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A Proposed Costing System for Agile Just-In-Time Supply Chains with Back-Flush and throughput Accounting

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Author's contribution

The sole author designed, analyzed, interpreted and prepared the manuscript.

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ABSTRACT

According to the new advances in the form of new firms, including JIT and Agile, further advances in technologies, computer programs, and the systems of official accounting all become necessary to be modified. Also, the considerations of kaizen costing systems, in addition to the new movements towards the concern of the customer, should come first as a result of the new movements towards the customer profit analysis. In a JIT supply chain, suppliers are responsible for informing their cus-tomers of their products. Within the context of the current research, it was suggested to use the sys-tems of Back-flush costing as well as throughput accounting systems to simplify the application of just-in time systems and agile systems to satisfy the requirements of achieving the policy of continu-ous improvement. Furthermore, the continuous debate between the different parties of the game supposed here will be realized and considered. The integration of competitors into various aspects of the supply chain has been made possible by the emergence of intelligent supply chains. Additionally, the rapid advancements in the industrial and technological landscape have placed a significant bur-den on the movement of goods and information, requiring efficient and cost-effective solutions to meet time-sensitive requirements and customer demands. It

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is even more promising to consider the potential for surpassing competitors in terms of achievements and capabilities. The continuous advancements in artificial intelligence have further emphasized the need for progress in both production quality and cost optimization. The rapid progress in both the just-in-time/agile and resilient systems has led to additional requirements for the implemented accounting system and the selected level of automated accounting system. Extensive analysis of various arguments within the scope of the present study has been conducted, promoting the adoption of a more reality-sensitive model for the application.

Keywords: Back-flush costing; throughput accounting; continuous improvement; JIT; agile system; intel-ligence supply chain; immediate production.

1. INTRODUCTION

Optimizing Just-in-Time (JIT) Supply Chain and Agile Systems with Back-flush Costing and Throughput Accounting is crucial for businesses seeking efficiency, cost reduction, and improved responsiveness. This approach streamlines the flow of goods and services, minimizing inventory, and reducing lead times. By incorporating Back-flush Costing, organizations can track and manage costs more effectively, while Throughput Accounting helps in focusing on the value-generating activities. Combined, these strategies enhance agility, enabling businesses to adapt swiftly to market changes and customer demands, ultimately leading to increased profitability and competitiveness.

In order to meet the requirements of continuous improvement, there has been a pressing need to develop cost systems that can support project management by providing the necessary information to address production flexibility, diversity, and cost reduction [1]. This has led to the streamlining of accounting procedures to minimize costs associated with measurement, reducing the volume and complexity of recorded operations. Additionally, efforts have been made to minimize storage costs in order to align with the objectives of JIT and Agile projects, which aim to eliminate stock outs, minimize waste, ensure zero defects, and maintain total quality control. Furthermore, there is a focus on reducing other cost elements, particularly those related to the number of purchase orders [2]. Agile supply chains focus on uncertain customer demand and other endogenous factors [3].

The just-in-time production system seeks, by following the policies to reduce spoilage, to reduce the volume of direct labor, and also by using computer-supported digital control machines. Customer knowledge as an intelligent supply chain has led to better values and sustainable levels of success [4]. JIT has a positive effect on most dimensions of performance in terms of reduced costs, lowered inventory, shortened cycle time, quick delivery, and flexible quantity [5,6]. In JIT practices, the scheduling of production and delivery is synchronized and accessible for the supply chain [7,8]. Olivera and Handfield [9] have observed that supply chain benefits can be reaped through building real-time supply chain capabilities [10]. Considering continuous improvement is the most recent influencer in cost systems, it may have become the most important endogenous factor affecting the firm's cost model and its performance function after it was in the past an exogenous factor [11]. Companies should be aware that the implementation of a continuous improvement program hinges on the understanding that even the smallest idea has the potential to yield significant outcomes [12]. Hence, the efficient implementation of Kaizen emphasizes the importance of adequate employee training. Kaizen becomes attractive because it enables companies to maximize their human productivity potential and enjoy numerous benefits [13]. In order to ensure continuous improvement, the organization should review and analyze its sustainability goals regularly [14]. The objective of this research is to develop a cost system tailored for just-in-time and agile production systems. This involves advocating for the utilization of the Back-flush costing method, which focuses on streamlining measurement and accounting processes to minimize costs [15]. The research also aims to complete the analysis in order to show the impact of using the accounting approach on the immediate flow of production (i.e., throughput accounting). Throughput accounting is used as an auxiliary input to provide cost data necessary for making various decisions and, at the same time, to avoid the various problems arising from trying to use the cost system according to activities in those projects [16]. Accordingly, the research aims to try to work with and employ the various previous methods of cost reduction in order to achieve the philosophy of just in time as well as the agile systems, which aim to reduce cost and achieve continuous improvement considerations that emphasize the importance of reducing cost continuously in support of consumer loyalty policies.

1.1 Plausibility and Limitations of the Research

The Back-flush costing method, also known as delayed costing in some regions, and its integration into accounting for Just-in-Time (JIT) or Agile production systems, holds significant significance in aligning with the nature of these systems. This is primarily due to the need for swift completion of accounting procedures and cost reduction resulting from accounting measurement. Moreover, it addresses the absence of recoding on accounting records for JIT/Agile production. Consequently, it becomes imperative for us to establish a scientific foundation based on time constraints and performance limitations [17].

Regarding the alternative approach known as throughput accounting (TA), it aims to deliver cost data promptly and at a reduced expense. This approach not only promotes the elimination of excess inventory but also emphasizes acquiring essential materials solely for production needs. By utilizing this method, we can establish a coefficient to gauge the productivity and efficiency of various economic entities, referred to as the excess rate. Furthermore, it bolsters the concept of an intelligent supply chain.

