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Optimizing Break-Even Point: A New Methodology for Identifying Critical Components and Managing Financial Stability

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ABSTRACT

Break-even point is subject to certain limitations, which are chiefly associated with the stability of parameters. To this end, firms should not rely solely on static parameters but should measure the rate of change of the company's stability. This rate of change is the most effective indicator of future risk, as it allows financial managers to evaluate whether to finance projects or not, depending on the risk level. This paper focuses on the company's equilibrium point after accounting for potential risk factors such as economic, political and geographic influences. The results indicate that a one-unit change in fixed cost results in an inversely proportional change in the price with respect to quantity. In addition, if variable cost increases by one unit, the price will increase by an equivalent amount. Furthermore, a one-unit decrease in quantity will result in a price hike that is equivalent to the fixed cost divided by the square of the quantity. Finally, a new equation is proposed to show how the price changes in response to a simultaneous change in all components.

INTRODUCTION

In today's rapidly changing investment environment, companies face immense challenges in making sound financial decisions. In order to succeed and remain stable, businesses must accurately assess the impact of any change and develop a comprehensive understanding of the components of the break-even point. The break-even point is a fundamental concept in financial management that helps businesses identify the quantity of production that must be sold to achieve profitability. It also assists entrepreneurs in forming a pricing strategy that covers costs and yields a gross profit.

The break-even point is an important concept in business and refers to the level of sales or revenue necessary for a company to cover all its costs and expenses, resulting in a zero profit. The significance of the break-even point lies in its ability to provide insight into a company's financial health and profitability. Given its importance, researchers have conducted numerous studies on the break-even point, exploring its effectiveness in different contexts. Some of the areas where break-even point analysis has been used include liquefied natural gas processes, deposit return systems, fisheries-based tourism, community health workers, ecopreneurship, risk factors in innovative projects, and winter oilseed rape production (Dario Cottafava et al., 2021; Fuksa, 2013; E. K. Kim et al., 2017; Rahmann et al., 2017; Saleh et al., 2021).

Researchers have investigated the effectiveness of break-even point analysis in various contexts, including liquefied natural gas processes, deposit return systems, fisheries-based tourism, and community health workers, among others (Cao et al., 2021; D Cottafava et al., 2021; Handayani et al., 2020). Additionally, the break-even point has been used in evaluating business operations in multiple contexts, such as ecopreneurship, risk factors in innovative projects, and winter oilseed rape production. For example, in the context of liquefied natural gas processes, break-even point analysis has been used to evaluate the economic viability of investing in such projects. Similarly, in deposit return systems, researchers have used the break-even point to determine the point at which the costs of implementing the system are covered by the revenue generated from returned containers (Cao et al., 2021; D Cottafava et al., 2021; Handayani et al., 2020).

1. LITERATURE REVIEW

In order to make proper decisions and ensure success and stability in a volatile investment environment, companies must determine the effect of any amount of change by studying the components of the break-even point. The break-even point is the point at which total cost and total revenue are equal, meaning that no net loss or gain has been incurred and that opportunity costs have been paid and capital has received the expected return. In other words, all costs associated with the investment have been accounted for and there is neither profit nor loss.

