

A simple purchase decision-making tool – development and use

Mansur M¹, Maligo C²

Abstract This work presents a digital tool that can help any distributor facing purchase decisions involving three possible suppliers of the same good. Upon purchasing, the product is going to be transported to storage terminals and shipped afterwards to the retail network. The tool offers a map-table output whose construction and features give it important characteristics: interactivity, speed of response, and a colorful simulator-like look. Considering the ongoing changes in Brazilian downstream fuel market, this work presents the creation of such a tool to demonstrate its use and potential application. The resulting tool showed high potential of application to real-life situations as well as adequate characteristics for education purposes.

Keywords: zone of influence, purchase, logistics, simulation, education.

1 Introduction

The importance of logistical strategy decisions in supply chain operations is well established. Planning and building the supply chain is important, but there are also daily decisions that can strongly influence its performance and thus are decisive for achieving the intended results. Among these decisions, purchase decisions³ may be one of the most frequent if one is dealing with several possible suppliers and constantly changing prices.

In such a scenario, the ability to take fast action can make a difference. Digital tools like software and, more specifically, simulators, are widely used today and can help plan and operate supply chains. They come with several levels of complexity and, of course, price. But do companies always need to spend a lot and have the best system? What if the solution could be created with a general-use software already available on the company's computers?

Similar reasoning – especially about the need for simplicity and for the ability to search for visual output – had already led to a tool that can determine and show how three zones of influence may change due to variations in transportation costs. [3]. Although its creation was primarily motivated by educational purposes, it was clear that the tool could perform well in real-life business scenarios where an inexpensive and simple software would be sufficient to provide immediate insight to the decision-maker.

The motivation, here, is to explore real-world business opportunities, although keeping the educational use of the results as an additional element. As to focus, since this work involves considering a day-to-day operational environment, it was assumed that the supply chain is running and its costs are known, even if there are some alternatives in aspects like transportation mode, for example. This allows changing the decision variable from transport cost to purchase cost of products at the entry point of the operation.

¹Milena Mansur (✉e-mail: mansur.milena@gmail.com)

²Carlos Maligo (e-mail: carlosmaligo@gmail.com)

Dept. of Industrial Engineering, Pontifical Catholic University of Rio de Janeiro (PUC-Rio), Rio de Janeiro, Brazil.

³ This work focuses on fast reaction to purchase price variations and the advantages of simulating future variations, but it is worth noting the relevance of these price as well. According to Ballou [1] the purchasing sector occupies an important position in most organizations and represents in general 40 to 60% of the value of the final of any product.

As we will see, the tool was developed on an MS Excel workbook whose spreadsheets have several tables with all the necessary data and portray, on the very last spreadsheet, the dashboard where the user fills in the current price available at the three input points, leading to a “map” showing which storage facility should receive the product from each supplier. To emphasize the zones of influence of each of the three entry points, different colors are assigned to each one and are displayed to each storage facility according to the tool’s calculations, thus visually showing from which entry point to supply each facility.

To demonstrate the use and potential application of the proposed tool, a fuel distribution scenario was used. The fuel distribution business is a good scenario for this purpose because companies typically establish a network of physical installations where they receive and store products, and from where they ship the products to their retailers. As can be seen, this network is similar to the one addressed by this work, so the proposed tool can handle it perfectly. In this industry, there is normally little space to maneuver between acquisition price, retailer’s price, and transportation and operation costs. It is a small-margins business, so any improvement counts. The proposed tool allows for faster reactions in the purchase decisions as the inputted price change.

2 Objectives

The objective of this work is to show the building and use of a simple but powerful tool to help decision-making involving several purchase alternatives.

Although the problem and its solution method are not new, this work’s contributions are the simplicity of the tool in terms of its construction and use, its easy customization, and its ability to generate a visual output. As will be seen, these features can be achieved with the use of simple, general-use software, thus avoiding special training and ensuring the low cost of the proposed tool.

The visual output was a must since the authors aimed to develop a tool that could also illustrate, during classroom lectures on Logistics, typical problems, and consequences of different purchase decisions.

To achieve these goals, this work departed from the tool presented by Maligo [3] and created a tool that focused on purchase alternatives, maintaining the visual output feature and the simulation-like abilities.

This work illustrates how this tool can be used by applying it to a recent much-discussed scenario in Brazil involving fuel distribution companies operating in the southern region of the country and how to quickly and easily determine the best option among three purchasing alternatives.

