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Analysis of life cycle stages and implementation of product life cycle costing in Hormozgan Gas Company

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ABSTRACT

The present study first seeks to study and analyze the different stages of the life cycle in the Hormozgan Gas Company and then implements product life cycle costing on the company. The data in the present study are extracted from financial statements and interviews with financial, technical, safety and health experts. The study is an applied one and in fact, a case study that has been done for the years 2012 to 2020. The results of research based on Di Angelo method show that the company is in a decline stage and should take urgent measures to increase the sales of its products or look for an alternative product. Examination of the life cycle by Dickinson method showed that the company is in the stage of maturity and will soon enter the stage of decline, so the managers of the company should seek to increase cash flows. Also, the calculation of product life cycle cost showed that the mentioned cost is significantly different from the accounting standards based cost, to the extent that in 2020, the application of the mentioned costing in income statement reduces the gross profit by 25%.

Keywords: life cycle, costing, Dickinson method

1. Introduction

Since costs and cost calculations are important and crucial in an organization, their measurement methods must also be considered. There are many methods for costing, but all of them are not suitable and the one that covers and examines all expenses and cost items from the design and planning stage to the stage of stopping and production line disposal is the most suitable one. The only costing method that takes into account all costs of product life cycle is the product life cycle costing.

Product Lifecycle (LCC) valuation focuses on the total value chain of the product in terms of cost. The product life cycle can be divided into two cycles:

1) Cost life cycle
2) Sales life cycle

The cost life cycle includes the sequence of activities performed within a business unit. These activities start from the research and development stage and include the stages of design, construction (supply), marketing and distribution (service delivery) to the customer, respectively. This is while the sales life cycle refers to the sales stage in the market from the time of product introduction to its elimination in the market, so it includes the stages of product or service introduction to the market, growth, maturity and decline (Shurozi et al. 2020).

The objectives of the product life cycle and the relations of this cycle are shown in the following figures:

Table (1). Product life cycle goals from different aspects

Feature	Target	Method
Producer	Maximize life cycle profits	Increase revenue and reduce costs
Customer	Maximize performance relative to price and cost after purchase	Study of performance life cycle interactions
Society - Government	Laws, regulations, fines, etc.	Minimize side effects such as pollution and unhealthy products

Table (2). Product life cycle communication

Production stages	Concept, design and development	Production and logistics support	Production and logistics support	Production and logistics support	Production and logistics support
Marketing steps	Setting up	Setting up	Growth	Maturity	Decline, agitation or exclusion
Strategic goals	Design for low production cost and consumption	Sales growth	Sales growth	Profit	Profits and cash flows
Performance indicators	Quality	Quality	Quality	Price	Price
Profit	zero	Negative, but incremental	Positive and increase for innovators, profit diversification depends on the state of the company in the industry	Roof and then lower	Decrease
Traditional costing	Research and development costs are tracked as course costs	Production cost criteria	Production cost criteria	Production cost criteria	Production cost criteria
Life cycle valuation	Production design criteria, innovation process for lower manufacturing and assembly costs	Production criteria, cost of logistics support, cost of consumption	Production criteria, cost of logistics support, cost of consumption	Production criteria, cost of logistics support, cost of consumption	Production criteria, cost of logistics support, cost of consumption

Product life cycle costing is one of the cost management methods that is used to identify and manage costs in the time interval between designing a new product and launching it and finally stopping production due to insufficient demand for that product in the market. The product life cycle costing method takes a broader view

than traditional accounting systems. Therefore, in addition to the initial investment costs, it considers operating costs and other costs that occur during the estimated life of the product. Life cycle costing (LCC) is a method of product life cycle management (PLM) that covers all the life cycle of the product, from its desigining to its launching and finally ceasing of its production due to insufficient demand for it. The product is used in the market.

Product life cycle management is the process of managing the entire product life cycle from idea, engineering design and manufacturing engineering to production, product delivery and support services. One of the tasks of PLM is to integrate the people, information, tools and processes of the organization to create a desirable infrastructure of product information. Today, PLM as a comprehensive solution for managing the development process of complex products, simulating the production process and plants, preparing for production, creation and presentation of the product, planning for product maintenance, collecting feedback, etc to improve the product quality and finally, engineering planning to dispose the product by introduction a new one. PLM will improve the product quality or development of new products by recording feedbacks in the form of customer needs. This approach is based on creating a coherent and integrated information infrastructure of product information and instant access to up-to-date information (Santos et al. 2020).