The increasing prominence of the break-even point in business has been attributed to its ability to identify the quantity of production that must be sold to achieve profitability and aid entrepreneurs in forming a pricing strategy that not only covers costs but also yields a gross profit. Consequently, the break-even analysis has been the subject of numerous studies in the existing literature. Various studies have been conducted to investigate the effectiveness of break-even point analysis in multiple contexts. For instance, Cao et al., (2021) examined the break-even point in the context of liquefied natural gas processes and refrigeration cycles, with a focus on technical and economic considerations. Cottafava et al., (2021) investigated the environmental break-even point for deposit return systems through a life cycle analysis of single-use and reusable cups. Handayani et al., (2020) studied the operational cost analysis of break-even point models in fisheries based tourism site governance. Other researchers have applied the break-even point to Community Health Workers (Gurley-Calvez & Williams, 2019), Ecopreneurship in Indonesia (Putri et al., 2019), the consideration of risk factors in innovative projects (Malozyomov et al., 2018), and the economic risks associated with producing winter oilseed rape (Mimra et al., 2018). Additionally, break-even point analysis has been used in the evaluation of business operations in various contexts(Barletta et al., 2018; Batkovskiy et al., 2017; Caplan, 1958; Chen, 2015; Deris & Baniasadi, 2006; Galabov, 2017; Kampf et al., 2016; E. K. Kim et al., 2017; S. Kim et al., 2017; Konishi et al., 2015; Manganelli, 2016; Nonis et al., 2014; Rahmann et al., 2017; Ramini et al., 2014; Syrůcek et al., 2018).

This paper presents a new methodology for determining the most critical component of the break-even point that is affected by changes in the market. This approach provides financial managers with the necessary information to make informed decisions on which components to manipulate in order to achieve an equilibrium situation. The break-even point is a crucial aspect of financial management that helps firms determine the level of sales necessary to cover their costs. However, it is important to note that the break-even point is subject to certain limitations, which are mainly associated with the stability of parameters. Therefore, financial managers should not rely solely on static parameters but should also consider the rate of change of the company's stability to make informed decisions about financing projects. In this contribution, I agree with the paper's focus on the company's equilibrium point after accounting for potential risk factors such as economic, political, and geographic influences. The paper's results indicate that certain factors, such as fixed and variable costs, can have an inverse proportional effect on the price with respect to quantity. The proposed equation also provides a comprehensive way of understanding how changes in all components can affect the price. This paper's insights can be valuable for financial managers who seek to make informed decisions about financing projects and managing their firms' financial health.

The methodology presented in this paper is innovative because it helps financial managers to determine the most critical component of the break-even point that is affected by changes in the market. By identifying this component, managers can make informed decisions about which component to manipulate in order to achieve equilibrium. This information is essential for firms because it can help them to optimize their profits and minimize their losses. The break-even point is a fundamental aspect of financial management that helps firms determine the level of sales needed to cover their costs. However, financial managers should not rely solely on static parameters when making financing decisions. Instead, they should consider the rate of change of their company's stability. This is because the break-even point is subject to certain limitations associated with parameter stability. Therefore, financial managers must take into account the potential risks of economic, political, and geographic factors that could impact their firm's stability. The findings indicate that certain factors, such as fixed and variable costs, can have an inverse proportional effect on the price with respect to quantity. For instance, if the fixed cost increases, the price must decrease to maintain the same level of sales, and if variable cost increases, the price must increase by an equivalent amount. Furthermore, the paper proposes an equation that provides a comprehensive understanding of how changes in all components affect the price.

2. RESEARCH METHODOLOGY

Partial derivation analysis is more effective than traditional financial analysis for this purpose as it can accurately measure the impact of any sudden changes in economic or political factors. This method can be used to evaluate the effect of a one-unit change in any given component on other components. In the case of a sudden change in the investment environment, management must take swift action to mitigate any potential losses. However, it is not always easy to determine the direction of the change, as the vector can be both positive and negative.

For effective break-even point analysis, it is necessary to first accurately define the components of the break-even point. Companies must conduct a thorough market study to determine the amount of their fixed costs, which remain constant regardless of output, such as salaries, rent, and machinery costs. This magnitude can be represented by the letter C. The profit margin is determined by the price (P), which is determined by the forces of supply and demand in a competitive market, and the variable cost (V), which is a corporate expense that changes proportionally with the amount of production or sales. Variable cost is comprised of multiple variables, so management must choose the most efficient elements for their environment, as these will eventually affect the net cost. The break-even point (N) is the number of units that need to be produced and sold in order to cover the fixed and variable costs.