3 Literature Review

This work is focused on a practical goal and presents simulations of real business decision-making scenarios. Simplicity and low cost are among its core features, so the literature review of related works was done keeping that in mind.

The literature review used the SCOPUS database available in <https://www.scopus.com>, accessed in February 2021.

The first search used the keywords ("purchase" AND "logistics" AND "simulation" AND "education" AND "zone of influence"). This combination covered all the main research topics cited in this work. The words itself are rather common, but their combination returned no results.

As a second step, the search was restricted to only three words in order to maximize the outcome ("purchase" AND "logistics" AND "simulation") and resulted in 81 studies returned. Based on the titles, abstracts, and keywords, these works were organized under the following main topics: warehouse automation; price forecast; simulation models using complex commercial software; linear programming; inventory management; decision-making techniques applied for supplier selection; purchase in online marketplaces (consumer behavior, machine learning); multi-agent system simulations of dynamic pricing decision problem; discrete event simulation. The second step shows that the available literature proposes models to optimize operations using decision-making techniques based on complex systems or sophisticated software.

For a focused assessment of works closely aligned to this work, a final search was conducted including the word "excel". This search returned only two results: both for Bottani E. et al. One of them investigates

the optimization of an asset management process in a real closed-loop supply chain, based on an adapted economic order quantity (EOQ) policy (2015), and the other seeks to minimize the environmental burden of a real closed-loop supply chain (2018). Both works referred to a pallet provider.

Table 1. Search summary.

Search in SCOPUS	Keywords	Number of results
Search 1	"purchase" AND "logistic" AND "education" AND "simulation" AND "zone of influence"	0
Search 2	"purchase" AND "logistic" AND "simulation"	81
Search 3	"purchase" AND "logistics" AND "simulation" AND "excel"	2

The literature review described above showed that there is no available simple tool capable of improving multi-provider purchase decision-making with the use of MS Excel. Additionally, it showed there is no previous work with direct application to the liquid fuel distribution business in Brazil.

4 Method

4.1 Overview

The tool is based on a MS Excel workbook consisting of several spreadsheets, each one containing one or more tables where the required data is entered and results are calculated. The distribution of tables among the spreadsheets is not relevant and may be done at the discretion of the creator to suit the simplicity and ease of use to handle each specific case.

The last spreadsheet⁴ is going to be referred to as the “dashboard.” This spreadsheet shows the “map”, the table of the purchase price of the product at the entry of the operation, and the table of the calculated total cost of the product when ready to be shipped from each terminal to the retailers.

The map, as it is going to be referred to in this work, is a table where the results are displayed. In this work, the position of each of this table’s cells representing an installation was defined in such a way as to match, as closely as possible, the region’s geographical map. Matching the map (table) to the real geographical map helps the user better understand existing relationships and greatly improves the power of visually showing (instead of just describing) the problem and the solutions in a classroom situation.

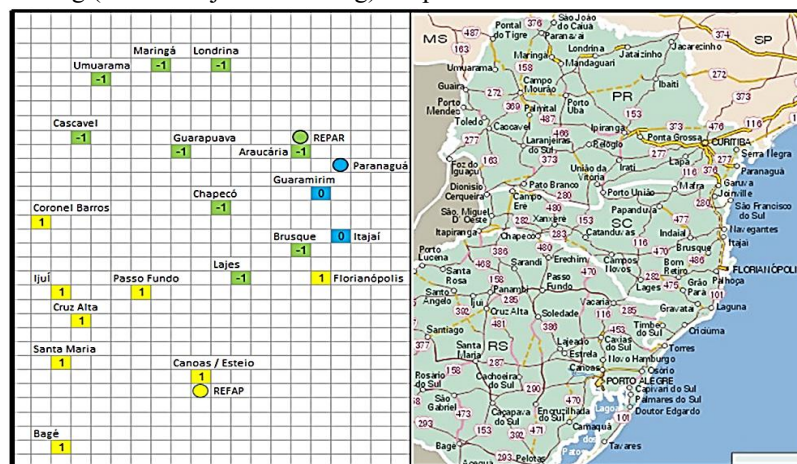


Figure 1 – The “map” (table) resembling the map of the region.[5]

⁴ As was already mentioned, the order of the spreadsheets is not relevant, but it seemed logical to have results displayed at the end.

It is strongly recommended to have the described items on the dashboard. This will allow all the inputs and outputs to be on the same spreadsheet, adding to the simplicity of use and helping catch the user’s attention to changes that can occur in the output should any input be changed.