Interaction between users and creation of integration between users, tools and processes are of other key points. Users in the form of various internal or external teams (suppliers) are able to interact with each other in the product development process and benefit from up-to-date information at all stages of development.

Today, the concepts of product life cycle have been increasingly considered by oil and gas industries and producers. Therefore, this study was conducted to investigate the life cycle stages and implement the product life cycle costing in Hormozgan Gas Company.

Product life cycle from the perspective of ISO 14001

In this standard, the assessment of life cycle has been taken to account widely because it can lead to sustainable development goals and organization-related environmental management (as defined in ISO 14001) is approved along with product-related environmental management. Life cycle assessment basically requires the collection and review of materials and energy inputs and outputs and the associated environmental impacts directly on the performance of a product or service system throughout its life cycle. The life cycle itself consists of successive and reciprocal stages of a product or service system from natural resource extraction to final disposal (Atia et al. 2020).

Life cycle assessment basically requires the performance of a product or service system throughout its life cycle to collect and examine the inputs and outputs of materials and energy and related environmental impacts directly. Revised environmental management standards require businesses to consider the life cycle of their goods and services (Armstrong et al., 2007). This includes the business process and it should be done by considering the entire life cycle of the product or service. Depending on the product and its use, raw materials, transportation and etc., use or discharge phase may be the main cause of environmental impacts.

According to ISO 14001, a systematic approach to environmental management can create long-term success for the organization and create options to help sustainable development by controlling or influencing the design, production and distribution of the organization's products and services. Using a life cycle perspective can prevent unwanted environmental impacts elsewhere throughout the life cycle.

Environmental aspects should be considered at every stage of the life cycle (design, supply, use, transportation, end of life, etc.) and not just activities within the organization. Consideration of environmental requirements at the design stage and during preparation, significant environmental effects should be provided during the delivery of products or services, during use and at the end of the product treatment life (Ohar et al., 2010). When applying the life cycle perspective to its products and services, the organization should consider the following:

1) Stage in the life cycle of a product or service
2) The degree of control over the life cycle stages

For example, a product designer may be responsible for selecting raw materials, while a manufacturer may only be responsible for reducing raw material

consumption and minimizing process waste, and the user is solely responsible for using and disposing of the product. The issuance of product full costs, i.e. the cost of research and development to distribution and subsequent services, has been of particular concern to oil and gas companies in recent years and has become a major concern in other companies. Also, how the life cycle affects the corporate governance, ownership and structure of the company has been of special interest to shareholders in order to increase their wealth. These concerns are also present in the minds of senior managers of Hormozgan Province Gas Company, so the present study was conducted to review and plan the product life cycle from the initial stages to after-gas service and even the related environmental costs in this company.

Research Targets:

1) Study and analysis of product life cycle stages in Hormozgan Gas Company
2) Implementation of product life cycle costing in Hormozgan Gas Company

Background Research

Generally, Supply chain design has a network configuration, which includes market specifications, producer selection, and methods of distribution and allocation of product groups to different markets. Extensive research has been done in this regard. According to Fine, supply chain design includes prioritizing the capabilities through which to develop and strengthen relationships between elements in a supply network and to connect these capabilities to each other as chains using dynamic processes (Dara et al. 2019). On the other hand, as soon as the design of a supply chain is completed, the management of supply chain pays attention to the design of the supply chain based on the type and life cycle of the product, the existing information and current coordination arrangements. Effective supply chain strategies combine different approaches. These strategies can include operational flexibility (assembling for order, manufacturing in accordance to order and reducing latency), contract arrangements, inventory management, and effective customer response (Medina et al. 2021). In another study, Kambano (2020) showed that functional products meet the basic needs of consumers and therefore have predictable demand and a longer product life cycle. This stability, in turn, creates competition that will lower profit margins. Most companies have technology innovations to prevent profit margins reductions. Although, the profit margins of innovative products may be higher, they will have a shorter product life cycle as well as unpredictable market demand.

