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Third-party logistics as a competitive advantage in Utilities spare parts management.

A. Navicelli*, F. De Carlo*

**Università degli studi di Firenze, Firenze, FI*
IT (Tel: +39 347-784-7059; e-mail: filippo.decarlo@unifi.it).

Abstract: The maintenance of a large gas distribution network requires daily interventions scattered throughout the territory and with a strong "non-stationary" nature. As a result, the location of spare parts used for maintenance operations is equally distributed throughout the country. Therefore, to increase the productivity of the maintenance teams, it is essential to bring the spare parts closer to their destination, in order to reduce the travel time of the maintenance teams to a minimum in order to reach the intervention address. In this regard, the use of a third party logistic provider is hypothesized, who autonomously manages the shipment and storage of spare parts at transitory warehouses near the first intervention of each team's day. The advantage of increased productivity of the maintenance teams is contrasted by the cost of shipping spare parts and the need for careful planning of in field operations. A basic general model was therefore developed to allow a preliminary assessment of the investment project. The goodness of the theorized model was then validated through its application to a case study, through an analysis of the differential costs between current model and new logistics management, evaluating the investment project with the typical techniques of the payback period (PbP) and net present value (NPV). Results obtained confirm the profitability of the theorized model, and the results obtained from the feasibility study are strongly in favor of the adoption of the new 3PL model for the studied company and so, generalizing, could be a winning strategy for all utilities company.

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Keywords: Supply Chain Engineering and Management, spare parts distribution, Third-party logistics, Utilities maintenance.

1. INTRODUCTION

1.1 General contest

According to Porter, (2008), companies base their profitability on five main activities, as referred by the concept of value chain. Among them, those linked to production are: operations, inbound and outbound logistics. Particularly, logistics has been the subject of studies and attention for its importance in bringing benefits to production (Digiesi et al., 2013). In the last thirty years, companies in each industrial sector have increased the use of a third party logistics (3PL) service provider that manages all or part of the logistics operations (Lieb and Bentz, 2004). At the same time, scientific studies on this issue increased, infact there are many publications in scientific journals on this subject which generated different interpretations of 3PL, analysed in depth by Marasco, (2008). A first definition provided by Lieb, (1992) identifies the third party logistics as the use of external companies to perform logistical functions that are traditionally performed internally. 3PL means any form of outsourcing of all or part of the logistical activities previously developed and managed by the company. A more accurate definition is given by Berglund et al., (1999), which identifies 3PL as the management and execution of at least two activities: shipping and storage of goods.A further definition of 3PL derives from considering, in addition to the tasks performed, also the nature of the relationship between company and logistics service provider. Murphy and Poist, (1998) claim that 3PL involves a deep relationship between the parties characterised by long-term contracts in order to be mutually profitable. An other definition describes 3PL as the relationship between supply-chain interfaces and integrated logistics providers, in which all types of logistics services are offered with all kinds of contracts, with the aim of increasing effectiveness and efficiency (Bask, 2001). In this article, the meaning of 3PL adopted is mainly the second one, limiting the logistics service provider to the transport and storage of articles at proprietary warehouses (Fumi et al., 2013). 3PL has become a topic of studies and research in the scientific literature because its adoption results in an improvement of the market competitiveness of both the logistics service provider and the user (Tate, 1996). In particular, if a cooperation, partnership or strategic alliance is established the economic benefits are linked to the reduction of logistics management costs, to the improvement of service level and end customer satisfactio, to a better access to new technologies and their application besides a reduction of invested capital in assets, facilities, equipment and human resources and a growth in flexibility and productivity. The result is a more effective market access and new skills acquisition (Larson and Gammelgaard, 2001). Through the analysis of the scientific literature, we find that 3PL has developed more in the e-commerce and retail sector in general, where logistics management is very complex

