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Analysis of the Use and Application of Mathematics in Economics: Demand and Supply Functions

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ABSTRACT

The aim of this study is to analyze how mathematics is used in economics in terms of the function of supply and demand, which is an important concept in the economy that explains the relationship between the price of goods or services and the quantity requested or offered. Using a mathematical approach, these concepts can be described more quantitatively and accurately, allowing for a more in-depth analysis of the functions of demand and supply. To determine the components that influence changes in supply and demand, mathematical models such as linear regression and elasticity analysis are used. In addition, the study examines how price changes affect market balance and how the functioning of supply and demand can be influenced by things that come from outside, such as government policies and the global economic situation. Research results show that analysis of the function of supply and demand using mathematical models gives us a better understanding of market dynamics. For example, analysis of demand elasticity shows how sensitive consumers are to price changes, and analysis of supply shows how prepared producers are for price changes. Policymakers and market players can make more strategic and informational choices by knowing these mathematical relationships. The study found that mathematics improved the predictability and accuracy of economic analysis and provided essential tools for good decision-making in various economic contexts.

Keyword: Mathematical Concept, Supply function, Demand function

1. INTRODUCTION

Research developments related to the use and application of mathematics in economics, especially in the context of the function of supply and demand, have shown significant trends in recent decades. Along with technological advances and increased access to more detailed economic data, researchers have been able to develop increasingly complex and accurate mathematical models to analyse market dynamics. Initially, research in this field focused on using basic models such as linear regression to understand the relationship between price and quantity of demand or supply[1], [2]. However, over time, more sophisticated methods of analysis such as econometric models, time row analysis, and linear programming began to be applied to deal with more complex data and capture more realistic market dynamics. This development is not only limited to theory, but also covers practical applications that affect economic policies and business decisions[3], [4]. For example, research on supply and demand elasticity has become an important foundation in determining government pricing and subsidy policies, as well as company pricing strategies. Moreover, with the emergence of big data and artificial intelligence, supply and demand analysis can now be done with higher precision, allowing for more accurate predictions of future market behaviour. Anderson, S.P. and de Palma (2020) combines mathematical and economic analysis to explain market dynamics on the function of product demand and supply[5]. Recent research also highlights the importance of external factors such as macroeconomic conditions, international trade policies, and climate change that can affect demand and supply. For example, a

case study on the impact of trade tariffs on the supply and demand of certain goods provides insight into how policy intervention can alter the balance of the market. In the context of economic globalization, research also increasingly focuses on the interaction between domestic and international markets, as well as how changes in one market can affect the other. Moreover, an interdisciplinary approach that integrates mathematics with other fields such as psychology, sociology, and computer science has opened up new perspectives in understanding consumer and producer behaviour Li, S., & Li, Y. (2023)[6] this article discusses the use of machine learning algorithms to predict demand in the supply chain, showing how the latest technology can improve the accuracy of demand prediction.

Research in this field is also increasingly driven by the development of software and analytical tools that enable more effective modelling and simulation[7]. For example, the use of machine learning algorithms to predict supply and demand patterns has become a highly active area of research, with potential applications in a variety of sectors ranging from energy to banking[8]–[10]. In addition, research on uncertainty and risk in supply and demand models, which takes into account factors such as price volatility and economic shocks, has made important contributions to the development of risk management strategies[11]. Overall, research developments in this field reflect the increasing complexity of the global economic environment and the need for more sophisticated and adaptive analytical tools. It also shows that mathematics is not only a tool in economic analysis but also a universal language that enables more effective communication between different disciplines and practitioners[12], [13]. With the continuous development of technology and research methodologies, it is expected that the mathematical analysis of the function of supply and demand will continue to progress, providing deeper insights and more innovative solutions to future economic challenges[14].

2. METHODS

This study employed an exploratory data analysis model. This research is conducted to find out the connections of mathematical concepts with the concepts of supply and demand. This research connects the function of demand and supply with the concept of equations of two variables and linear functions. Approach to building demand and supply functions with linear equations of two variables using steps:

1) employing table-based data on supply, demand, and price levels;
2) knowing variables;
3) displaying data graphically;
4) creating the linear equation of two variables using various techniques.

The method for creating supply and demand functions using linear functions in the following steps:

1) Using table-formatted data for the demand, offer, and price rates;
2) Figuring out how to assemble and calculate the cartesius times;
3) Visualizing data in a graph format; and
4) figuring out a linear function using function values of known data.

The investigation was also carried out to look for mathematical notions that might arise from the books' discussion of supply and demand.