In recent years, researchers have focused most of their efforts on factors that cause changes in product life cycle stages. Lutin et al. (2021) believed that according to product segmentation, the product life cycle associated with each of them can be identified. They studied the aluminum industry on a case-by-case basis and found that environmental and economic performance assessments could be used in parallel with life cycle costing. They provided a practical framework for integrating the life cycle evaluation system and the life cycle costing system.

Shamszadeh and Esfandian (2015) in their research examined the cost of product life cycle. In this study, an attempt has been made to briefly discuss the issues of product life cycle and to introduce their costing methods. This can pave the way for more cost management and reduction of product costs and customer costs.

Bahri Sales and Rezaei (2016) presented a model for environmental management accounting with a fuzzy AHP product life cycle approach. In this article, while examining different aspects of management accounting and output production cycle, using fuzzy hierarchical analysis, they rank the compliance with different environmental criteria of production in Tabriz Wire and Cable Manufacturing Company. According to the research findings, quality, air, water or soil emissions, pollution forecasting, costs of pollution forecasting and flexibility had a low rank which it makes a necessity to take measures to improve these criteria.

Shurozi et al. (2016) examined the impact of new product development capabilities on organizational effectiveness with the mediating role of product advantage and product life cycle flexibility. The study population includes all senior and middle managers of the Razavi Economic Organization. There are 17 companies and institutions operating in this holding, which provide services in the form of a healthy food value chain with the aim of ensuring food security. The questionnaire used in the research is a translation of the article by Arendt et al. (2018). Data obtained

from research questionnaires were tested using structural equation modeling and research hypotheses were tested by hierarchical regression. According to the results, all research hypotheses were confirmed from the perspective of managers. Findings indicated that new product development capabilities have a positive and significant effect on organizational effectiveness with the role of mediating product advantage and product life cycle flexibility.

Research Methods

Product life cycle costing is a costing approach that seeks to determine the costs of a product over its life cycle. This costing method is a management tool that not only provides complete information about the costs of product life stages, but also offers ways to reduce the cost of the product at every stage of its life. Meaning that it offers target costing for the design and planning stage, Kaizen costing for the product production stage, withdrawal costing for the post-production stage, product and costing systems that are used to calculate the cost of stopping the production line.

In this research, first, the product life cycle for Hormozgan Gas Company has been calculated based on Dickinson and DiAngelo methods and their results have been interpreted. Then, the product life cycle costing for Hormozgan Gas Company is calculated. Hidden costs, including environmental costs, are also included in this calculation.

The first method:

Di Angelo's model of accumulated profit to asset ratio (2006): In this model, the accumulated profit to asset ratio is used to determine the different stages of the company's life. In this model, it is argued that mature companies meet their financial needs from domestic sources; But growing companies depend on external financing. The determination of each company's life stages according to this model is as follows:

1) If the ratio of accumulated profit to total assets is less than 33%, the company is in decline;
2) If the ratio of accumulated profit to total assets is between 33% and 67%, the company is in the growth phase;
3) If the ratio of accumulated profit to total assets is more than 67%, the company is in the maturity stage.

The calculated Di Angelo index for all the years of 2012 to 2020 shows the decline stage for the company because all the obtained numbers are less than 33%.

In order to predict the future of the company, the Di Angelo index is assumed to have a linear relationship with time. After finding points on the chart based on the data of financial statements and calculating the Di Angelo index for the years 2012 to 2020, we used The Microsoft Excel regression analysis. Finally, a regression line with a coefficient of -0.1661 and intercept of 2.3766 was obtained. As can be seen, the slope of the line is descending and based on regression analysis, it can be argued that the regression line hits the horizontal axis in 1430 where the accumulated profit of the company will be zero and this is not a good sign for the company. The projected results indicate a decline in accumulated profits in the coming years, which sounds the alarm for management.

In the next step, it is assumed that the movement of Di Angelo index in Hormozgan Gas Company is non-linear. After calculations, the following regression curve was plotted. As can be seen, the regression predicts that in the year 1402, the accumulated profit of the company will reach the point zero, which will make the profitability of the company worse than the linear method.

Since the purchase and sale prices of the gas company are often applied on a regular basis, in the next step, an attempt was made to neutralize the effect of this factor by setting 2012 as the base year and adjusting prices based on the fuel price index. Therefore, the calculations of Di Angelo method were performed again with new Sudanese numbered numbers.