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because of the need to have highly capillary stores in the territory. It also appears that 3PL is applied to spare parts such as in the automotive and aeronautical sectors. In the first case, a 3PL service provider is used for the complexity and breadth of the supply chain. (Feng and Tian, 2008). In the aeronautical sector, 3PL is widely used because the high cost and variety of spare parts make it difficult to keep them in stock. (Zanjani and Nourelfath, 2014). The logistical model adopted is based on integration with 3PL service providers that ship items to both final customers and pick-up points (post offices, lockers, etc.) scattered throughout the territory. In addition to the automotive and aero sectors, there are many sectors where third-party suppliers are used in the logistics management of spare parts in order to optimize the economic performance of the maintenance activities (De Carlo, 2013). Among these, there are no cases of application to the maintenance of utilities distribution networks. The difficulty of applying this distribution model is mainly due to the following reasons:

- the use of bulky spare parts that are often unsuitable for the requirements of ordinary couriers;
- the presence of company vehicles for maintenance technicians that can be used to transport spare parts;
- the large number of maintenance personnel available due to the old maintenance management to be redeployed.

In the recent past, thanks to decisions taken at national and European level (for example, resolution 631/2013/R/gas for Italian gas utilities), which require the remote reading of public utility consumption through remote metering, the mix of maintenance interventions on the distribution network has changed profoundly, and with it the types of spare parts used. In particular, there was a sharp increase in the percentage of interventions to replace old meters compared to other ordinary maintenance interventions on the distribution network, with a consequent increase in spare parts of small size (smart metering) easily dispatched with common couriers. In addition, maintenance on smart metering (battery changeover, replacement) will keep the mix of maintenance interventions unchanged even after replacing the entire fleet of meters. For these reasons, utilities have similarities both for the complexity of the logistics network and for the type of goods managed with the automotive sector; consequently, a logistics model with 3PL service providers for the management of spare parts could be technically feasible and profitable.

1.2 Research questions

In all the contexts in which utilities were managed by public companies until a few years ago, as in Italy, they did not take care of adopting the most economically solution but relied on external suppliers only in indispensable cases such as the delivery to worksites of bulky materials that requires special shipments. The maintenance of ordinary parts (counters etc.), that involves most of the maintenance operations on the proprietary network, is managed as described in Fig. 1. The maintainer arrives at the company warehouse from his home and here he starts his work shift. Then he arrives at the first maintenance address of the day "a".

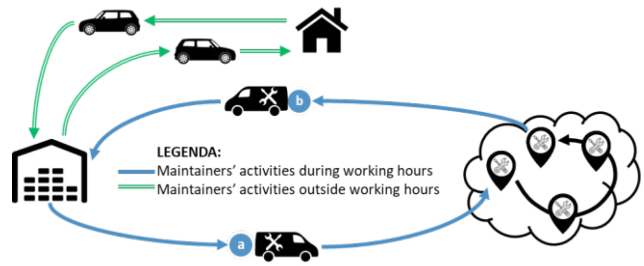

Fig. 1. Typical model of logistics management of spare parts in utilities in the absence of 3PL service providers.

At the end of the daily works, he returns to the company warehouse "b" where the work shift ends and then returns home by car. The activities indicated by letters in Fig. 1 have no added value for the technicians. The productivity of the maintenance workforce is thus limited. There is a second organisational method that increases the productivity of the workforce, in which the company vehicles are entrusted to the maintainers, as illustrated below in Fig. 2:

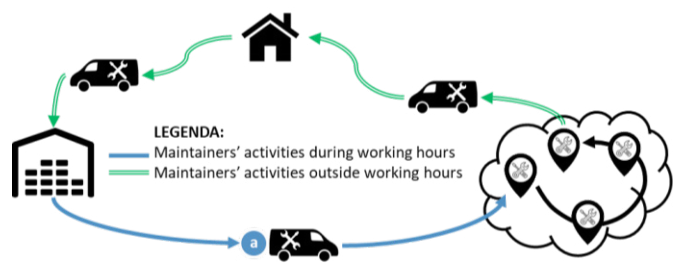

Fig. 2. Alternative general model of the current logistics management of spare parts.

