordable price, x, and the willing price, y.

Based on the above mentioned, we can construct the demand curve by using probability distribution function. For example, the number of potential consumers for a good in an area is expressed as N in a certain period of time; x_i represents the price individual consumer i is able to buy; y_i represents the highest price he/she is willing to pay; $f(x,y)$ is the bivariate probability density function, and symbol $\odot$ represents the expression of $x_i \odot y_i = \min\{x_i, y_i\}$ When the price of the good is set at p, the required condition to meet individual i's demand can be expressed as $x_i \odot y_i \geq p$. Therefore quantity demanded, Q, and the price, p, have the following relation:

$$Q = N \cdot P_r\{(x,y) \mid x \odot y \geq p$$

$$= N[\sum_{\substack{y \\ y \geq p}} \sum_{\substack{x \\ x \geq y}} f(x,y) + \sum_{\substack{x \\ x \geq p}} \sum_{\substack{y \\ y \geq x}} f(x,y)]$$

where $P_r\{\ \}$ represents the value of probability function. (1)

Now, If $f(x,y)$ is a bivariate continuous probability function, equation (1) can be written as

$$Q = N[\int_p^{\infty}\int_y^{\infty} f(x,y)dxdy + \int_p^{\infty}\int_x^{\infty} f(x,y)dydx] \qquad (2)$$

By equation (2), it is it is easy to derive that

$$\frac{\delta}{\delta p}\int_p^{\infty}\int_y^{\infty} f(x,y)dxdy < 0 \text{ and } \frac{\delta}{\delta p}\int_p^{\infty}\int_x^{\infty} f(x,y)dydx < 0\ ,$$

Consequently, we can get $\frac{\delta Q}{\delta p} < 0$.

Based on the analysis, equation (2), the demand function still meets the law of demand: Other things being equal, when the price of a good rises, the quantity demanded of the good falls.

Furthermore, equation (2) can be simplified either as equation (3) or equation (4).

$$Q = N[\int_p^{\infty}\int_p^{\infty} f(x,y)dxdy] \qquad (3)$$

$$Q = N[1 - F_x(p) - F_y(p) + \int_{-\infty}^{p}\int_{-\infty}^{p} f(x,y)dxdy] \qquad (4)$$

where $F_x(p) = \int_{-\infty}^{p}\int_{-\infty}^{\infty} f(x,y)dydx$, $F_y(p) = \int_{-\infty}^{p}\int_{-\infty}^{\infty} f(x,y)dxdy$.

Let us define $\varepsilon_f(x,y) = f(x,y) - g(x)h(y)$, equation (4) will become

$$Q = N\left[1 - F_x(p) - F_y(p) + \int_{-\infty}^{p} g(x)dx\int_{-\infty}^{p} h(y)dy + \int_{-\infty}^{p}\int_{-\infty}^{p} \varepsilon_f(x,y)dxdy\right]$$

$$= N\left[\bar{F}_x(p)\right]\left[\bar{F}_y(p)\right] + N\cdot\int_{-\infty}^{p}\int_{-\infty}^{p} \varepsilon_f(x,y)dxdy] \qquad (5)$$

where $\bar{F}_x(p) = 1 - F_x(p)$, $\bar{F}_y(p) = 1 - F_y(p)$.

Under specific circumstances, variable x and y are random independent variables, $f(x,y)$ will become $g(x)h(y)$. Then equation (5) can be written as

$$Q = N\left[\bar{F}_x(p)\right]\left[\bar{F}_y(p)\right] \qquad (6)$$

From equation (5), we can find that an individual demand is influenced not only by his/her affordability and willingness but also by the correlation, $\varepsilon_f(x,y)$, between the variable x and y. Now, if the distribution can be normalized, then we can use bivariate normal distribution approach to construct the demand function. Furthermore, we can understand how an individual demand is influenced by his/her affordability, willingness and the correlation between affordability and willingness. The results are presented in Section 3.