2.1 Defining price in terms of other elements

Now, the price is defined as (P) in terms of other elements (C, V, and N). The break-even equation is

$$n = \frac{C}{P - v} \ldots\ldots\ldots (1)$$

The order of the terms in equation (1) is rearranged as follows:

$$c = n\,(P - v\,)$$
$$c = n\,P - nv$$
$$n\,P = c + nv$$
$$P = \frac{c + nv}{n} \ldots\ldots\ldots (2)$$

Equation (2) provides an interpretation of the pricing study in terms of variable cost, fixed cost and break-even quantity. Through partial derivation analysis, this equation can be used to calculate the rate of change, with the ultimate goal of determining the amount of change required to return the investment to an equilibrium situation. This will enable the company to decide which component in the equation should be modified in order to recoup the investment.

In this paper, partial derivation is employed to explore the amount of change in each parameter namely fixed cost, variable cost and production quantity. In addition, the complete dynamic break-even point equation is presented.

2.2 Change in fixed cost and stability of other components

For this scenario, all components remain constant but fixed cost is subject to change, which can be attributed to internal factors such as salary, rent, and the purchase of machinery. Therefore, the price with respect to fixed cost should be derived using partial derivation as follows:

$$\frac{\partial P}{\partial C} = \frac{(1)(n) - ((0)(C + vn)}{n^2}$$

$$\frac{\partial P}{\partial C} = \frac{1}{n} \ldots \ldots . \ldots (3)$$

$$\frac{1}{Production\ Quantity}$$

Equation (3) reveals that a one-unit change in fixed cost results in an inversely proportional change in the price with respect to quantity, provided that the other components remain constant due to the company having reached the maximum machine capacity and the lowest level of variable cost. As such, the only available option is to increase the price by ($\frac{1}{n}$).

- The fixed cost change will affect the price by ($\frac{1}{n}$).

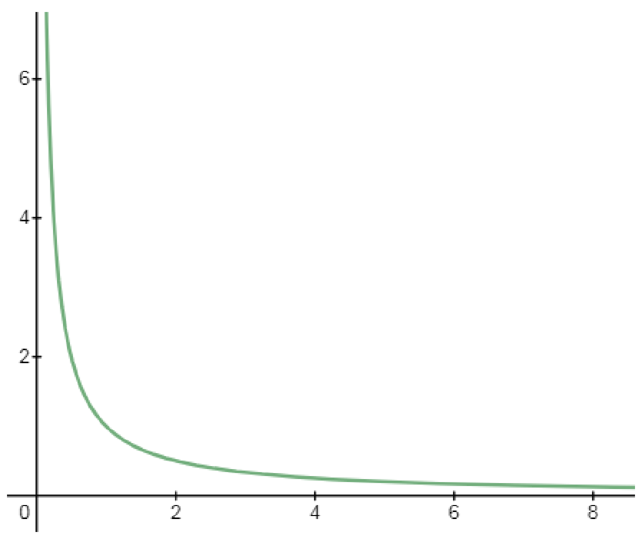

Figure 1. The effect of fixe cost change on the new price

$$P_c = f(c) = \frac{1}{n}$$

By using limit of a function:

$$\lim_{n \to \infty} \left(\frac{1}{n}\right) = 0$$

This implies that any alterations in fixed cost will not influence the new price if the quantity of production is significantly increased.

2.3 Change in variable cost and stability of other components

The variable cost is comprised of both internal and external components. Changes in the investment environment, such as skilled labor turnover, currency depreciation and rising raw material costs, can alter this cost structure due to the associated transition costs. The price can be derived with respect to variable cost, provided that all other components remain constant.

$$\frac{\partial P}{\partial v} = \frac{(n)(n) - ((0)(C + vn)}{n^2}$$

$$\frac{\partial P}{\partial v} = 1 \dots \dots \dots (4)$$

Equation (4) indicates that if variable cost increases by one unit, the price will correspondingly rise by an equivalent amount. Consequently, variable cost is the most critical component to consider as any change will have a drastic effect on the price.