In the alternative general model, the maintainer, starting from his own home, reaches the company warehouse where he starts his work shift. From here he goes to the address of first intervention "a"; at the end of the day, he goes back home with the company vehicle. The new model makes it possible to extend the time available for maintenance work during working hours, since there is only one daily passage from the warehouse. The comparison with Fig. 1 shows, in fact, the absence of activity "b". However, the "a" activity still exists, which, as it has no added value, can be optimized. As described in detail, a possible way to optimise the current logistics model is to entrust third parties with the shipping and storage of spare parts. Based on the ideas proposed, the first research question concerns the identification of the appropriate spare parts management model using 3PL provider (briefly called afterwards 3PL model) with the objective of optimizing the productivity of the maintenance resource Once the correct logistical model has been identified, its technical and economic feasibility will have to be assessed in order to established what are the enabled characteristics of the 3PL provider and if the model is economically feasible. In this context the research questions are the following:

RQ1: Which 3PL model could be applied to increase the productivity of the maintenance workforce?
RQ2: What supplier characteristics are indispensable for the technical feasibility of the theorized logistics model?
RQ3: Is the theoretical model economically viable?

2. METHODS

Based on what mentioned in the previous chapter, the logistics model for the spare parts management involves the use of a 3PL supplier that takes over the shipping and storage of components necessary for maintenance teams. After an accurate planning of maintenance interventions, consisting mainly of the replacement or installation of smart meters, spare parts are shipped, through a logistics service provider, which stores them at its own storage and pick-up points, as close as possible to the address of the first intervention of the day for which those spare parts are needed. Another phase consists in reverse logistics to the company warehouse of the replaced assets. In this way, the path of maintenance workers is reduced as much as possible, increasing their hourly productivity. A diagram of the theorized logistic model is presented in Fig. 3:

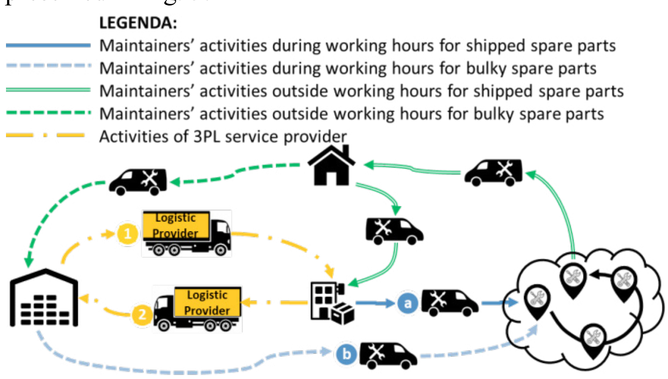

Fig. 3. Theorized logistics model with 3PL provider.

As schematized in Fig. 3, the spare parts that can be shipped are sent to picking points "1". The maintainers start their work shift at the picking points where they leave the waste materials accumulated during the previous working days, which will then be shipped to the warehouse "2". Then, they make the journey to arrive at the first service address of the day "a". At the end of the operations, they finish their work shift and come back home with the company's vehicle. In the few cases in which spare parts cannot be shipped, operators start their work shift at the warehouse and make a longer journey to reach the first daily intervention "b". The main advantage of this model is the increase in labour resource productivity through reduced distances and journey times "a". However, this is in contrast with the need to sustain the shipping costs of the logistics provider. To determine whether the pros are preferable to the contraindications, we have subjected the model to an economic assessment using two main deterministic valuation criteria with discounted cash flow (DCF) for business investments. The discounted payback period of the invested capital and the Net Present Value (NPV) value at the end of the useful life of the investment are used. Assuming constant profits in each period, the value of the payback period (t for which NPV=0) will depend on the discount rate "r" and the ratio between initial investment and undiscounted Cashflow according to the following equation:

$$\frac{I_0}{Cashflow_0} = \sum_{t=1}^{N} \frac{1}{(1+r)^t} \qquad \text{Eq. 1}$$

In this way it is possible to quickly evaluate the investment through the graph in Fig. 4:

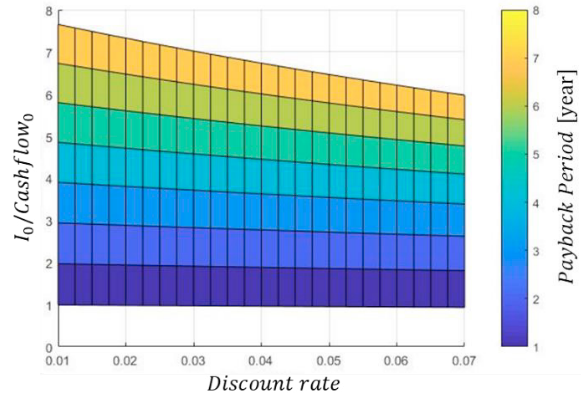

Fig. 4. Business investment valuation.