As can be seen in Table 4, all indicators are still less than 0.33 and the company is in decline during all the years under review.

In order to predict the future of the company, the Di Angelo index is assumed to have a linear relationship with time. After finding points on the chart based on the data of financial statements and calculating the Di Angelo index for the years 2012 to 2020, we used Microsoft Excel regression analysis. Finally, a regression line with a coefficient of 1.5615 and intercept of -21.568 was obtained. As can be seen, the slope of the line is ascending and based on regression analysis, it can be seen that the regression line in the year 1410 exceeds 0.33 and from this year onwards, the company exits the decline stage, in other words, with the current trend, It takes years for the company to emerge from the downturn.

In the next step, it is assumed that the movement of Di Angelo index in Hormozgan Gas Company is non-linear. After calculations, the following regression curve was plotted. As can be seen, the regression predicts that in the year 1418, the index will pass 0.33 and from this year onwards the company will be out of the decline phase. In other words, with the current trend, it will take 18 years for the company to exit the decline phase.

In the next section, Dickenson (2011) method is used to perform calculations. This method, unlike the previous one, which is based on accumulated profits, emphasizes on cash flows.

Table 3. Di Angelo Index

2012	2013	2014	2015	2016	2017	2018	2019	2020	Year
0.025	0.079	0.086	0.03	0.02	0.07	0.04	0.04	0.062	Di Angelo Index

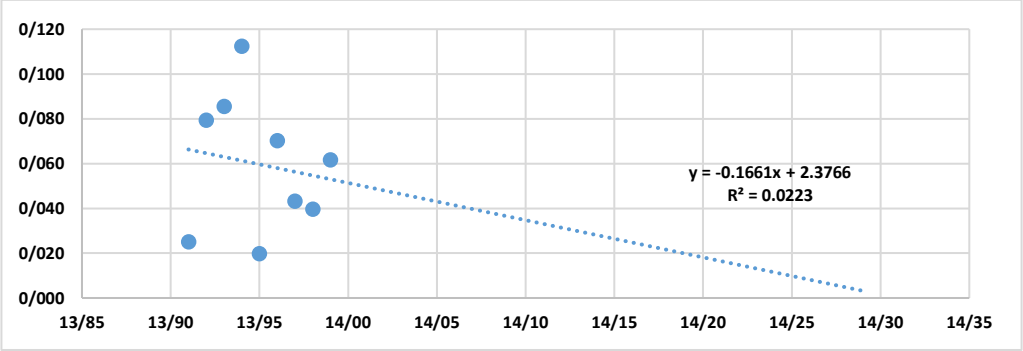

Figure 1. Linear regression of the relationship between year and DiAngelo index

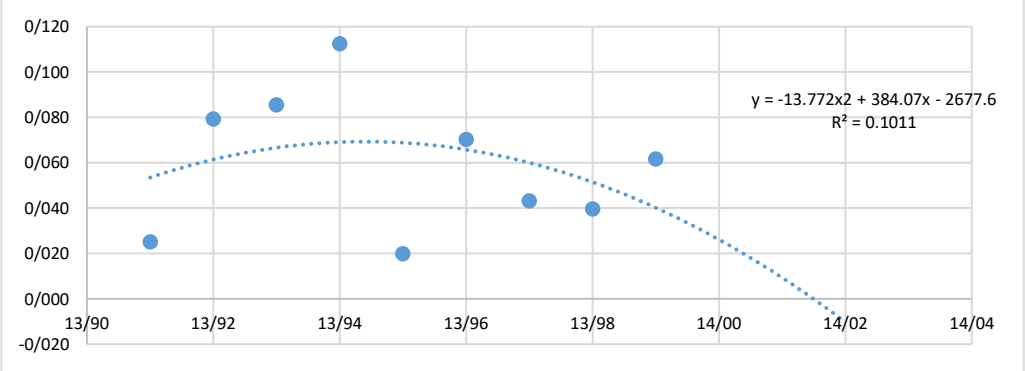

Figure 2. Nonlinear regression of the relationship between year and Di Angelo index