The layout of the dashboard is also important given the educational objective of the tool. This single spreadsheet can be easily shown to an audience during a presentation and, as the results react instantaneously to changes in the input variables, several situations can be proposed and their corresponding results will be readily displayed on the screen.

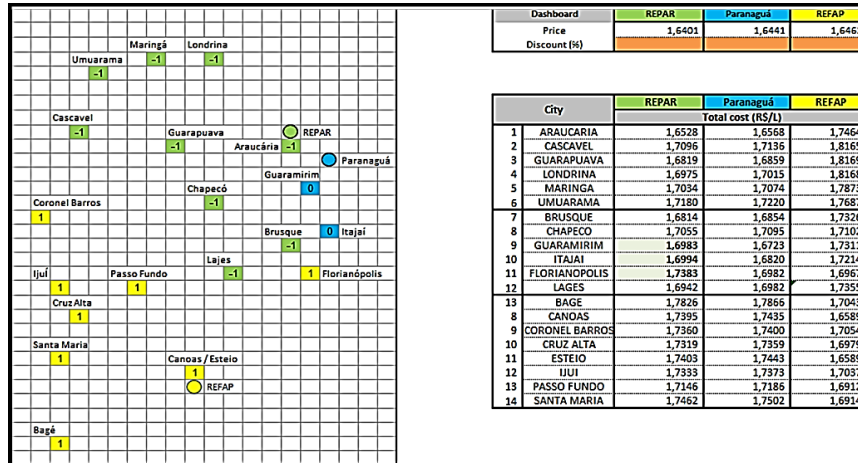


Figure 2 – Layout of the dashboard

4.2 Purchase price table

On the upper-right part of the dashboard (see Figure 2), there is a simple table where the user will input the purchase price at each one of the suppliers and the discount, if any, to be applied to these prices in the calculations.

The purchase price is the object to be studied, since the logistical network is set and its costs are known. Each supplier is assigned a color, with its use explained in Step 3 – the map.

Under each purchase price, the user can fill in a discount amount. If a discount is entered, all calculations will consider the purchase price less the discount amount. Providing a different cell to explicitly inform a discount amount has two advantages. First, it helps the user keep the current price unchanged to serve as a reference price (reference scenario) and, second, it emphasizes the variation that causes the output changes, giving the user useful hints when investigating other scenarios or when negotiating a price to achieve specific targets.

4.3 Total cost table

On the bottom-right part of the dashboard (see Figure 2) the user sees the table where the calculated total cost is shown. This table uses the price (and discount, if any) entered on the purchase price table, as well as the transportation and other costs entered or calculated on the other spreadsheets, to calculate the total cost of the product at the shipping bay of each storage facility.

Going down this table line by line, one can easily see the lowest cost at each terminal and consequently identify the corresponding entry point. Up to now, all that the user needed was a simple MS Excel workbook. It is the map and its capabilities that are going to allow the leap in quality, analysis, and communication that makes this a distinct and unique tool.

4.4 *The map*

On the left part of the dashboard (Figure 2) the user sees the map. As explained in the overview, its resemblance to a geographical map of the region where the operation is carried out is intentional and helps the user grasp the output at a glance, analyze it, and search for alternatives through simulation.

The map is a table--it could not be different since we are in a MS Excel environment--but its construction and features give it important characteristics: interactivity, speed of response, and a colorful simulator-like output.

The three circles in the map represent the location of the three existing suppliers. The storage installations are represented by common rectangular cells. Users can designate these elements however they wish. In the example shown in Section 4, the cities' names were used.

Each supplier is assigned a color, which should match those shown on the other tables of the dashboard. This helps the user to keep track of the amounts related to each supplier. More importantly, each storage installation cell on the map shows the color that corresponds to the supplier associated with the lowest cost solution among the three possibilities, as calculated and shown in the total cost table. This is one of the important simulation-like features of the tool: the ability to change colors to match the amounts and to show the user the best solutions and the zone of influence of each supplier. At this point, it is easy to imagine the power afforded by the tool to its users, as they can now literally see the consequences of any change in a supplier's price. Section 4 – Example will discuss in more depth the simulation possibilities of the tool.