The general model presented shows that the value of the $Cashflow_0$ can be calculated as follows:

$$\sum_t [Cm_t \cdot (Tasis_t - Ttobe_t) + Ckm_t \cdot (Dasis_t - Dtobe_t)] - \sum_s Cs_s \qquad \text{Eq. 2}$$

Where:
t= Intervention team
s= shipment
Cm_t= hourly manpower's cost for the t-th team
$Tasis_t$-$Ttobe_t$= time difference between as-is a to-be for the t-th team
Ckm_t= unit kilometric cost of the t-th team
$Dasis_t$-$Dtobe_t$= kilometric difference between as-is and to-be for the t-th team
Cs_s= unit cost of the s-th shipment

For the calculation of Eq. 2 it is first necessary to calculate with the greatest possible accuracy the times and distances travelled by the maintenance teams in the to-be model to compare them with the current ones. The calculation of these values is very complex and requires computer skills that are not always part of the company's know-how and therefore require consultancy. For this purpose, the Google distance Matrix API is used, which allows, through the construction of a specific URL address, to obtain an output matrix containing times and distances between two GPS coordinates: https://maps.googleapis.com/maps/api/distancematrix/json?origins=41.43206,8.38992&destinations=42.86748,11.20699&departure_time=1486975200&key=12a34bc
The basic parameters for the operation of the API are the origins and destinations coordinate of the intervention teams and an activation key of the application. In addition, there is the "departure_time" parameter that allows you to activate the traffic forecast model for the correct evaluation of the travel time at specific times. The API can be implemented on Excel by writing two different macro functions, one for distance calculation and one for travel time calculation. In this way, to obtain times and distances between two points, simply insert only the two pairs of coordinates on the spreadsheet. To complete the calculation of Eq. 1, it is also necessary to have the characteristics of the company spare parts, which can be obtained from the management software of the articles in stock, the manpower costs employed, and the kilometric costs of the company vehicles used, which are internal corporate characteristics. It is also necessary to know

the restrictions on the size of spare parts and the relative shipping costs, which can be obtained downstream of an economic offer of the selected 3PL service provider. Once the model is built, all that remains is to test it with a realistic case that could give an indication of the quantities at stake and the associated costs, as well as a preliminary assessment of the applicability of this model to real industrial cases. In addition, the case study may highlight anomalies and limitations of the architecture studied.

3. CASE STUDY

The model proposed in the previous section must pass the economic feasibility test, which is assessed by estimating the differential costs between the as-is and to-be model, before being applied. Due to the extreme number and variability of the factors that determine the convenience of this type of company investment, it is not possible to define a simplified analytical model that allows a quick evaluation of the opportunity to use a 3PL provider for spare parts logistics. Since the study intends to evaluate the theorized model the specific case needs to be studied and the feasibility assessed on a case-by-case basis. Even if a case study research is time consuming and their conclusions hardly generalised it was chosen for its outstanding strength in the study of the phenomenon in its natural setting and meaningful, that allow to generate relevant theory from the understanding gained through observing actual practice. (Voss et al., 2002) : The selected case study is a large Italian natural gas distribution company for civil and industrial users. The company currently adopts a classic spare parts management model, in which all activities are managed internally as shown in Fig. 5:

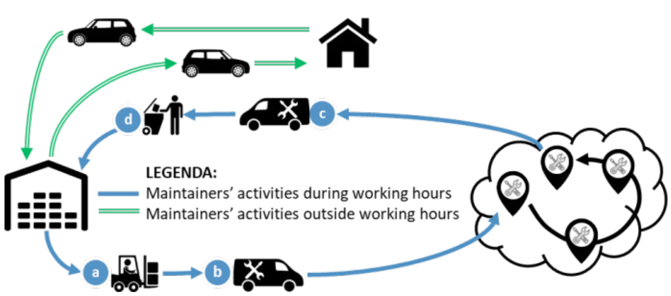

Fig. 5. Logistics management model (as-is).