Table 4. Di Angelo Index

2012	2013	2014	2015	2016	2017	2018	2019	2020	Year
0.025	0.12	0.1	0.1	-0.4	0.031	0.14	0.18	0.21	Di Angelo Index

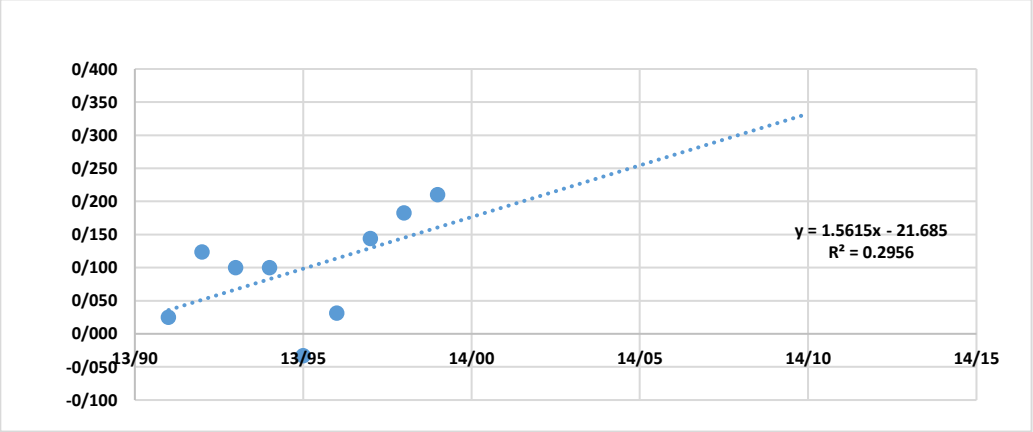

Figure 2. Linear regression of the relationship between the year and the adjusted index

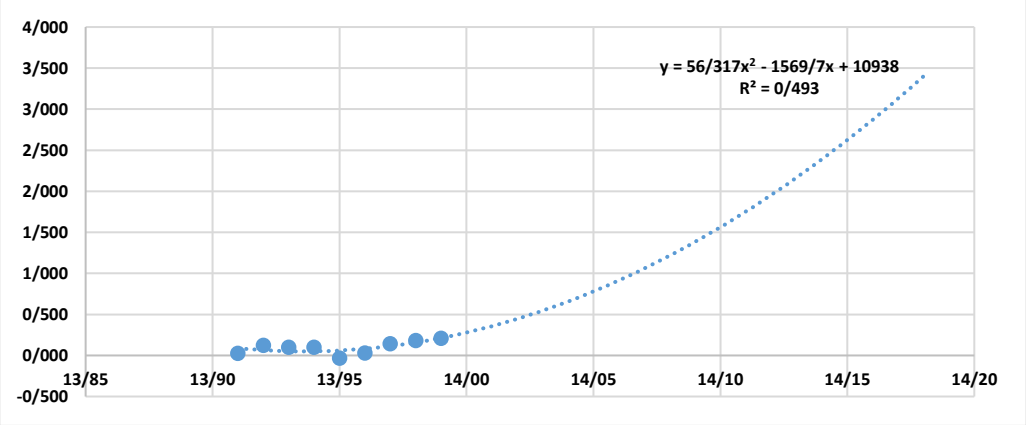

Figure 3. Nonlinear regression of the relationship between year and adjusted index

The second method:

Dickinson divides the corporate life cycle (CLC) into five stages: birth, growth, maturity, decline, and stagnation. The characteristics of each state are summarized in Table 5 as follows:

As shown in Table 6, according to the results of Dickinson's method, the company has been in stages of introduction, growth, growth, introduction, growth, maturity, maturity, growth and maturity, in the years of 2012 to 2020, respectively. Comparing these results with standard curve of product life cycle, these results do not show a logical trend. For this reason, in the next step, the most important and influential factor (government profit share) that caused this irregular trend was eliminated. After recalculation, more logical results were obtained that are more consistent with the standard product life cycle. Thus, the gas company has been in the stages of introduction, growth, growth, introduction, growth, growth, growth, growth and maturity in the years of 2012 to 2020, respectively. It should be noted that return of company to the introduction stage in the year 2015 is due to the unprecedented changes in payables that caused a significant reduction in operating cash flows, and therefore Dickinson's formula unusually shows the introduction stage. According to the above results, the company is now in the maturity period and may soon enter the phase of decline. To predict the timeline of the company's decline, the predicted data for at least 3 next years are required.