The variable cost change will affect the price by 1.

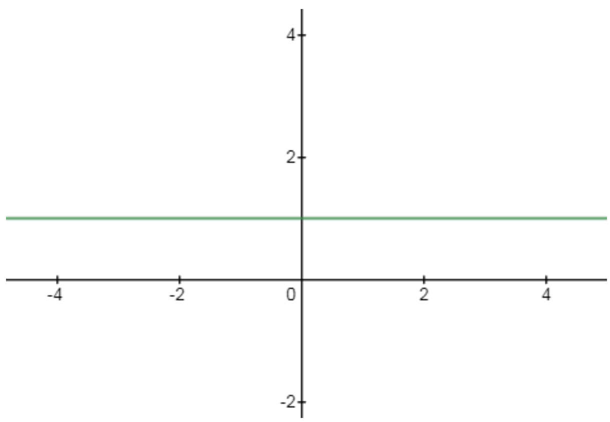

Figure 2. The effect of variable cost change on the new price

$$P_v = f(v) = 1$$

By using limit of a function:

$$\lim_{v \to \infty} (1) = 1$$

This implies that a change in variable cost will lead to an equivalent change in the price. In other words, there is a perfect positive correlation, meaning that the variables move together in the same direction and at the same rate 100% of the time.

2.4 Change in production quantity and Stability of other components

The quantity level that is equivalent to the break-even point can be significantly altered by various factors, such as the aging of spare parts and the inefficiencies in the maintenance team. Therefore, it is necessary to analyze the price's sensitivity to any degree of change in the quantity level. The following equation describes the relationship between price and quantity:

$$\frac{\partial P}{\partial n} = \frac{(v)(n) - ((1)(C + vn))}{n^2}$$

$$\frac{\partial P}{\partial n} = \frac{-c}{n^2} \dots\dots\dots (5)$$

Equation (5) illustrates the inverse relationship between quantity and price, which states that a one-unit decrease in quantity will result in a price increase that is equivalent to the fixed cost divided by the square of the quantity. If a company produces a large quantity and the associated fixed cost amount is small, the new equilibrium price will only be marginally affected. On the other hand, if the quantity is small and the fixed assets are significant, a change in the production of quantity could have detrimental consequences due to the difficulty in making a significant leap in price.