3. Effects of Changes in Affordability or in Willingness or in the Correlation between them.

In this section, we will use the bivariate normal distribution model to study how the market demand for a good is affected by changes in consumers' affordability or in willingness or in the correlation between them.

As we pointed out in Section 2, if consumers' affordable price, x, and willing price, y, can be normalized to meet the requirement of bivariate normal distribution, we can get the following equation:

$$f(x,y) = \frac{1}{2\pi\sigma_x\sigma_y\sqrt{(1-\rho^2)}} e^{\frac{-1}{2(1-\rho^2)}\left[\left(\frac{x-\mu_x}{\sigma_x}\right)^2 - 2\rho\left(\frac{x-\mu_x}{\sigma_x}\right)\left(\frac{y-\mu_y}{\sigma_y}\right) + \left(\frac{y-\mu_y}{\sigma_y}\right)^2\right]} \quad (7)$$

where μ_x: mean value of x,

μ_y: mean value of y,

σ_x: standard deviation of x,

σ_y: standard deviation of y,

ρ : correlation coefficient of variable x and y.

Then the demand function can be expressed as

$$Q = N\int_p^\infty\int_p^\infty \frac{1}{2\pi\sigma_x\sigma_y\sqrt{(1-\rho^2)}} e^{\frac{-1}{2(1-\rho^2)}\left[\left(\frac{x-\mu_x}{\sigma_x}\right)^2 - 2\rho\left(\frac{x-\mu_x}{\sigma_x}\right)\left(\frac{y-\mu_y}{\sigma_y}\right) + \left(\frac{y-\mu_y}{\sigma_y}\right)^2\right]} dxdy \quad (8)$$

Now, if let us define $u = \frac{x-\mu_x}{\sigma_x}$, $v = \frac{y-\mu_y}{\sigma_y}$, then

Q can be written as follows.

$$Q = N\int_{\frac{p-\mu_y}{\sigma_y}}^\infty \int_{\frac{p-\mu_x}{\sigma_x}}^\infty \frac{1}{2\pi\sqrt{(1-\rho^2)}} e^{\frac{-1}{2(1-\rho^2)}\left(u^2 - 2\rho uv + v^2\right)} dudv \quad (9)$$

Furthermore, suppose $w = \frac{u - \rho v}{\sqrt{(1-\rho^2)}}$, equation (9) can be expressed as

$$Q = N\int_{\frac{p-\mu_x}{\sigma_x}}^{\infty}\int_{\left(\frac{p-\mu_y}{\sigma_y}-\rho v\right)/\sqrt{(1-\rho^2)}}^{\infty} \frac{1}{2\pi} e^{\frac{-1}{2}\left(w^2+v^2\right)} dwdv. \tag{10}$$

By equation (10), it is easy to derive that $\frac{\delta Q}{\delta \mu_x} > 0$, and $\frac{\delta Q}{\delta \mu_y} > 0$.

Consequently, we can get the following property 1 and property 2.

Property 1. In general, as the consumers' average income increases, the average price they are able to afford, μ_x, will increase at the same time. Then quantity demanded will also increase.

Property 2. As consumers are increasing their willing price, the average price, μ_y, will increase at the same time. Then quantity demanded will also increase.

Now, taking the partial derivative of Q with respect to ρ, we can obtain $\frac{\delta Q}{\delta \rho} > 0$

(the proof is provided as follows), and get the following property 3 and property 4.