2. METHODS

2.1 Research Plan

This research into the following sections: The first section deals with an analytical study of the most important elements of the performance of JIT/Agile systems. The second section deals with the use of the Back-flush costing system to meet the elements of performance in JIT production firms. The third section deals with the study of the use of the throughput accounting, to develop the application of the back flush costing system. The fourth section deals with the design and development of the proposed model for the integration events between the Back-flush costing system and the throughput accounting system. The fifth section deals with the most important findings and recommendations of the research.

2.1.1 A comprehensive examination of the key components influencing the efficiency of Just-in-Time (JIT) and Agile production methods

JIT/Agile production initiatives are focused on minimizing inefficiencies across various stages of production, marketing, and administrative operations, both at the product level and in all other associated activities. These initiatives have been identified by various names and descriptions, with a key emphasis on the reduction of waste throughout the product life cycle. Research by Hariyani et al. [18] suggests that agile production can be viewed as a strategic approach to launching new products in dynamic markets. Essentially, the goal is to be prepared for unforeseen customer preferences and fluctuations in demand [19].

Based on the foregoing, the loss is represented in many places. It includes various production activities that do not add value; also, the occurrence of damage or defects in production sometimes requires a restart of products to rework. In other words, the main objective of the agile system is to try to predict changes in the endogenous variables affecting the production process in states of uncertainty [20].

Zhai [21,22] studied coordination schemes to solve buffer space hedging and lead-time hedging issues in prefabricated construction supply chain management with game theory models.

2.1.2 The just-in-time (JIT) production system is viewed as thorough due to its incorporation of various elements that impact the attainment of immediate objectives, which can be outlined as follows [23]:

- **Reducing the inventory of merchandise and raw materials until they reach zero stock. It should be noted here that a set of sub-goals stem from the previous point, the most important of which are:**

1. Work on the supply in a timely manner, which requires Suppliers to be partners to producers.
2. Reducing the cost of handling raw materials and finished goods.
3. Reducing the time lost in producing products that may be difficult to dispose

of after, and limiting the start of production to what is received by orders from customers

4. Reducing the start-up time so as to result in a speedy start of implementation production orders and the ability to fulfill those orders in a timely manner.

2.1.3 Job diversity for workers and multitasking, results in the following sub-benefits:

1. Workers do not feel repetition in the work they perform and get rid of the phenomenon of boredom and routine performance.
2. No choking points bottleneck due to a lack of abundance of a particular specialty of workers.
3. Linking one worker to several jobs will result in continuous encouragement to reduce the cost.

- **Total quality control:** In light of the JIT/agile systems, both damaged and defective production and those that need to be restarted are considered among the things that are intended to be disposed of.
- **Preventive maintenance:** In order to ensure comprehensive quality control and minimize any potential increase in the cost of quality due to marketing failures, the maintenance service was strategically designed to prioritize prevention rather than just repair [24]. This approach, driven by the desire to achieve zero-loss policies, aims to address any potential faults before they occur.
- **The internal organization of the factory:** The JIT production system focuses on optimizing the production process by positioning consecutive stages of production in close proximity. Through the integration of production centers within the manufacturing facility, the system aims to minimize costs associated with handling products and raw materials. This streamlined approach helps to enhance efficiency by reducing unnecessary work capacity.
- **Operational control standards:** Considered several performance evaluation criteria that were appropriate to be used in traditional projects, such as standards of workers' efficiency.

2.1.4 From all of the above, the development of standards has tended to adopt operational standards that take into account many considerations, including Kaplan and Norton views [25]:

- **Pull System:** The primary goal of the immediate production system is to establish a connection between the demand for production elements, particularly raw materials, and the demand for the final product. On the other hand, the JIT production system aims to eliminate any bottlenecks or choke points that may hinder the smooth flow of production. This includes addressing issues caused by specific machines or processes, which can lead to disruptions or imbalances in the production process [26].

The importance of integrating the different performance units involved in the formation of these projects is made clear in the preceding discussion. Fig. (1) presents the essential elements for enhancing the productivity of JIT production companies.

Accordingly, it is clear that the application of the immediate production system has resulted in a focus on determining the stages of production flow and production quality problems, which motivates the administration to quickly treat and solve previous problems, by developing the production flow and reducing the number of times of handling raw materials and products, and making integrated centers adjacent or shifting to what was previously called the integrated cell system [27].

2.1.5 Following the JIT production system in modern projects has resulted in a number of effects, which the researcher can summarize in the following points:

- Reducing the number of production elements of a product.
- Work to follow the direct download method.
- Low importance of analysis of deviations from cost standards.

Having evaluated the nature of JIT/agile production organizations, we investigate the factors that have prompted the move away from traditional cost accounting methods, seeking to devise effective solutions that are tailored to the characteristics of these firms.

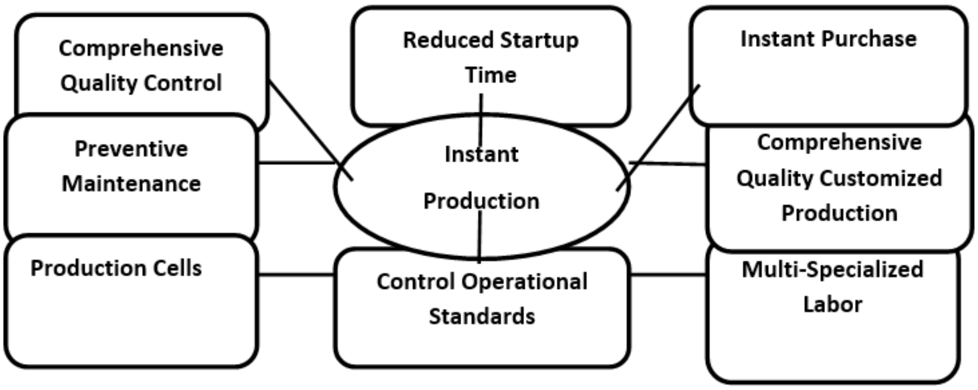

Fig. 1. Elements for Developing the Productivity of the JIT

The JIT system or agile system aims to minimize the number of suppliers in order to maintain a stable supply process for production. This, in turn, promotes the streamlining of accounting procedures for recording the supply and handling of materials, as well as reducing the costs associated with them and any damages to the received raw materials. Gunasekaran and Yusuf [28] indicated that researchers view the agile production paradigm as the post-mass production concept that focuses on meeting global competition by quickly responding to the dynamic demands of the customers.