- The production quantity change will affect the price by $\frac{-c}{n^2}$

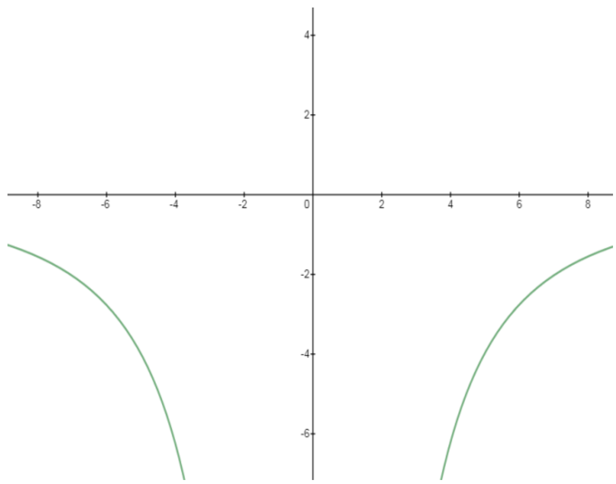

Figure 3. Increase in fixed cost amount

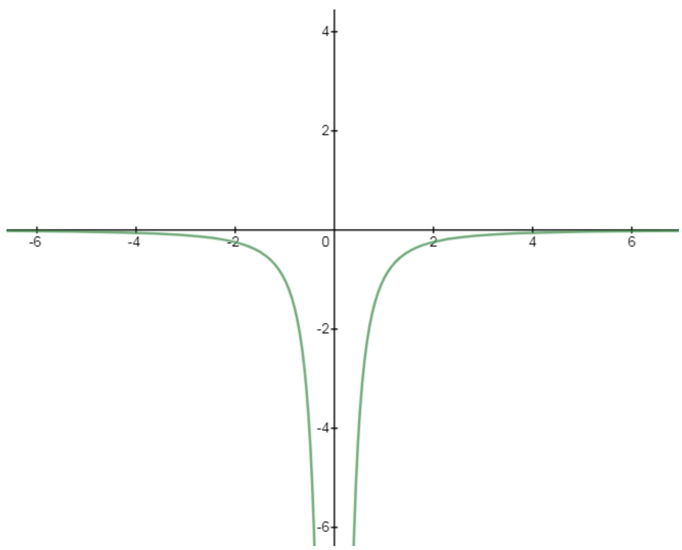

Figure 4. Decrease in fixed cost amount

$$P_n = f(n) = \frac{-c}{n^2}$$

By using limit of a function:

$$\lim_{n \to 0} \left(\frac{-c}{n^2}\right) = \infty$$

The graphs above demonstrate that as fixed costs increase and production quantity decreases, the resulting impact on the new price will be significant.

2.5 The complete change amount

To determine the price change resulting from a difference in fixed costs between c_1 and c_2:

$$\Delta C = c_2 - c_1$$
$$\Delta P = \Delta C \cdot \frac{\partial P}{\partial C}$$

$$Price\ Change\ Amount = (fixed\ cost\ change\ amount)\ X\ (rate\ of\ change)$$

The same methodology applies to the remaining factors (V, N), and the resulting change in price can be expressed as follows:

$$\Delta P = \Delta C. \frac{\partial p}{\partial c} + \Delta v \cdot \frac{\partial p}{\partial v} + \Delta n. \frac{\partial p}{\partial n}$$

2.6 The complete dynamic break-even point equation

The complete dynamic equation can demonstrate the cumulative effect on price if all components are changed simultaneously. This scenario can be addressed mathematically using the del operator, allowing for a single function $\mathrm{P(c, v, n)}$ to capture the price changes with respect to the breakeven point components. Therefore, This function can determine the point-to-point price transition caused by changing the direction of other variables $(\hat{\mathrm{x}}, \hat{\mathrm{y}}, \hat{\mathrm{z}})$.

$$\nabla . P = \frac{\partial p}{\partial n} + \frac{\partial p}{\partial v} + \frac{\partial p}{\partial c}$$

By making rearrangement for the above equation it becomes as follows:

$$\nabla . P = 1 + \frac{1}{n} - \frac{c}{n^2}$$

Equation (6) captures the new price if all other variables are altered by varying amounts, thus illustrating price point transitions from point (a) to point (b). Therefore, this equation provides a comprehensive description of the price change when all components are modified simultaneously.

$$\nabla . P = \frac{n^2 + n - c}{n^2} \dots \dots \dots (6)$$

This denotes the following:

$$\text{Dynamic Price Change} = \frac{(\text{Production })^2 + \text{Production} - \text{fixed cost}}{(\text{Production })^2}$$

2.7 Laplace operator

The rate of change of all the break-even point factors has been presented, but what is the acceleration of this change? Is the change stable or is there a continuous state of fluctuation, with the magnitude increasing or decreasing over time? The Laplace operator is the solution to this question, as follows:

$$\nabla^2 = \frac{\partial^2}{\partial x^2}\,\hat{x} + \frac{\partial^2}{\partial y^2}\,\hat{y} + \frac{\partial^2}{\partial z^2}\,\hat{z}$$

The application of the Laplace operator on the break-even point equation produces a scalar quantity which is a function of the price.

$$\nabla^2 P = \frac{\partial^2}{\partial c^2} + \frac{\partial^2}{\partial v^2} + \frac{\partial^2}{\partial n^2}$$

By definition, the complete equation No. 2 which can be derived twice in respect to each factor:

2.8 First (fixed cost)

$$\frac{\partial P}{\partial C} = \frac{1}{n}$$

$$\frac{\partial^2 P}{\partial C^2} = \frac{-1\,.\,(0)}{n^2}$$

$$\frac{\partial^2 P}{\partial C^2} = 0$$

This implies that the rate of change for fixed cost remains constant, indicating that there is no risk and the situation is stable over time.