The cells' ability to take on the same color as the best option supplier is achieved through a combination of a formula with the use of conditional formatting of the cells. The formula (1) consists of a series of if-then-else statements assessing which is the lowest cost and, thus, the best choice among the three suppliers, and then assigning a corresponding value to the cell. In this work, the values used were “-1”, “0” and “1”:

$$=IF(AND(AD12<AE12;AD12<AF12);-1;IF(AND(AD12>AF12;AE12>AF12);1;IF(AND(AD12>AE12;AE12<AF12);0;"E"))) \quad (1)$$

The formula (1) shows an additional feature. The last if-then-else was not mandatory since, if the values do not meet the first two conditions, the third condition could be assumed as true. Although logically correct, this assumption was avoided and a third if-then-else was used and will return as its output an “E” (for “error”) in case none of the conditions was met. This feature is especially useful during debugging and final validation of the map since it alerts for errors in the formulas. Such errors are quite easy to make when constructing the formulas at each cell, as every one of them carries several references to other tables' cells.

After the formula finds the supplier associated with the lowest total cost and assigns its respective code to the cell (“-1”, “0” or “1”), the conditional format feature comes into action. Since the cells representing the storage installations will show the supplier's code thanks to the formula, the conditional format in these cells is programmed to fill it with one of the three suppliers' colors according to the cell's value. The result is that each storage installation is represented by a cell showing each supplier's code and color.

This combination of formula and conditional format is the core of the tool and accounts for its advantages: simplicity, user-friendliness, instant answers, and color-enhanced output.

4.5 *Transportation costs and other costs*

Since this work is focused on purchase alternatives and the tool is intended to be used in real-life settings, it was assumed that the transportation costs are known and therefore can be considered fixed costs. The problem here does not involve location decisions. The network is already established, so not only transportation but other common costs, like terminal operation costs and taxes, were considered fixed costs. This is relevant because it means that the tool will deal with the purchase price as the only variable, and transportation and other costs will not influence the purchase decisions.

Although considered fixed, transportation costs will not be neglected. All other costs will not be considered for simplification purposes. It should be noted that all other costs can be easily added in a real-

world application since they are related to installations, locations, or products, and can be handled with the introduction of more tables in the workbook. Transportation cost will be considered because it is the main cost [3] (besides the product cost itself) and will help keep the shipping price (purchase price + transportation cost) closer to real ones, adding reality to the simulations despite the simplified formulas.

As shown in the example below, considering the freight costs and the purchase price is sufficient to demonstrate the zones of influence of the three suppliers.

5 Example

5.1 Background

In Brazil's southern region, distributors can purchase products from REFAP, in Canoas/RS, and ship to terminals by truck or by train; or the purchase may be from REPAR, in Aracuária/PR, with distribution by train, by truck or by OPASC pipeline; or, finally, the decision could be for import products, landed at the port terminal of Paranaguá/PR and distributed by tanker trucks.⁵

Distributors will not necessarily choose the same transportation solutions, even more so because their terminals may have different capacities and receiving modalities (pipeline, train, or only by truck). For academic purposes, this paper will address road freight and pipeline freight options, with a focus on product cost delivered at distributors terminals.

By contrast, in the cities of Guaramirim, Itajaí, and Florianópolis, in the state of Santa Catarina, the main type of transportation is the OPASC pipeline, so this simulation used the cost of pipeline freight charged by TRANSPETRO (Petrobras' logistical operator) for handling fuels and considered the base price plus the additional price for loading tanker trucks.

5.2 Purchase price table and Total cost table

In the present example, it was considered the price published⁶ by Petrobras (Petróleo Brasileiro S / A) for diesel oil A S10 delivered at the REPAR and REFAP refineries with the base date of 9/12/20. For the price of the imported product arriving at the port of Paranaguá, it was used the Import Parity Reference Price⁷ published by the ANP weekly.

The total cost table consolidates the product acquisition costs at the refineries, or at the port, and the discount, if any, with the transportation costs to the terminals, that were entered or calculated on the other spreadsheets.

5.3 The map

In our example, the map shows the fuel distribution installations in Brazil's southern region. The region is supplied by two refineries (REPAR and REFAP). Close to REPAR is the port of Paranaguá, with its important liquids terminals which offer an alternative of supply through importation. These are, thus, the three suppliers of the example scenario.

The cells representing the storage installations were located on the map close to the nearest city. In this example, they are going to be referred to as FDT (fuel distribution terminal). This work considered FDTs

⁵ There is a third refinery at the southernmost border of the region, which was not included in this work because, since its production is only approximately 10% of REFAP's, it does not influence the scenario herein.