2.1.6 Using the Back-flush costing system to meet the requirements of just-in-time, agile firms

The preceding section delved into the components of performance in JIT/agile production companies. Through the discussion, it became evident that there is a pressing requirement to accomplish the objectives of prompt procurement and delivery while simultaneously striving to minimize costs. This can be achieved by implementing the Back-flush cost as a measure to attain ongoing improvement considerations [29].

It has been observed that the control method stemming from traditional costing systems is not suitable to a large extent for application in JIT/agile production [30], and it is considered the best example of the above, that the analysis of efficiency deviations in the standard costing system, in light of traditional establishments, has encouraged to increase the volume of production, which is against a lack of acceptance under JIT production firms [31]. Agility was the emerging and gradually dominant concept introduced to explain these firms' strategies for thriving in uncertain environments and responding to change [32]. Although there are several definitions of agile production, some authors, like Guo and Tang [33] indicated that researchers view the agile production paradigm as a post-mass production concept that focuses on meeting global the dynamic demands of customers.

From the above, we note that until now, in light of the considerations and requirements of JIT production facilities have not been able to formulate an integrated cost model but only some proposals to simplify performance and evaluate operating results. In the next part we will discuss the validity of the Back-flush costing system for application in JIT production facilities and thus try to reach the most important assumptions, principles, and steps necessary.

It is worth noting that the Back-flush costing system has been introduced, relying on the quantity of the product as the amount of output, under the assumption that there is no production stock in operation. As a result, it is possible to ascertain the average share of the unit produced in the cost of raw materials. Subsequently, by calculating the total production cost of raw materials and subtracting it from the cost of the purchased quantity on the invoice, the cost of raw material inventory (if any) is determined. Aigbedo [34] among others, have pointed to the effective role played by the Back-flush costing determination system as an accounting method that suits the nature of JIT production firms, which helps to reduce the accounting procedures for accounting registration, which saves both the time and the cost associated with accounting rules.

In addition to this, the JIT production system has resulted in the changing of many cost elements into direct cost elements. Horngren et al. [35], for example, indicated that, reverse-flow costing system (Back-flush) focuses initially on the project outputs and then follows the backwards method in determining the cost of the goods ready for sale, assuming the absence of commodity stock or raw material stock, which contradicts the traditional method of cost accounting [36].

The rationale behind simplifying procedures and adopting the reverse flow costing system over the traditional system for cost determination may be questioned by some. However, a concise explanation can be provided by considering the nature of immediate production projects, where the volume of orders is typically small in size but numerous in quantity. The matter that leads to the application and use of cost standards, whether for materials or for transfer costs, is an obstacle to the speedy provision of cost data and the application of accounting procedures. This encouraged the need to shorten the procedures. As some have pointed out, instead of setting cost criteria to complete the control process, it has become more focused on setting a target cost. From the beginning design and production are carried out in light of it, which ultimately results in a cost reduction and a shortening of the procedures and steps necessary for the control process. On the other hand, the process of attention to identifying and analyzing deviations has shifted [37].

In Back-flush costing, ledger entries are recorded after production is finalized and goods are sold. This approach eliminates the need to deal with intricate details that historically posed challenges in tracking cost elements and allocating indirect costs during production. Mahajan et al. [38] have pointed out that:

> *"Back-flushing means looking at the product's bill of materials and reducing inventory records".*

In this regard, we are interested in discussing the claim of energy disruption and the occurrence of many elements of indirect expenditure in exchange for the actual inventory of final production units, until the accounting cycle begins [39], the progress that occurred in the control methods by introducing digital control machines, which are related to controlling the quality of products, judging their suitability to the desires of customers, and at the same time automatically counting the actual sound production, without any additional cost or effort, can refute the previous claim resisting the application of the reverse flow costing method in the accounting recording.

Conversely, Manoj et al. [40] highlighted the resemblance between the reverse flow costing method, the costing approach, and the preparation of accounts on a periodic system basis. This similarity lies in the fact that all three methods wait until the end of the period to record the book, leading to a delay in providing information for project management to make decisions until the period's completion. However, to respond to that, it is necessary to point out the big difference between the two inputs, which is the difference between the time of the end of production and the time of the end of the accounting period. Production in JIT firms is characterized by its short period and flexibility, which may take very short periods, which refutes the previous criticism [41].

In the reverse flow costing system, the focus lies on successfully finishing and delivering production to the customer. If production progresses based on an independent order or payment and if delivery occurs punctually, any postponed registration does not result in a noticeable information delay. This absence of delay hinders comparisons and promotes the utilization of the target cost approach [42].

Above all, the approach targeted for its application focuses on an important aspect, which is the attempt to get rid of unproductive activities that do not achieve the added values, including, as many writers indicated, those related to the allocation of indirect costs [43], and this is related to the multiplicity and complexity of the procedures for recording, identifying, and recording deviations in the price of direct materials, as the goal is to try to reach the lowest cost that can eventually achieve the goals of continuous development [44].

According to what the researcher previously indicated, the Back-flush costing system is based on starting with outputs and considering that the output point is the accounting registration point. Trigger point, and back-to-back allocate the cost between the goods ready for sale and the stock (consisting of raw material stock and work-in-progress stock).

At the outset, we briefly refer to the form of accounting registrations which summarizes them in three steps that include determining the purchase cost and recording it, proving the cost of finished production, and finally the stability of converting complete production into sold production.