As shown in Fig. 5, the maintenance technicians begin their work shift at the company headquarters where they pick up and then load onto the car the materials they need to carry out the operations of a working day (a). Then they make the journey to reach the first intervention address of the day (b). Once all the work is completed, they return to headquarters (c) and after discharging any waste materials (d) they end their work shift. The transition to the new 3PL model will result in a differential variation of some of the activities currently carried out, as indicated in Fig. 6:

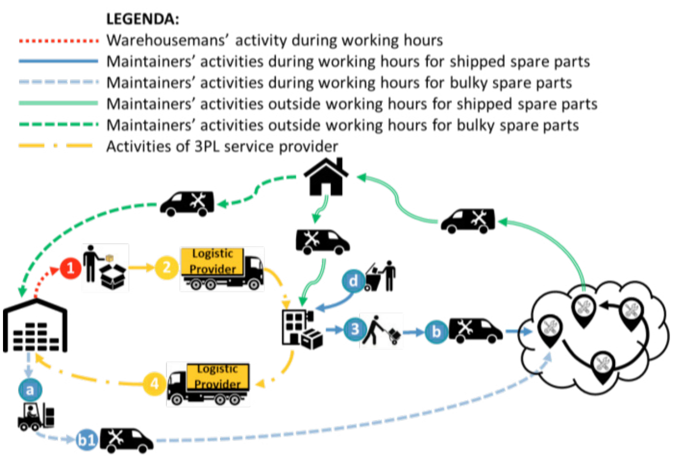

Fig. 6. Evaluated logistics model with 3PL suppliers.

In this case the logistic provider sends the materials prepared by warehouse personnel to picking points very close to the first intervention address of each maintenance team "1-2"; it also takes care of the reverse logistics of the replaced assets "4". After an accurate planning of the interventions, two different processes are distinguished according to the size of the required spare parts. If dispatchable, all shipping orders are prepared by warehouse personnel with the materials necessary for the maintenance technicians' work "1". They are then shipped "2" to the pick-up points closest to the first service of the day. Maintenance teams start their work shift at the picking point where the items needed for the day were sent, here they will take care of the unloading of any waste materials "d" and then drop the spare parts shipped "3"; they will then go to the address of first intervention "b" and at the end of the operations terminate their shift. Finally, supplier 3PL sends the waste materials to the company warehouse "4". If the materials are too bulky or heavy, the maintainers start their work shift at the warehouse where they pick the necessary materials "a" and then go to the first intervention address "b1". The economic valuation of the 3PL model was therefore carried out by comparing the as-is and to-be differential costs, calculated on the data recorded in 2016. The costs introduced in the model, with reference to Fig. 6, are due to the introduction of shipping and reverse logistics activities performed by 3PL service provider (activity "2" and "4"). In addition, the to-be model for shipping materials also includes the activities of preparing "1" shipment orders, entrusted to warehouse personnel, and drop of materials at picking point "3" which replace the picking activity from the company warehouse in the as-is model. Savings are instead due to the complete elimination of the re-entry to warehouse during working hours "c" and the evident reduction of the itinerary to reach the first intervention address of each maintenance team "b". With reference to Fig. 5 and Fig. 6, the total cost of the activities of the as-is model for the year 2016, and the estimated cost of the to-be model activities for the same year, are shown in Tab. 1. As shown in Tab. 1, the value of the differential cost for 2016 is more than 240k€. This value, when evaluating the company's investment, is exactly equal to the undiscounted cash flow. To calculate the deterministic indices of payback period and net present value, it is necessary to define the value of the initial investment.

Tab. 1. Activities costs of the as-is and to-be models.

Activities	Cost As-Is	Cost To-Be
a	32.618,26 €	6.817,38 €
b	136.696,95 €	6.716,84 €
c	137.013,13 €	n.d.
1	n.d.	11.667,55 €
2	n.d.	16.907,03 €
3	n.d.	17.132,38 €
4	n.d.	4.721,60 €
Total annual cost (2016)	**306.328,35 €**	**63.962,77 €**
Differential cost		**242.365,58 €**

The investments required for the implementation of the new stock logistics model are shown in the Tab. 2. Their sum will be equal to the value of the initial investment.