⁶ Available in <https://petrobras.com.br/pt/nossas-atividades/precos-de-venda-as-distribuidoras/>

⁷ Available in <http://www.anp.gov.br/precos-e-defesa-da-concorrenca/precos/precos-de-paridade-de-importacao>

with at least 2,000 m³ of storage capacity. This simplification does not impact any aspect of the tool's performance and was made to keep the map less cluttered to facilitate understanding. Keeping the map "clean" is also useful when education is an objective and there is no need to reproduce the sample network in its entirety.

In our example, the map shows the scenario on September 12, 2020 (see Figure 2). This is going to be the reference scenario to analyze the consequences of purchase price changes.

5.4 *Transportation cost*

In Brazil, the fee charged for road transport between two points has a minimum value established by the National Agency for Transport over Land (ANTT). Thus, the values were calculated using the parameters of Resolution ANT 5,890 / 2020, based on Table A (Load capacity), for hazardous liquids' loads. Additionally, the calculation takes into account the empty-return fee, which is 92% of the one-way freight as provided for in § 6 of Art. 5 of said Resolution.

As for the transfer operations from the suppliers to FDTs by road, the simulation used tanker trucks of 40 m³ capacity. Transportation from the FDTs to the retailers is done in smaller trucks. This second transport operation was not considered in this work for simplification purposes. Their cost is not impacted by changes of suppliers, so they do not influence purchase decisions.

5.5 *Simulations*

To demonstrate the tool's capabilities, two simulations are described below. The first simulation shows the effect of a price reduction at REPAR. The second one shows a reduction in the import price at Paranaguá.

Simulation 1. REPAR is the biggest refinery in our example. It is located on the northeast corner of the map. Its competitors are the port of Paranaguá, located due southeast approximately 100 km from REPAR, and REFAP, the other refinery in the scenario, which is 660 km to the south. In the reference scenario, the price at Paranaguá port is 0.24% higher than REPAR's, and REFAP's price is 0.37 % higher than REPAR's (see Figure 2). In this scenario, REPAR represents the best supplier to 9 FDTs of the total 19 FDTs considered, while the port of Paranaguá is the best option for only two of those.

If the REPAR refinery lowers its price, the expectation is that additional FDTs would be supplied by it. To show this effect, Simulation 1 was run applying a discount amount of 1.5% at REPAR. The result is shown in Figure 3, a left-hand map. REPAR has captured 2 FDTs: one previously supplied by Paranaguá and the other by REFAP. It would be easy for REPAR to verify if the captured volume compensates for the lower income that results from the discount amount offered. This could be done repeatedly by simulating the impact of every cent of discount. This simulation ability is a major asset of the tool and a great help to decision-makers, who would be able to predict the market reactions before any price change. In other words, the user is now able to really see the zones of influence of each supplier through the colorful output on the map.

Likewise, the simulations can be used to determine a target price. Supposing REPAR would like to increase its sales (and production), the question to be answered would be: what is the new breakeven point? Or, in other words: what discount amount is sufficient to capture a new demand volume that represents the desire increase in sales? Running a series of simulations could lead to the answer. All that the users would have to do is to lower REPAR's price (increasing the discount amount) little by little until the number of newly acquired, or captured, FDTs totaled the production volume aimed for.

As can be seen, once the model is available (the dashboard and, of course, the map), it becomes easy to imagine a variety of applications to suit the users' needs. The speed of response allows the generation of many scenarios, and even a simple trial-and-error procedure will allow answering user questions about the relationship between price and zone of influence.

Simulation 2. The Port of Paranaguá is located in the city of Paranaguá, about 100 km. from REPAR. In 2019, this port was the third main gateway for diesel oil imported by Brazil. In the country, imports of petroleum-based fuels are relevant to complement domestic supply.

In the reference scenario, the influence of the Port of Paranaguá covers only the Guaramirim area and up to Itajaí, thus serving 2 FDTs. Due to the proximity between the port and the region in question, even though Guaramirim and Itajaí have pipeline transportation from REPAR as their main type of transportation, the base scenario's price makes road transportation viable. As expected, for short distances, although the pipeline provides fewer losses and additional operational safety, road transport is still the cheapest and is usually the preferred choice.

In the FDTs of Guaramirim, Itajaí, and Florianópolis, in addition to the cost of pipeline transportation from REPAR, the distributor also pays a fee for loading tanker trucks, which ends up increasing the cost of transportation by pipeline and could favor road transport depending on the purchase price of the products.