Three alternative methods of implementing a Back-flush costing system are referred to by Hicks [45] and Zhang [46]. In this manner, numerous accounting restrictions associated with recording the exit of materials can be addressed.

- **First method:** It is to cancel the production in process account. But this method will not help to shorten a lot of accounting procedures.
- **Second (shortened) methods:** It does not recognize an account for merchandise inventory or production in process, but it is noted on this method that it is very brief and assumes several assumptions, the most important of which are:

- Purchases are made in small quantities.
- Purchases are made immediately before use.
- Immediate sale and delivery.

While these assumptions may be theoretically sound, adherence to them does not result in the desired level of disclosure and fails to offer sufficient cost information on various project transactions.

- **Third method:** It eliminates the production-in-progress account and the finished production account. It is noted in this method that the accounting registration points are represented at the point of purchasing raw materials, where the actual cost is used in evaluating the inputs, and at the point of the goods' transformation into ready-to-sale goods, where the standard cost is used in evaluating the outputs. The constraints of proving the cost of full production and at the same time, becoming more realistic, for fear that purchasing in relatively large quantities, may result in high deviations in the price, and therefore resorted to the need to refer to the price deviation.

As a consequence of the aforementioned factors, the implementation of reverse flow costing systems led to the categorization of accounts into two distinct types. One type involves the computation of operating materials, while the other focuses on calculating transfer costs. Additionally, this system facilitated the division of the immediate production project into logical input and output points, which we refer to as accounting registration points. Consequently, the inputs were recorded based on the actual cost, whereas the outputs were recorded based on the standard cost. It is important to note that the determination of input value is solely based on the standard cost. This entire process aids in the implementation of a continuous development policy. By excluding the production-in-progress account, the issue of determining homogeneous equivalent production has been resolved. Lastly, it is worth mentioning that the previous system clearly indicates advancements in productivity between the two accounting recording points.

2.2 Using the Throughput Accounting and the Back-flush Costing

It was found by the researcher from several previous studies, Staubus [47], Barkhordari and Denavi [48] that the large number of activities will complicate the application of activity-based costing, and the increase in activities that do not add value will complicate the achievement of the basic objective of activity-based costing, which could be avoided by reducing the volume of accounting activities when applying the Back-flush costing. However, the problem of the reverse flow costing system not indicating the development of high-cost activities and the correction of this criticism may lead to an additional trend towards further cost reduction, which represents one of the aspects of criticism of the reverse flow costing system that made the application incomplete. It needs an additional system to complete that deficiency, which is what you see achieved when applying the activity-based costing system, which includes an analysis of activities with a view to getting rid of those activities that do not add value to the enterprise.

It has been shown from the discussion of the activity-based costing system in many previous places [49,50]. It is considered necessary and important to achieve accuracy in measuring the cost of various activities and thus accurately determining the cost of production in the end, which can often avoid activities that do not achieve value.

Nevertheless, Vokurka and Lummus [51] empirical findings have demonstrated that despite the aforementioned benefits, activity-based costing may not always yield a return that surpasses the cost of implementation. Particularly in rapid production environments with numerous small orders, the process of gathering the necessary data to derive cost information based on activities is deemed highly costly. This contradicts the objective of cost reduction pursued by such projects, thereby providing a compelling rationale for the limited adoption of the cost system.

From all of the above, it is clear that there is some conflict between the application of the activity-based costing system, which results in a high cost of measurement, and the philosophy of immediate production projects, which are based on cost reduction in various ways and means, which encouraged Japanese companies not to expand the application of the cost system. Depending on the activities, restrict its used [52] and shift to an interest in applying the reverse flow costing system and surplus accounting, all with the aim of achieving cost reduction [53].

Confirming the aforementioned, it was noted that Zimmer [54], stresses the significance of the two systems coexisting by expressing:

> *“Some sectors of the accounting world would want to set throughput accounting (TA) against activity-based costing (ABC).... That's a whole lot of junk because you need to add information, and they're both adding something. [ABC] doesn’t tell you anything about how the business can make money; it doesn't tell you how many [products] they can make or how fast. But [TA] will never tell you the right price to go to the market for a product.”*

The accounting system is designed for the JIT/agile of production throughput accounting in a way that works to provide cost data ,about those establishments that are characterized by dollars in purchasing and production synchronous firms. At the same time, the accounting system for JIT/agile production has shortened many of the constraints of cost recording, such as the constraints of allocating additional cost to products, which were common in the traditional costing system.

It has been observed that the prior application aligned with the trend among numerous companies towards implementing optimal systems and enhancing production technology efficiency. This shift aimed to move away from conventional production methods towards utilizing cutting-edge systems supported by computer-assisted production technology. The expansion systems in production technology aim at dividing resources into controlled (scarce) and uncontrolled resources in order to support and develop the exploitation of these controlling resources in order to reduce the total cost of the project. In addition to the foregoing, these systems aim to work on increasing the surplus resulting from the firm by focusing on controlling resources and increasing the degree of their exploitation, and finally working to reduce the total operating cost of the firm on the basis of extracting a rate of surplus at the level of each of the controlling resources, which is the matter. This has confirmed and indicated the importance of using the throughput accounting system for JIT/agile production as a complement to the efforts to reduce costs in immediate production firms.

The accounting system for the immediate flow of production is considered a short-term cost system, which simplifies the procedures for determining the cost, helps to develop the exploitation of scarce resources, and is easy to apply. This system is divided into three cost measurement processes, which can be summarized as follows:

- **Surplus rate:** It refers to the rate at which the system achieves surplus funds resulting from sales operations, compared to a specific denominator used in determining it, such as the hours of operation of certain machines or the size of a certain investment.
- **Inventory cost:** It refers to the amounts that have been invested in the stock as a result of purchasing products or raw materials for the purpose of reselling or manufacturing them.
- **Operating costs:** This is represented by the sufficient costs required to convert the raw material into a finished product.