Table 5

CFF	CFI	CFO	IF	level
CFF>0	CFI<0	CFO<0	IF	**Birth**
CFF>0	CFI<0	CFO>0	IF	Growth
CFF<0	CFI>0	CFO<0	IF	Maturity
CFF ≤ or ≥ 0	CFI>0	CFO>0	IF	Fall
If none of the above exist, the company is in a recession				
CFO = Cash from operating activities CFI = Cash from investing activities CFF = Cash from financing activities				

Table 6. Dickinson Index

year	CFO	CFI	CFF	Adj-CFF	Life cycle stage	Life cycle without governments profit share
2012	-259,973	-83,214	288,722	288,722	Introduction	Introduction
2013	43,044	-352,205	247,756	326,727	Growth	Growth
2014	78,486	-339,809	293,481	543,313	Growth	Growth
2015	-48,993	-316,611	381,830	563,852	Introduction	Introduction
2016	144,617	-429,753	369,905	529,476	Growth	Growth
2017	747,133	-432,629	-335,105	66,030	Maturity	Growth
2018	1,281,739	-902,648	-78,097	306,823	Maturity	Growth
2019	831,408	-1,463,120	909,576	909,576	Growth	Growth
2020	5,480,580	-4,977,259	-47,527	-47,527	Maturity	Maturity

Calculating the cost of the product life cycle

In this part of the research, the cost of gas in the entire product life cycle has been calculated. The cost of product sold, which is calculated in profit (or loss) statement, only includes the costs from sending materials to production line to the completion of production phase, while product life cycle costs includes costs before sending the materials such as R&D costs to post-production costs such as guarantee and disposal of an old production line. Therefore, product life cycle costing stages include research and development, distribution, marketing, maintenance costs, service management, and warranty and cessation of production. In this regard, in the present study, research and development costs were collected in the form of research costs and included in the calculations. In addition, information on hidden and overt environmental costs was collected and included in the calculations. Hidden environmental costs were measured carefully in collaboration with the HSE department of Hormozgan Gas Company. Maintenance costs in Hormozgan Gas Company include transportation service, paint protection repairs, relief repairs and inspection and safety, all of which were taken into account in the calculations. Finally, the cost of the product life cycle in different years was calculated and after deducting it from sales, gross profit was obtained based on product life cycle costing. As can be seen in Table 4-4, the cost of life cycle has increased significantly in recent years. In addition, the company's gross profit, which is calculated based on product life cycle costing, in some years is significantly lower than the company's gross profit, which in turn is of great importance. For example, in the year 1399 (2020), gross profit calculated base on product life cycle costing is 25% lower than its counterpart which is calculated based on accounting standards, this should be considered by company’s officials.

Table 7. Calculation of product life cycle cost

Year	2016	2017	2018	2019	2020
Cost of gas according to profit and loss	1.126.748.000.000	1.711.862.000.000	2.540.775.000.000	2.524.304.000.000	4.065.912.000.000
Research and development costs	936.126.521	142.570.000	1.456.060.846	8.348.553.734	4.776.510.671
Direct costs of installing a new line	0	0	0	0	0
Sales distribution costs and after-sales service	1.821.579.537	2.595.217.380	3.315.983.409	4.693.037.165	16.868.235.284
Environmental and health costs	1.881.356.789	2.199.535.557	6.732.908.930	6.085.622.184	5.107.246.953
Repair and maintenance costs	4.917.855.247	1.028.724.621	31.638.745.882	43.320.753.338	97.737.109.329
Cost of collecting out-of-category lines	1.136.304.918.094	1.717.828.047.558	2.583.918.699.067	2.586.751.966.421	4.190.391.102.237
Sale	1.871.798.000.000	2.533.198.000.000	2.692.581.000.000	2.980.988.000.000	4.554.293.000.000
Cost of life cycle	1.136.304.918.094	1.717.828.047.558	2.583.918.699.067	2.586.751.966.421	4.190.391.102.237
Gross profit based on life cycle	735.493.081.906	815.369.952.442	108.662.300.933	394.236.033.579	363.901.897.763
gross profit	745.050.000.000	821.336.000.000	151.806.000.000	456.684.000.000	488.381.000.000
Decrease in gross profit due to life cycle	9.556.918.094	5.966.047.558	43.143.699.067	62.447.966.421	124.479.102.237
reduction Percentage of gross profit	1.3	0.7	28.4	13.7	25.5