2.9 Second (variable cost)

$$\frac{\partial P}{\partial v} = 1$$

$$\frac{\partial^2 P}{\partial v^2} = 0$$

This implies that the rate of change in variable costs is constant over time. Consequently, there is no acceleration in the rate of change.

2.10 Third (production quantity)

$$\frac{\partial P}{\partial n} = \frac{-c}{n^2}$$

$$\frac{\partial^2 P}{\partial n^2} = \frac{c\,.\,(2n)}{(n^2)^2}$$

$$\frac{\partial^2 P}{\partial n^2} = \frac{2cn}{n^4}$$

$$\frac{\partial^2 P}{\partial n^2} = \frac{2c}{n^3}$$

The production quantity is the primary factor driving price changes. As production quantity increases, the price must be adjusted accordingly in order to reach the break-even point. However, if the company reaches a point where production quantity continues to decrease but the price is already at its peak, the company will be at risk of bankruptcy. Mass production companies are less likely to suffer this fate, as the rate of change of the velocity of production quantity with respect to time is typically low (the denominator is n^3).

2.11 The total acceleration of the price development effect can be expressed as follows

$$\nabla^2 P = 0 + 0 + \frac{2c}{n^3}$$

$$\nabla^2 P = \frac{2c}{n^3}$$

$$\nabla^2 P = \frac{2\ (\,fixed\ Cost\,)}{(Production\ Quantity)^{\ 3}}$$

It is imperative to closely consider the rate of change in production quantity before investing or financing a company. Companies with a high rate of change should be avoided, as this indicates a higher degree of risk, whereas those with a low rate of change are perceived to be more secure.

3. PRACTICAL IMPLICATION

The practical implication of this research is that financial managers can use the proposed methodology to identify the most critical component of the break-even point that is affected by changes in the market. By doing so, they can make informed decisions about which component to manipulate in order to achieve an equilibrium situation. This approach can be particularly useful for companies operating in a volatile investment environment, where changes in market conditions can have a significant impact on the firm's financial health.

Financial managers can use the insights provided by this research to optimize their profits and minimize their losses. For example, they can use the proposed equation to determine how changes in fixed and variable costs will affect the price with respect to quantity. This information can help them to make pricing decisions that will cover costs and yield a gross profit. Additionally, financial managers can use this research to evaluate the financial risks associated with various projects and determine whether they are viable.

Overall, the proposed methodology can help financial managers to make more informed decisions about their firm's financial health. By identifying the most critical component of the break-even point, they can develop a comprehensive understanding of the factors that are affecting their firm's profitability. This approach can help companies to achieve stability and succeed in a rapidly changing investment environment

CONCLUSIONS AND RECOMMENDATION FOR FUTURE RESEARCHES

The stability of a company is largely contingent upon the quantity of production. Companies with large production quantities are generally more stable and better equipped to tackle market challenges than those with low production quantities. Furthermore, the variable cost is a complex element. Stable companies are typically reliant on multiple variable cost elements, which ensure that product prices remain relatively resistant to changes in individual elements. On the contrary, if a company is heavily reliant on one variable cost element, representing 80% or 90% of the total, then any change in such an element will have a significant impact on the price.