To clarify, it should be emphasized that implementing the throughput accounting approach in just-in-time production can significantly impact the efficiency and effectiveness of utilizing limited resources, which serve as bottlenecks in the project. By establishing an excess rate for each unit of scarce elements, it becomes possible to enhance the utilization of these units, thereby optimizing their usage. This, in turn, supports the objective of continuous development by increasing the exploitation rate and also highlights the progress of costly activities within the organization. The overall performance of the project is contingent upon its development, which we have previously identified as a weakness in the Back-flush costing system. To address this, the throughput accounting system has been adopted to rectify the criticism, along with the integrated and coordinated implementation of activity-based costing, either in full or in part. In this context, Dubey and Gunasekaran [55] pointed out the importance of reaching a surplus rate that is used in evaluating performance at the firm level and at the level of the different performance departments.

> Surplus Rate = Surplus / Production in process value + Total other costs (at the level of the project or department)

It has been suggested to develop the return of the previous surplus rates at the level of the different performance departments and at the level of the different performance-based individuals, and here many developments appeared. A distinction has been made between two categories of performers. The first category is those who work on machines or resources that represent choke points, and these surplus measures are designed for them on the basis of working to reduce or eliminate the cost of production in operation as well as other cost elements, which is the matter, which in turn encourages and gives the surplus rate a more vital role in terms of its importance in providing different data on the project costs in the form that suits the implementation of the goal of cost reduction and even indicates the relative development that can be made in the process of cost reduction as a result of each sub-activity separately.

For workers operating on machines or resources that are not scarce, the surplus rate has been restructured to incentivize adherence to production schedules while continuously reducing implementation times. This approach highlights their efficiency without promoting increased production during times of reduced implementation times. Additionally, providing additional training programs and leveraging the functional diversity of workers in immediate production facilities can enhance their ability to improve product quality, quality control, promotional efforts, and more. These strategies underscore the significance of accounting practices in JIT/agile production for cost reduction.

According to the foregoing, the system of accounting for the JIT flow of production in the short term indicates that the direct materials component is the only variable cost component, while the rest of the cost components are fixed cost components [56]. To clarify this, in order to show the impact of the throughput accounting approach on the immediate flow of production in the evaluation and development of performance, it is noted that the surplus is a function consisting of four sub-variables, including [57]:

i. Sale price.
ii. Raw material purchase price.
iii. Raw material utilization rate.
iv. The amount of surplus generated.

The inclusion of the surplus as a dependent variable and an independent variable in the same function is of particular importance when taking into account the cumulative effects of the surplus from previous years on the surplus number for this year, which strengthens the use of the function in the various stages of accounting forecasting and avoids many statistical problems that face estimating parameters (values) for this function.

In order to expand the use of the concept of throughput accounting in order to expand sales and to rationalize the use of direct materials, which ultimately helps in the expansion of production, to the extent that does not result in the presence of a large stockpile, keeping pace with the goals of immediate production projects, it is necessary to start reviewing the factors that represent some constraints on the surplus, which can be summarized in the following [58]:

i. Uncompetitive selling prices.
ii. The need to distribute goods to specific consumers at a specific time.
iii. There is a scarcity of high-quality goods.
iv. Supplier delays in delivering raw materials and irregular supply
v. There is a shortage of productive resources for the project.

The significance of throughput accounting for JIT/agile production lies in its emphasis on the facility's capacity to meet consumer demand. However, a major drawback is the restriction of direct materials cost as the sole variable cost component, treating other costs as fixed [59]. This highlights the importance of integrating activity-based costing and time-driven activity-based costing alongside throughput accounting, or viewing the latter as a complement to Back-flush costing for tracking transfer costs [60]. Fig. (2) illustrates the impact of partial optimization on project profitability.

The figure presented earlier shows that only the direct materials cost is deducted from the selling price in order to determine the surplus amount, with the assumption that other cost elements (transfer costs) remain fixed. This reflects the transformation in cost allocation for JIT/agile firms, where previously fixed costs have been reclassified as direct costs for activities such as raw material handling, supply order processing, and machinery depreciation. This underscores the importance of adopting multiple cost approaches, ultimately supporting the utilization of both the Back-flush costing system and the surplus flow accounting system [61].

In order to resolve more controversy in this part, we can, after the previous presentation, confirm that there are many aspects of integration between the Back-flush costing system and the surplus flow accounting system.

The proposed model for rooting the integration between the two costing systems (Back-flush and the Throughput accounting system) for JIT/Agile production:

It is noticed from the analytical study that it was carried out with the aim of rooting for both of the previous developers, the existence of complementarity between them in each of the procedures, and the goal and concept of each of them.

In terms of procedures, the procedures of each of the previous two systems (i.e., the Back-flush costing and the throughput accounting) are almost integrated with each other and similar at the same time. The procedures of each of them aim to simplify the process of recording cost elements and not follow complex registration stages, which impede the achievement of the goal of JIT/agile production firms, and to provide cost information as quickly as possible.

In the meantime, it has been noticed that high-automated firms require the application of the above-mentioned suggestions and are including both the features of the JIT and agile systems from one side and the resilient systems from the other. The new features here in our suggested model are:

1. We assumed that our model was applied in a state of uncertainty.
2. The comprehensive feature of our model is that it includes the effects of the endogenous variables, measured through the application of the JIT/agile systems, and also the effects of the exogenous variables, measured through the application of the resilient systems.

The formation of this model should try to present and affect the results of the measurement and the intersection features of both systems, a matter that will ensure the accuracy of our model's results and the high rate of goodness of fit of this model.