Conclusion

In the first step, the calculated Di Angelo index for all the years 2012 to 2020 shows a decline stage for the company because all the obtained numbers are less than 33%. In order to predict the future of the company, the Di Angelo index is assumed to have a linear relationship with time. Based on the regression analysis, it was predicted that the regression line in the year 1430 hits the horizontal axis where the accumulated profit of the company will be zero and this is not a good sign for the company. The projected results indicate a decline in accumulated profits in the coming years, which sounds the alarm for management. In the next step, the movement of Di Angelo index in Hormozgan Gas Company was assumed to be non-linear. After performing the calculations, it was predicted that in the year 1402, the accumulated profit of the company will reach zero, which will make the profitability of the company worse than the linear method. Since the purchase and sale prices of the gas company are often applied on a regular basis, the next step was to neutralize the effect of this factor. The results show that the regression line in the year 1410 exceeds 0.33 and from this year onwards the company exits the decline phase, in other words, with the current trend, it takes 10 years for the company to exit the decline phase. In the next step, the movement of Di Angelo index was assumed to be non-linear. After calculations, it was predicted that from the year 1418 onwards, the company will be out of the decline phase, in other words, with the current trend, it will take 18 years for the company to exit the decline phase.

In the second part of the analysis, Dickinson's method was examined. According to the results of Dickinson method, the company was in the stages of introduction, growth, growth, introduction, growth, maturity, maturity, growth and maturity in the years of 2012 to 2020, respectively. Compared with the standard curve of product life cycle, these results did not show a logical trend. For this reason, in the next step, the most important and influential factor (government dividend share) that caused this irregular trend was eliminated. After recalculation, it was found

that the gas company was in the stages of introduction, growth, growth, introduction, growth, growth, growth, growth and maturity in the years of 2012 to 2020, respectively. Noteworthy, the return of the company to the introduction stage in the year 2015 (1394) was due to unprecedented changes in payments which significantly reduced operating cash flows, and therefore Dickinson's formula abnormally shows the introduction stage. According to the above results, the company is now in puberty and may soon enter a phase of decline.

In the third part of the analysis, the cost of the product life cycle was calculated. The costs of the product life cycle was calculated in different years and after deducting it from sales, gross profit was obtained based on product life cycle costing. The results showed that the cost of life cycle has increased significantly in recent years. In addition, the company's gross profit, which is calculated based on product life cycle costing, in some years is significantly lower than the company's gross profit, which is noteworthy. For example, in the year 1399, gross profit based on product life cycle costing is 25% lower than its counterpart of profit or loss statement based on accounting standards.

Practical suggestions based on research results

1) Considering that according to the calculations of Di Angelo method, the company is in a decline stage in both cases and its accumulated profit will reach zero in the near future, it is suggested that the following measures be taken to increase the accumulated profit in the coming years:
   A. No distribution of profits as much as possible and accumulating them.
   B. Increase gas sales revenue by increasing sales volume
   C. Increasing gas sales revenue by increasing the selling price
   D. Reducing the cost of the product by reducing the cost of gas distribution
   E. Increasing research costs and their quality in order to design and produce new products, including hydrogen, which is used in developed countries, to get out of the decline phase.
2) Since the results of Dickinson method shows that the gas company has just entered the stage of maturity, it is suggested that in order to make the most of this stage, while managing the quality of the product, the company should manage prices and profits in order to increase the length of maturity stage and remain in this stages for decades.
3) Considering that the cost of the product life cycle in the gas company is significantly higher than the calculated cost of the company in the financial statements and this has led to a reduction in operational profit of up to 25% in 1399 (2020), it is recommended that Do the following:
   A. Increasing the volume and selling price to compensate for the increase in cost according to the product life cycle method
   B. Reducing the cost of gas distributed in different parts
   C. Reducing and optimizing maintenance costs
   D. Reducing and optimizing environmental costs
   E. Training and upgrading human resources to achieve the above goals

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