Proof

By using equation (8), if we let

$$Z = \int_{-\infty}^{p}\int_{-\infty}^{p} \frac{1}{2\pi\sigma_x\sigma_y\sqrt{(1-\rho^2)}} e^{\frac{-1}{2(1-\rho^2)}\left[\left(\frac{x-\mu_x}{\sigma_x}\right)^2-2\rho\left(\frac{x-\mu_x}{\sigma_x}\right)\left(\frac{y-\mu_y}{\sigma_y}\right)+\left(\frac{y-\mu_y}{\sigma_y}\right)^2\right]} dxdy,$$

we can get the following equation.

$$\frac{\delta Q}{\delta \rho} = N\frac{\delta Z}{\delta \rho}. \tag{11}$$

Now, let $u = \frac{x-\mu_x}{\sigma_x}$, $v = \frac{y-\mu_y}{\sigma_y}$, Z can be written as follows.

$$Z = \int_{-\infty}^{\frac{p-\mu_y}{\sigma_y}}\int_{-\infty}^{\frac{p-\mu_x}{\sigma_x}} \frac{1}{2\pi\sqrt{(1-\rho^2)}} e^{\frac{-1}{2(1-\rho^2)}\left(u^2-2\rho uv+v^2\right)} dudv$$

$$= \int_{-\infty}^{\frac{p-\mu_y}{\sigma_y}}\int_{-\infty}^{\left(\frac{p-\mu_x}{\sigma_x}-\rho v\right)/\sqrt{(1-\rho^2)}} \frac{1}{2\pi} e^{\frac{-1}{2}\left(w^2+v^2\right)} dwdv$$

where $w = \dfrac{u - \rho v}{\sqrt{(1-\rho^2)}}$.

Taking the partial derivative of Z with respect to ρ, we obtain

$$\frac{\delta Z}{\delta \rho} = \int_{-\infty}^{\frac{p-\mu_y}{\sigma_y}} \frac{-1}{\sqrt{2\,\pi}}\, e^{\frac{-v^2}{2} - \frac{(-p+\mu_x+v\rho\sigma_x)^2}{(2-2\rho^2)\sigma_x^2}} \left[\frac{v}{\sqrt{(2-2\rho^2)}} + \frac{2\rho(-p+\mu_x+v\rho\sigma_x)}{\sqrt{\left((2-2\rho^2)^3\right)}\,\sigma_x}\right] dv$$

$$= \frac{1}{2\pi\sqrt{(1-\rho^2)}}\, e^{\frac{-v^2}{2} - \frac{(-p+\mu_x+v\rho\sigma_x)^2}{(2-2\rho^2)\sigma_x^2}} \Bigg|_{-\infty}^{\frac{p-\mu_y}{\sigma_y}}$$

$$= \frac{1}{2\pi\sqrt{(1-\rho^2)}}\, e^{\frac{-1}{2(1-\rho^2)}\left[\left(\frac{p-\mu_x}{\sigma_x}\right)^2 - 2\rho\left(\frac{p-\mu_x}{\sigma_x}\right)\left(\frac{p-\mu_y}{\sigma_y}\right) + \left(\frac{p-\mu_y}{\sigma_y}\right)^2\right]} > 0\,, \qquad (12)$$

Together with equation (11) and (12), it leads

$$\frac{\delta Q}{\delta \rho} > 0\,.$$

Property 3. Other things being equal, if the consumers' income and their willingness are positively correlated, $\rho \in (0,1]$, then quantity demanded will increase as || increases. The stronger the correlation $|\rho|$ is, the larger the quantity demanded is.

Property 4. Other things being equal, if the consumers' income and their willingness are negatively correlated, $\rho \in [-1,0)$, then quantity demanded will decrease as $|\rho|$ increases (i.e. ρ decreases). The stronger the correlation $|\rho|$ is, the smaller the quantity demanded is.

According to property 2, once the quality of the good is improved, the willing price will increase. Then the quantity demanded will increase. On the other hand, if the price of the substitute good declines, the price they are willing to pay for the original good will decline at the same time. Then the quantity demanded will decrease.

Now, we know that the quantity demanded of goods will change as consumers' average income change. However, will the quantity demanded of goods still be unchanged if the consumers' average income does not change but the income inequality is growing? The problem will be discussed in next section, and we will propose our viewpoints by the newly constructed demand curve in this section.