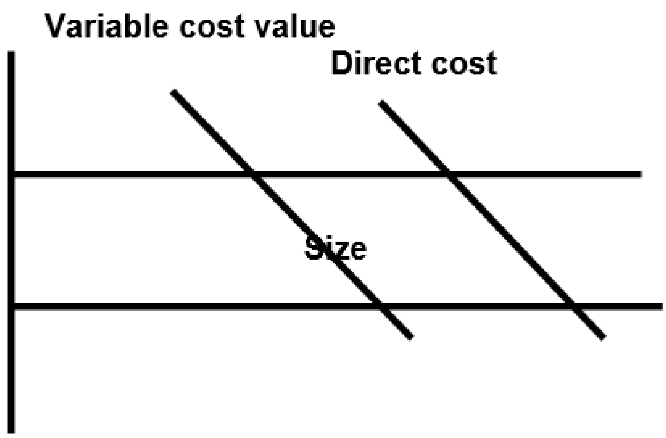

Fig. 2. Maximizing the profitability of production (The Surplus Production)

1. Measuring the exogenous variables facing the new automated firm will support the application of the new intelligent green supply chain between the different production firms.
2. The concept of the green supply chain was considered here with more focus on the environmental variables in an uncertain state of the art, depending upon the intensive usage of resilient systems.
3. The current used new model has pointed to more additional advantages, as it can without any doubt pick up the intangible effects resulting from the existence of some differences between different parties of the game, either in terms of different systems used or different accounting approaches applied, or finally, the different partners of the intelligent supply chain supposed .

In terms of the concept, both the Back-flush costing system and the throughput accounting system, or what I called super-variable costing [62], both seek to not recognize the existence of commodity stocks and also to try to simplify the accounting performance as one of the activities that do not add productive value to the JIT/agile production firms. In this regard, the system of accounting for the throughput is complementary to the system for determining the cost of the Back-flush. Back flush costing represents one of the aspects of interest in the accounting system for the immediate flow of production. This stems from the fact that the latter system gives special attention to calculating an average of the accounting surplus at the level of each of the controlling resources, and accordingly, it can be referred to the development in the time of delivery and in the number of times the materials are handled.

Furthermore, the Back-flush costing system and the throughput accounting system have not only addressed the criticisms directed towards the activity-based costing system, but they have also highlighted the significance of selectively applying it to specific private activities rather than all activities within a firm. This approach aims to mitigate the various challenges that arise from its implementation, particularly the exorbitant costs associated with it and the limited returns obtained. All of the foregoing has been formulated in an integrated form, which helps the JIT/agile production firms obtain the expected output from each of the previous systems in a way that supports their orientation towards reducing costs and achieving considerations of continuous improvement [63].

Simultaneously, the Back-flush costing system and the throughput accounting system have both achieved a suitable foundation. This foundation supports the cost accounting library, which adds scientific significance to this research. Additionally, it paves the way for other researchers to delve deeper into these topics. The ultimate goal is to comprehensively study the requirements of JIT/agile production firms, which hold a tangible presence in the market [64]. This necessitates further studies and research to strengthen the scientific justification for their existence. Furthermore, it emphasizes the economic feasibility of investing in these firms and, ultimately, discovering modern systems that are suitable for their implementation. These systems will enable the firms to effectively carry out their activities, achieve their objectives, and uphold the established philosophy [65].

As we have already mentioned, the results of the Back-flush costing system, although they provide quick cost information at a low cost and help in taking many decisions, are not suitable for the process of performance evaluation during the various project pillars or the performance evaluation of the various production cells. Here came the system of accounting for the throughput accounting and helped to calculate the surplus rate at the level of the different production cells and at the level of the various controlling resources, which eventually helped to solve the problem of performance evaluation and to reach objective and appropriate methods, which prompted us to emphasize the unity and integration of the analysis (i.e., the unity of the ultimate goal of the application).

In addition to the foregoing, the Back-flush costing system and the throughput accounting system represent short-term costing systems that are suitable for taking appropriate decisions in these circumstances, which indicated the importance of their integration with the activity-based costing system to complete the need for long-term decisions. Varsei et al. [66] and Yun [67], although both the Back-flush costing system and the throughput accounting system recognize an approach that approximates the variable costing approach, with some elements considered fixed in the short term. However, in the long term, all cost elements are considered variables, which support the application of the previous systems in addition to the application of the activity-based cost system on certain activities characterized by their high cost, justifying the resulting return from the measurement cost that is incurred when applying this cost system. Hence, it can be noted that the previous application will help to switch to the application of the comprehensive download approach, which in turn helps, in the end, to take strategic decisions for the firm and support the trend towards taking into account the considerations of continuous improvement.

To optimize the benefits gained from the previous explanation, it has been proposed to utilize a model that reduces costs and addresses the various obstacles encountered by the project. This involves maximizing the surplus while navigating multiple constraints that impact the firm's performance. The available programs are designed to achieve this objective. For instance, within linear programming systems, one suggestion is to employ a proportional function that considers the appropriate allocation of additional cost elements. This function takes into account all aspects of negotiation and the combined effects of both internal and external variables faced by the JIT/agile production firm. It aids in rationalizing the utilization of scarce resources and making informed decisions. Through application, game theory emerged as the preferred approach, emphasizing the significance of multiple parties involved in the game. This complexity adds challenges to the decision-making strategy, aligning it with practical realities. A proportional hommollifier function, incorporating the positive effects of the Elgibaly function [68] and the negotiating impacts of decisions and various parties, is employed to maximize the firm's objectives. Consequently, these considerations have shaped the formulation of the functions within the aforementioned model. For more detailed information on the model's development, please refer to Elgibaly [69].

$$\textbf{Max: } U = G\,[X - C\,(y) - S\,(X, Y)]$$

Whereas G [X - C (y)] represents the net return of the firm's probability of making a certain decision (here we can consider it as the revenue from the sale of the commodity, which takes the form of probability in its amount and on the date of its realization as an endogenous variable among other estimated variables), and S (x, y) represents the cost of direct materials. The cost elements were considered the only variable, and here they take the form of a function affected by the quantity used and the quality of the direct material as well as the level of its quality... etc., and with the passage of time and the high productivity of the immediate production firm, using the surplus rate model, which makes the model more inclined to represent the firm's situation in the long run instead of the short run, we can use (ri), which gives an indication of the high productivity of the raw material used (the only variable cost component). According to this case, the surplus maximization model takes the following form:

$$\text{Max.}$$

$$a., y., S\,(X, Y)\ \{\sum_{1=1}^{2} f\,(r_1).\ [\sum_{1=1}^{2} G\,(X_1 - c\,(Y1) - S\,(x1, Y_1)\ f\,(x1\ \{a., Y., r...)\}$$