Following the reasoning in Simulation 1, if importers at the port of Paranaguá lower their price, one would expect to see more FDTs being supplied by it. Simulation 2 was run with a discount amount of 0,3% at Paranaguá, and the impact is shown in Figure 3, right-hand map. As a result, Paranaguá captures 10 FDTs, all previously supplied by REPAR.

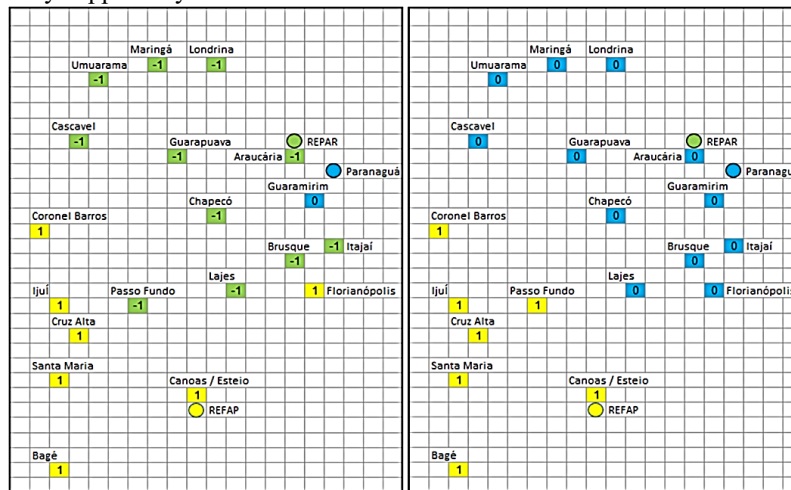


Figure 3 – Results of Simulation 1 (left) and Simulation 2 (right)

This allows us to highlight two main aspects: first, that competition against imports is extremely sensitive, since a small discount altered a large zone of influence; moreover, it demonstrates that REFAP, in Rio Grande do Sul, is somewhat shielded from the competition against imported product arriving at Paranaguá due to the great road distances: although REPAR's entire area of influence resulted altered, only one FDT served by REFAP was impacted.

The example described above was inspired by a study by a team from PUC-Rio analyzing the near-future of the fuel distribution market in Brazil [4]. This study proposes that REFAP's market is naturally protected both from REPAR and the Paranaguá imports because REFAP is located a long distance to the south from those competitors. The two simulations used discount amounts over REPAR and Paranaguá prices to represent commercial attacks by these suppliers on REFAP's market. Both simulations showed big changes in REPAR and Paranaguá markets due to these price variations, but little impact on REFAP's market. In addition to validating the theoretical predictions, this tool's colorful maps clearly show the alterations in zones of influence.

6 Results

The results of the study were rewarding since the tool provided fast and visually rich output as intended. The interactivity with the tool makes it easy for users to simulate as many variations as desired. This is important because it gives users the required information to be able to react rapidly to price changes.

Additionally, users can simulate price changes - not only to predict consequences of changes and prepare for them but also to assess scenarios and the discount amounts that would lead them to approach suppliers to negotiate.

The map's colorful output proved useful to further enhance - and in a real-time way - the effects on suppliers' zones of influence when price variations occur.

The construction and testing showed that the tool has the potential to deal with more complex problems. A suggested future development is the introduction of different transportation costs. This could allow comparing the impact of price variations on companies operating in the same region but using different transport solutions.

It is worth noting that the tool is ready for educational use. A video projection of the dashboard is easily made using standard classroom equipment, and the map's instant reactions to input price changes catch the audience's attention. It is recommended to use the discount amount cells to produce these changes, as this will show the relationship between size or amount of discount and its consequences.

7 Conclusion

This work described how to build and use a tool to help decision-making involving several purchase alternatives. The use of a commonly used software leads to a low-cost solution that is easy to build and requires minimum training to be used.

The tool is customizable and can handle a network of dozens of storage facilities, with an appealing visual output that is one of its major differentials. Additionally, the visual output of the tool offers good results when used for educational purposes during presentations or lectures on Logistics.

Like good simulation models, the scenarios built with the proposed tool provide users with instant responses and a colorful visual output. As a result, simulations become easy and the assessment of many variations takes only a few minutes.

Good performance in real-life situations was an expectation. The example demonstrates the tool's ability to handle a real-life scenario. Finally, no limitations were detected as to its application to other businesses.

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