Decreasing the amount of fixed cost through cost capitalization can improve a company's stability. Moreover, the change in price is contingent upon the production quantity, as the complete change equation (dynamic equation 6) illustrates:

$$\nabla.P = \frac{n^2 + n - c}{n^2}$$

What if fixed cost reaches production quantity? Then, the change equals one.

$$n = c$$

$$\nabla.P = \frac{n^2}{n^2} = 1$$

$$\nabla.P = \frac{\partial p}{\partial v}, \quad if\ \{C\ = N\}$$

This is a particularly concerning situation for a company if its fixed cost is equal to the production quantity, as the entire dynamic equation will have the same effect as a change in the variable cost. Finally, the break-even point components are derived from the income statement and the established equation demonstrates the weight of quantity of production in comparison to fixed and variable costs, it is highly recommended that international standards consider including product prices and production quantities in the income statement for each year, and comparing these figures to previous years.

The discussion above highlights several areas for future research that could contribute to our understanding of the relationship between production quantity, variable and fixed costs, and company stability. One potential area of investigation is the impact of changes in individual variable cost elements on product prices. While the importance of diversifying variable cost elements to ensure stability is emphasized, further research could explore how changes in individual variable cost elements impact product prices. Such research could help companies better understand the potential risks associated with relying heavily on one particular variable cost element. Another area for future research could be the relationship between fixed costs and production quantity. The discussion underscores the potential risks associated with fixed costs equaling production quantity, but further research could explore the relationship between fixed costs and production quantity more broadly. For instance, researchers could investigate the optimal ratio of fixed costs to production quantity for different types of companies and industries. Developing new models for analyzing company stability is another promising area for future research. The dynamic equation presented in the discussion provides a useful framework for understanding the impact of changes in production quantity, fixed costs, and variable costs on product prices. However, further research could explore the development of new models that take into account other factors that may impact company stability, such as market demand, competition, and technological advancements. Finally, the discussion recommends including product prices and production quantities in income statements to better understand the weight of production quantity in comparison to fixed and variable costs. Future research could conduct a comparative analysis of income statements across industries and countries to identify patterns and trends that could inform best practices for ensuring company stability. Such research could shed light on the different approaches and strategies employed by companies in different regions and industries to ensure stable and profitable operation

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APPENDIX: Mathematical proof

To simplify and proof the above equations, let's assume the following data as it is presented in table 1.

Table 1. Assuming data

Description	*Value*
C	60,000 $
P	5 $
V	2 $
N	20,000 unit

Considering equation 1 or 2, the break-even point is 20,000 unit of production.

- Equation (3):

If fixed cost increases by one dollar, then the price will increase proportionately by $ 0.00005 in order to maintain the company's stability. This is evidenced by substitution in equation number two, which states that:

$$P = \frac{60{,}001 + 20{,}000\ X\ 2}{20{,}000}$$

$$P = 5.00005\$$$

$$\frac{\partial P}{\partial C} = \frac{1}{n} = 0.00005$$

- Equation (4):

Given evidence by substitution in Equation 2, which states that:

$$P = \frac{60{,}000 + 20{,}000\ X\ 3}{20{,}000}$$

$P = 6.0\$$

$$\frac{\partial P}{\partial v} = 1$$

The price rose by $1 following an increase in variable cost of $1, thus restoring equilibrium.

- Equation (5):

To demonstrate the change, evidence can be provided by substituting values in Equation 2:

$$P = \frac{60{,}000 + 19{,}999\ X\ 2}{19{,}999}$$

$P = 5.00015\$$

$$\frac{\partial P}{\partial n} = \frac{-c}{n^2} = 0.00015\$$$

A one-unit decrease in quantity will lead to an increase in price of 0.00015 $, equivalent to the fixed cost (60,000 $) divided by the square of the quantity (19,999). This price adjustment is necessary to re-establish equilibrium.

- Equation (6):

Given evidence by substitution in equation number 6 which is as follows:

$$\nabla . P = \frac{n^2 + n - c}{n^2}$$

$$\text{Dynamic Price Change} = \frac{(20000\ )^2 + 20000 - 60000}{(20000\ )^2}$$

$$P = 0.9999\$$$

The results of equations 3, 4, and 5 can be added together to obtain the same value.

$$P = 0.00005 + 1 - 0.00015$$