Subject to:

$$\sum_{1=1}^{2} F\,(r_1).\ \{F\,(s\,(X_1, Y_1).\ f\,(X1\ I\ a., Y., r,) - V\,(a) = F$$

$$A, \text{Eargmax}\ (\sum_{1=1}^{2} F\,(\ s\,(X_1, Y_1)\ .\ f\,(X_1\ I\ a., Y., r,)\ V\,(a)$$

$$a.\ A$$

Nevertheless, in order to advance the existing mathematical model and consider the variety of resources available (some of which are limited while others are not, mainly exogenous variables, etc.), along with the various negotiations and discussions regarding the selection among different options such as producing, purchasing, or accepting/rejecting certain additional external orders, it is imperative to proceed with the enhancement of the aforementioned model. This enhancement involves taking into consideration the impact of the adjusted Hommolifier values on the distribution of surplus resulting from the allocation of resources within the firm, as well as the presence of numerous trade-offs and negotiations during internal decision-making processes, which often lead to the selection of a specific set of resources.

The steps involved in preparing the previous model include the following stages:

1. Assuming that each of the scarce resources works for the benefit of a number of production cells and that there are a number of alternative uses that can allow a mixture of exploitation or benefit bundle of usage, which gives a surplus or return represented by the function (V).
2. There are a number of production cells that can be allied together (M) in a cooperative game, which is at the same time a part of all the production cells of the firm (N), with the condition of free exchange of information between the previous production cells, and the need for each cell to know the scarce resources of each of the other cells (which represents the main features of the intelligent supply chain).
3. When a negotiation takes place between two cells to achieve a mutual benefit between them, this negotiation must result in the occurrence of a specific alliance, which takes the form {i,d}, indicating that the negotiation has come to a positive conclusion.
4. To indicate the importance of the passage of time and the succession of periods, the parameter (d) is used to find the present value in period 0 for future periods. From here, the surplus realized for center (i) as a result of the alliance process with other centers, according to the cost borne by this center, represented by the symbol rti, during the succession of periods, can be expressed by the following relationship:

$$\cap\, 1 = \sum_{\infty}^{1-0} I = a\,([1 - d)\,K\,(Mt1) - E_{tv}]\,d_t$$

Whereas M_{it} is the operational capability of the control elements of the production cell (i), which represents a part of the operating capability of the firm as a whole. From here, the model has acquired a long-term character after using the discount coefficient.

From all of the foregoing, it is noted that the return is entered or presented to each production cell, which has an operational capacity of M in case q, and can be obtained by the following:

$$S\,(M, q) = \sum_{A \subset q} \frac{(U\,(A) - 1)\,!\,(U\,(N) - U\,(A)\,\{\bar{V}(A) - \bar{V}\,(A/M)\}}{U\,(N)\,!}$$

Whereas U (A) is the number of elements and relationships that lie on q, as well as:

$V\,(X) = V\,(U, \Sigma\, C^{a})$
$C\, \Sigma\, q$
$M\, \Sigma\, q$

A represents the value of the assignment between the different centers of the outcome of the negotiation.

Various efforts were made in previous studies before arriving at the subsequent adjusted version for equitable distribution, which took into account the varying impacts of alternative constraints, negotiations, and goals.

$$S\,(i,N) = \sum_{M \subset N} \frac{C\,|M|\,-1\,|M|\,)!\,V\,|N\,|\,M\,|\,(t)}{|N|\,!}$$

Whereas $|N|, |M|$, is the measure of quantitative value (Cardinal numerically expressed or scaled for groups $|N|, |M|$).

To complement this descriptive function, this complement must be used:

$$\bar{V} \blacktriangleright : 2^{N} \quad IR^{+}$$

Whereas:

$$V(M) - V(N) - V(V/M)$$

$$M \Sigma N$$

Aresearch has done, (Charnes et al, 1978) by introducing a standard value of the proportionality in the previous value relations, we can call it the hommollifier function as follows:

$$h\,|M| = \frac{|M|}{|N|} V^{-}|M| + \frac{|N| - |M|}{|N|}$$

Here, the boundary of the equilibrium of utilities limits of the equilibrium for a match between different production cells grows to the value determined by our scale by overlapping the proportional function in cooperative games.

In fact, the model in this formulation has achieved what has been proposed since the beginning, with the existence of a desire to measure the endogenous and exogenous variables that illustrate the existence of agile and resilient systems in a single multi-function (closed loop) supply chain.

The effectiveness of certain assumptions from this prior model has been demonstrated in various contexts, particularly in allocating additional costs among different performance centers. Therefore, we believe it is suitable to extend its application in formulating the objective function of the JIT/agile production facility. This approach takes into account multiple constraints that govern its performance, ultimately aiming to maximize the surplus.

The game that has been established between the suggested model for implementation and the research goals aimed at cost reduction has revealed the comprehensive nature of the model. By considering all explicit cost elements, including those directly influencing surplus generation, as well as other relevant factors, the effectiveness of the model becomes evident [70]. The non-explicit, resulting from the negotiation processes between the previous production cells, indicates more precisely the possibility of reaching a more acceptable plan to reduce the cost, the effect of which extends to the future, which leads to the acquisition of both the Back-flush costing system and the throughput accounting system, a feature that assists in the achievement of the goals in the long term without limiting them to the short term.