4. Effects of the Growing Income Inequality on the Demand for Living Necessities.

When the income inequality is growing, the variance of the consumers' income is increasing, that is, the variance of the consumers' affordable price is increasing. By equation (10), we will get the following property.

Property 5. Other things being equal, if the price of a good, p, is higher than the consumers' average affordable price, μ_x then quantity demanded, Q, will increase as the income inequality is growing. On the contrary, if the price of a good, p, is lower than the consumers' average affordable price, μ_x then quantity demanded, Q, will decrease as the income inequality is growing.

Proof

By equation (10), taking the partial derivative of with respect to , we can get the follows.

$$\frac{\delta Q}{\delta \sigma_x} = N \int_{\frac{p-\mu_x}{\sigma_x}}^{\infty} \left[\frac{\delta}{\delta \sigma_x} \int_{\frac{\frac{p-\mu_x}{\sigma_x} - \rho v}{\sqrt{(1-\rho^2)}}}^{\infty} \frac{1}{2\pi} e^{\frac{-1}{2}\left(w^2+v^2\right)} \, dw \right] dv$$

$$= N \int_{\frac{p-\mu_x}{\sigma_x}}^{\infty} \left[\frac{1}{2\pi} e^{\frac{-1}{2}\left(\left(\frac{\frac{p-\mu_x}{\sigma_x} - \rho v}{\sqrt{(1-\rho^2)}}\right) + u^2\right)} \left(\frac{p-\mu_x}{\sqrt{(1-\rho^2)}\,\sigma_x^2}\right) \right] dv \qquad (13)$$

Therefore, by equation (13), we get

$$\begin{cases} 1.\ \dfrac{\delta Q}{\delta \sigma_x} > 0, \text{ if } p-\mu_x > 0; \\ 2.\ \dfrac{\delta Q}{\delta \sigma_x} = 0, \text{ if } p-\mu_x = 0; \\ 3.\ \dfrac{\delta Q}{\delta \sigma_x} < 0, \text{ if } p-\mu_x < 0. \end{cases}$$

In general, the prices of most living necessities are lower than the consumers' average affordable price. By property 5, we can get the result that the quantity demanded of living necessities will decrease as the income inequality is growing.

5. The Strategies of Increasing the Consumption of Living Necessities.

Based on the discussion in section 4, we have known the demand for the lower priced necessities will decline as the income inequality is growing. Therefore the firm that produces the living necessities should make some strategies to improve this unfavorable situation. As the properties in section 3 indicate, we can provide the following strategies to increase the consumption of living necessities.

Strategies 1. According to property 2, the firm might put forward some appropriate policies to raise the consumers' willing price.

Strategies 2. According to property 3, since the consumers' income and their willingness are weakly positively correlated for the living necessities, the firm might provide some policies to increase the consumers' correlation coefficient between consumers' income and willingness.

In order to get the strategies above, the firm might improve the qualities, design, packaging and/or to extend other potential functions of the living necessities. For example, the firm may involve tourism function and organic healthy function in farming products. Therefore, people will be more willing to consume more farming products, and the correlation coefficient between consumers' income and willingness will increase. And then, according to property 3 and property 4, quantity demanded will increase as ρ increases. Moreover, The change of function can also add some values to farming products. Thus, the prices of the farming products will arise, and the firm's revenue will increase at the same time.

6. Conclusions

This study is using bivariate normal distribution model to construct a demand function, which still meets the law of demand. Based on the study, we find that quantity demanded of goods will change when the consumers' affordable price, willing price, and the correlation between affordable price and willing price change. Furthermore, we also find that the phenomenon of the growing income inequality will decrease the quantity demanded of living necessities.

The effects of growing income inequality will cause the income gap between living necessity industry and other industries to widen. The firm who produces the living necessities should avoid the situation by establishing proper policies, such as improving the qualities, design, packaging and/or to extend other potential functions of the living necessities. Then, the consumers might strengthen their purchasing willingness, and the firm might increase his revenue.

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