2.1 Mathematical Relationship with Demand

The demand function shows the relationship between other variables that affect consumers over a certain period of time and the quantity of products they demand. If you look at it in the real economy, these variables are very many. However, economists generally argue that the quantity of products consumers will ask for or buy in a given period of time is influenced by five major variables: (1) product price, (2) consumer income, (3) price of other comparable goods, (4) expected price for the future, (5) consumer appetite, and (6) advertising costs. So, mathematically, the request function above can be written as[15]:

$$\boldsymbol{Q_{dx,t} = f\left(P_{x,t}, P_{y,t}, Y_t, P^e_{x,t}, S_t A_t\right)}$$

Information:

$\boldsymbol{Q_{dx,t}}$ = The amount of product X purchased/requested by the consumer in the period t

$\boldsymbol{P_{x,t}}$ = The price of the product X in the period t

$\boldsymbol{P_{y,t}}$ = The price of the Y product in the period t

$\boldsymbol{Y_t}$ = Consumer income in period t

$\boldsymbol{P^e_{x,t}}$ = Product price X expected in the forthcoming period, t+1

S_t = Consumer appetite at the t-period
A_t = Advertising purchases on period t

According to economic theory, there is a functional relationship between the consumer's variable quantity request and the other five free variables (other factors that are taken into consideration as constants) as follows:
$Q_{dx,t}$ have a negative relationship with $P_{x,t}$
$Q_{dx,t}$ have a negative relationship with $P_{y,t}$
$Q_{dx,t}$ have a negative relationship with Y_t
$Q_{dx,t}$ have a negative relationship with $P^e_{x,t}$
$Q_{dx,t}$ have a negative relationship with S_t
$Q_{dx,t}$ have a negative relationship with A_t

Of the six free variables mentioned above, the product price variable is considered the most important, while the other five are considered constant. Therefore, the request function can be rewritten to:

$$Q_x = f(P_x)$$

When converted into a linear equation form, the form typically looks like this:

$$Q_x = a + bP_x$$

Information:

Q_x = Number of items requested
P_x = Product price x
$a + b$ = Parameters

Two key aspects of the function of demand, an economic principle, can be inferred from this equation:

1. Because of the law of demand, which states that "if the price of a product rises or falls, then the quantity of product requested by the consumer will decrease or increase, assuming other variables are constant," parameter b is negative.
2. Level 1 free variable P_x, which means that when this request is explained, its function will be represented as a straight line with a negative (slope) that falls from top left to bottom right.

2.2 Mathematical Relationship with Supply

The relationship between the number of goods a manufacturer offers for sale and the other factors influencing it within a specific time frame is depicted by the supply function. The primary criteria are: (1) the product's price; (2) the degree of technology available; (3) the cost of the inputs (factors of production); (4) the cost of other production-related items; and (5) the producers' expectations for future prices. From a mathematical perspective, the functional relationship that exists between the manufacturer's product amount and the five independent factors that affect it is as follows:

$$Q_{sx,t} = f\left(P_{x,t}, T_t, P_{F,t}, P_{R,t}, P^e_{x,t+1}\right)$$

Information:
$Q_{sx,t}$ = The quantity of X products offered by the manufacturer in the period t
$P_{x,t}$ = The price of the product X in the period t
T_t = Technology available in the period t
$P_{F,t}$ = Price of the factors of production in the period t
$P_{R,t}$ = Price of other related products in the period t
$P^e_{x,t+1}$ = Producer expectations for product prices in the t+1 period

In economic theory, the functional relationship—which is regarded as constant—between the producer's variable quantity of product offered and the other five free variables is as follows:

$\boldsymbol{Q_{sx,t}}$ have a positve relationship with $\boldsymbol{P_{x,t}}$
$\boldsymbol{Q_{sx,t}}$ have a positve relationship with $\boldsymbol{T_t}$
$\boldsymbol{Q_{sx,t}}$ have a positve relationship with $\boldsymbol{P_{F,t}}$
$\boldsymbol{Q_{sx,t}}$ have a positve relationship with $\boldsymbol{P_{R,t}}$
$\boldsymbol{Q_{sx,t}}$ have a positve relationship with $\boldsymbol{P^e_{x,t+1}}$

The offer function can be further reduced by assuming that the product price variable has the most influence and that the other four variables are constant. In this case, the offer function becomes:

$\boldsymbol{Q_{sx}} = g(\boldsymbol{P_x})$
Information:
$\boldsymbol{Q_{sx}}$ = quantity of X products offered by the Manufacturer
$\boldsymbol{P_x}$ = Product price X

The linear equation that results from the transformation of the Offer function is:

$\boldsymbol{Q_{sx} = a + bP_x}$

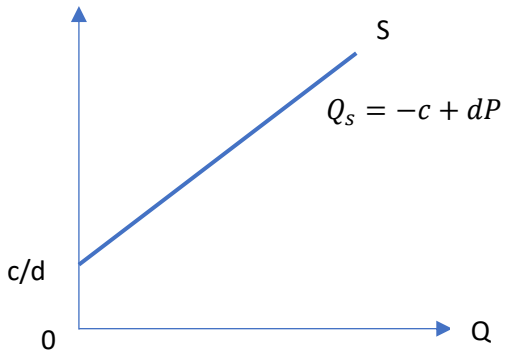
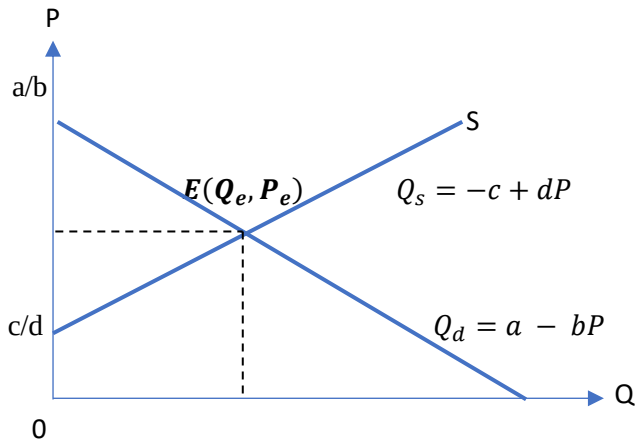


Figure1. Supply Function Curve is linear

- A linear supply curve is usually a straight line with a positive slope if $\boldsymbol{b > 0}$
- If a is positive, the supply curve will intersect the $\boldsymbol{Q_{sx}}$ axis at point a
- The larger the value of b, the sharper the inclination of the bidding curve.

2.3 Market Equilibrium

The price $\boldsymbol{Q_{sx} = a + bP_x}$ and $\boldsymbol{Q_s = -c + dP}$ quantity balance in the market will be produced by this market equilibrium. The amount of product that the consumer requests and the quantity that the manufacturer offers must match in order for the market to be in balance.



$Q_d = Q_s$ The cost of the product given and the product requested are the same. ($Q_d = P_s$). By concurrently solving a system of linear equations between the supply and demand functions, the algebraic equilibrium of the market can be reached. (simultan). graphically represented by the point where the supply and demand curves cross.

Because both the price and the amount of the balance have positive values, it has economic significance when the supply and demand curves are pointing in the direction of 1. On the other hand, if one of the variables has a negative value, the curve may not always cut to a 1, indicating that it lacks economic significance.

3. RESULT AND DISCUSSIONS

The economic model that can be used to answer supply and demand-related questions was created based on the findings of research on the analysis of the application of mathematics to the sciences of economics, in particular demand and supply and the balance of the market. The link between the quantity of items (Q) demanded and the price (P) is represented by a demand function. "When prices go up, the amount of demand decreases, and when prices go down, the number of demand increases" is how the law of demand is expressed. The following are some instances of economic cases that will be covered in this subject that are resolved via the use of mathematical techniques and applications:

The demand and supply data set is predicated on the following, which takes the relationship between the variables P and Q into consideration. The assumptions of the relation of variables p and q in the demand data set are the reverse, that is, relative to the inverse, if the functional relationship between them in the supply data is relative to straight. Thus, an economic model based on the following data assumptions will also be obtained by mathematical procedures.

Table 1. Demand and Supply Data

Price	Demand	Supply
20.000	500	100
40.000	400	200
60.000	300	300
80.000	200	400
100.000	100	500

$$\frac{P - P_1}{P_2 - P_1} \qquad \frac{Q - Q_1}{Q_2 - Q_1}$$

$$\frac{P - 20000}{100000 - 20000} \qquad \frac{Q - 500}{100 - 500}$$

$$-400P + 80000 = 80000Q - 4000000$$

$$-80000Q = -4800000 + 400P$$

$$Q = 60 - \frac{1}{200} P \qquad \frac{1}{}$$

Using the mathematical linear function Q = 60 – 1/200P, the demand function based on the case may be produced. 500 units of the items were required at the time, when the price of the goods was Rs 20,000. Less things are demanded in greater quantities when the price is higher, and vice versa. According to the chart below:

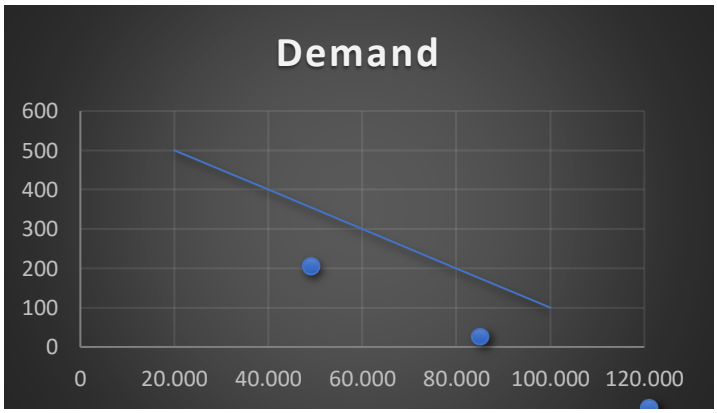


Figure 1. Demand Curve

Ps and Qs are then the analysis for the supply function. The maxim "if the price of goods rises, then the quantity of goods will increase, and vice versa" refers to the law of supply. It is assumed that, aside from what is thought to be constant, there are only two significant variables: P and Q. Next, offer functions that were obtained mathematically:

$$\frac{P - P_1}{P_2 - P_1} \qquad \frac{Q - Q_1}{Q_2 - Q_1}$$

$$\frac{P - 20000}{100000 - 20000} \qquad \frac{Q - 100}{500 - 100}$$

$$400P - 800000 = 80000Q - 800000$$

$$-80000Q = 0 - 400P$$

$$Q = \frac{1}{200} P$$

Ps and Qs are then the analysis for the supply function. The maxim "if the price of goods rises, then the quantity of goods will increase, and vice versa" refers to the law of supply. It is assumed that, aside from what is thought to be constant, there are only two significant variables: P and Q. Next, offer functions that were obtained mathematically:

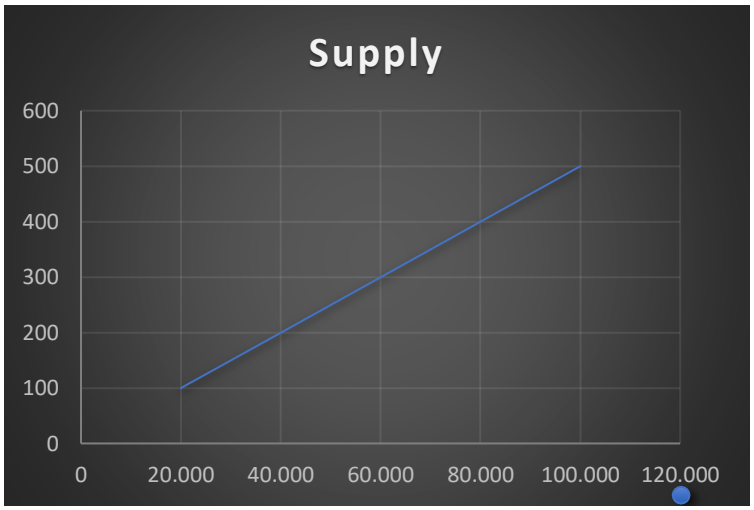


Figure 2. Supply Curve

Then, in order to get the market balance algebraically, linear equations between the functions of supply and demand are performed simultaneously. It can be described geometrically by cutting off the supply and demand curves, as shown in the following graph:

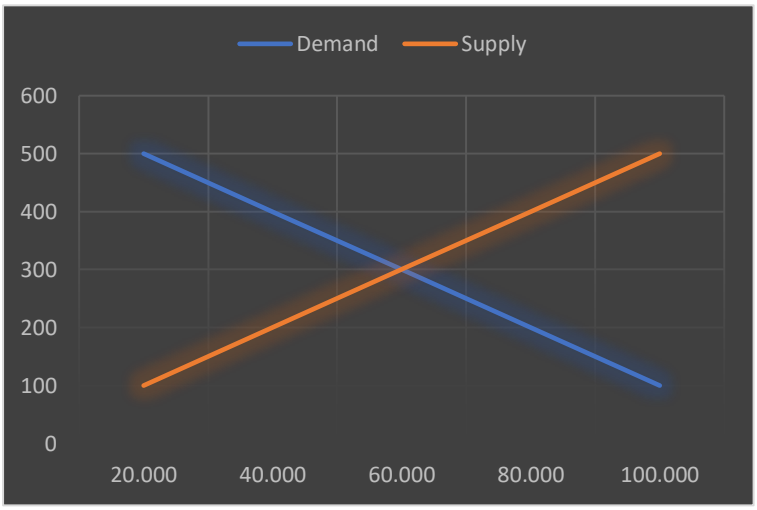


Figure 3. Demand-Supply Curve

4. CONCLUSIONS

This research analyses the use and application of mathematics in economics, with a focus on the functions of supply and demand. Through a quantitative approach, the study identified factors that influenced the dynamics of supply and demand and developed accurate mathematical models to predict market behavior. The results of the analysis showed that the relationship between demand and supply functions was constructed on the basis of mathematical ideas. By looking at coordinate points based on the concepts of linear functions, the use of the mathematical model provides a clearer and deeper understanding of how prices, income, and other external factors influence market balance. By using elasticity analysis, this study reveals the sensitivity of demand and offer to price changes, helping policymakers and market actors formulate more effective strategies. Advanced research in this field needs to consider additional variables and more innovative methods to strengthen understanding of complex and evolving market dynamics.

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