In addition to the foregoing, adding the effect of negotiations to the function of maximizing the realized surplus has made the model dynamic and removed it from the cycle of static that characterizes traditional surplus maximization models, especially linear programming models, etc., which gives an additional advantage to this work and is inherently suited to the environment around JIT/agile production firms, which makes the model more feasible [71].

This model also refers to another more advanced dimension, which is related to the development of performance appraisal methods in JIT/agile production firms. Furthermore, apart from its effectiveness in maximizing surplus within the limitations imposed on the controlling resources, the model also differed from the traditional Shapley model [72] in terms of the equal distribution of surplus among production cells. Instead, it prioritized fairness and realism in allocation by considering the operational capacity of each production cell when determining the surplus distribution plan resulting from the match.

3. RESULTS AND DISCUSSION

In order to validate the efficiency of the suggested model, we implemented it in a hypothetical scenario based on a case study similar to the one utilized by Elgibaly model. After making various enhancements to the model and the computer software used, we anticipated a surplus of 4000 units resulting from the utilization of a particular resource. This surplus was projected to be divided among the various stakeholders in the supply chain. Following the initial implementation of the computer program, partnerships were established among the partners involved.

(M1, M2, M3, M4)	**3840**
(M1, M2, M4, M5)	**3760**
(M1, M3, M4, M6)	**3680**
(M2, M4, M5, M6)	**3560**
(M2, M3, M5, M6)	**3320**
(M3, M4, M5, M6)	**2800**
(M1, M2, M3, M4, M5, M6)	**4000**
V { I, J }|	**1800**
V { I }	**0**
I # J	
IΣN	
MΣN	
S (I,J)	
VΣ2 – IR⁺	

Based on the foregoing, the objective function has been formulated as follows:

Mini, α

Subject to:

M1 + M2 + M3 + M4	**+α >3840**
M1 + M2 M4 + M5	**+α >3760**
M1 + M3 + M4 + M6	**+α >3680**
M2 + M4 + M5 + M6	**+α >3560**
M2 + M3 + M2 + M6	**+α >3320**
M3 + M4 + M5 + M6	**+α >2800**
I + J ⁺	**α >1800**
I⁺	**α >0**
M1 + M2 + M3 + M4 + M5 + M6	**α = 4000**

The solution sequence in the previous model resulted in a satisfactory allocation of the surplus among the different supply chain partners, which appears in the following proportional allocation function:
V (M) = {1060, 940, 640, 560, 420, 380}

The following table summarizes the result of the negotiations that took place between the different parties and partners of the supply chain.

Table 1. Summarizes the result of the negotiations

Compromises between Cells	Allocated Surplus	Available Energy	Possible Alliances	Excess Demand	Competed Partner
380	1060	3840	M1, M2, M3, M4	1440	M1
220	940	3760	M1, M2, M4, M5	1160	M2
180	640	3680	M1, M3, M4, M6	850	M3
150	560	3560	M2, M3, M5, M6	710	M4
120	420	3320	M3, M4, M5, M6	540	M5
100	380	2800	M3, M4, M5, M6	480	M6

The results obtained earlier were based on a hypothetical scenario to validate the proposed model and its practical applicability. It is expected that the availability of additional data in the future will confirm the aforementioned results.

4. SUMMARY AND CONCLUSION

During the current work, a whole picture was drawn, including the effect of the intelligent supply chain and how rationally directing and managing this chain could affect the whole cost management system, especially in large firms and organizations. Back-flush costing and throughput accounting has organized and analyzed the performance in JIT/agile [73]. This application has given a better chance to understand how to make the intelligent supply chain in favor of the new automated companies with the concern of both endogenous and exogenous variables.

Optimizing a Just-in-Time (JIT) Supply Chain and Agile Systems with Back-flush Costing and Throughput Accounting offers several key benefits [74]:

1. **Improved Efficiency and Reduced Waste:**

   - **JIT Supply Chain:** Minimizes inventory holding costs and potential waste by receiving materials only when needed for production.
   - **Back-flush Costing:** Eliminates the need for detailed cost tracking during production, reducing administrative overhead.
   - **Throughput Accounting:** Focuses on maximizing throughput (units produced) rather than allocating costs to specific products, aligning with the JIT and Agile goals of fast production cycles.

2. **Enhanced Visibility and Decision Making [75]:**

   - **Agile Systems:** Respond quickly to changes in customer demand and market conditions.
   - **Throughput Accounting:** Provides real-time data on bottlenecks and production flow, allowing for quicker adjustments.

3. **Increased Profitability [76]:**

   - **JIT and Agile:** Reduce overall lead times, leading to faster product delivery and potentially higher customer satisfaction.
   - **Back-flush Costing and Throughput Accounting:** Simplify cost calculations, potentially leading to more accurate cost estimates and pricing strategies.

4. **Better Alignment [77]:**

   - **JIT, Agile, Back-flush Costing, and Throughput Accounting:** All share a focus on continuous improvement, waste reduction, and efficient resource utilization. Aligning these systems promotes a cohesive approach to production and cost management.

Here's an additional point to consider:

- **Back-flush Costing** may not be suitable for all companies, particularly those with complex production processes. However, it can be very effective in a JIT environment [78].
- **Overall, optimizing these systems together can create a lean and responsive production environment that maximizes profitability and customer satisfaction [79].**

Based on the information provided, the researcher can confidently assert that the outcomes of this research serve as a solid foundation for implementing cost determination through Back-flush and managing the just-in-time/agile production flow.

The most important results of the current model's application can be summarized in the following points:

1. The model has confirmed its validity in cases of continuous bargaining between the different parties in the supply chain.
2. The application has produced objective and most acceptable results due to the goodness of fit of the model and the realization of the different powers and weaknesses of each partner.
3. The model can be considered a way of distributing the capabilities of each partner as well as the level of organization of the deal as competitive or cooperative between the different competing parties of the supply chain.
4. Further studies are still required to maximize the application and further realize the different states of uncertainty.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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