Tab. 2. Initial investments.

Activities	Preventive
Editing management software (SAP)	125.000€
Spare parts 3D design (Autodesk)	20.000€
Integration systems (STR)	20.000€
Total Investment	**165.000 €**

Considering the 5% discount rate "r", the net present value curve is shown in Figure 8:

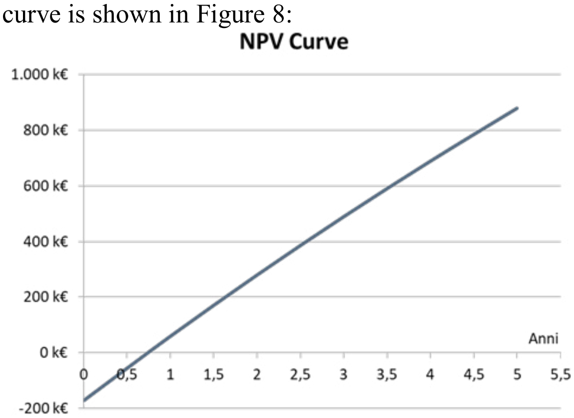

Fig. 7. Net Present Value curve of the investment proposal. The NPV at 5 years is about 880 k€ and the PbP 9 months. Both deterministic indices for assessing corporate investment are in favour of implementing the 3PL logistics model.

4. DISCUSSION

In the previous chapter, the PbP and NPV of the investment were calculated through the accurate evaluation of the annual cashflow of a case study. For this calculation it was necessary to have a complete picture of all the activities described in Fig. 5 and Fig. 6 and for this reason, together with the judgement of logistics experts, the probability distribution functions (PDF) of some unknown parameters were assumed. These parameters are related to internal activities of the to-be model and not therefore available in the company knowledge base or related to economic values not present in the estimate of the selected 3PL provider. All parameters with their PDFs are described in Tab. 3.

Tab. 3. Specifications of the probability distribution functions of the assumed parameters.

Factor	PDF	Mean	St. Dev.
Single order warehouse picking time	Lognormal	28 min	8 min
Single order shipping setup time	Lognormal	10 min	5 min
Unit cost of packaging	Normal	0,50 €	0,20 €
Single order drop time from picking point	Lognormal	15 min	7,5 min

As described in the previous section, the economic evaluation was based on the registered 252 working days for a total of about 19000 "stories" of maintenance interventions in the year 2016. The parameters of Table 3 were supposed equal to their average value to make a punctual estimate of the annual cash flow. At this point, to have a stronger result, we moved to an interval estimate. According to Mooney, (1997) the Monte Carlo simulation of the differential cost model implemented on the @Risk software was carried out, performing 100 000 extractions of the assumed parameters, thus obtaining the PDF of the cost of the as-is and to-be model as reported in Fig. 8:

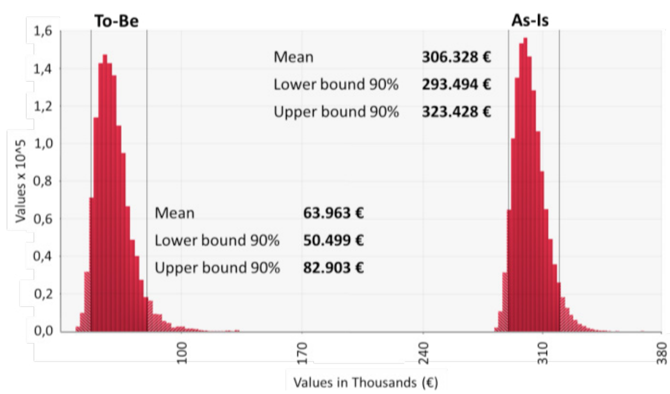

Fig. 8. Annual total cost of as-is and to-be logistical models.

The probability distributions of the two models are very far from each other and the probability that the to-be model has a higher cost than the as-is model, identified by the overlap of the two probability distributions, is practically zero. The probability distribution of the differential cost is instead represented in Fig. 9:

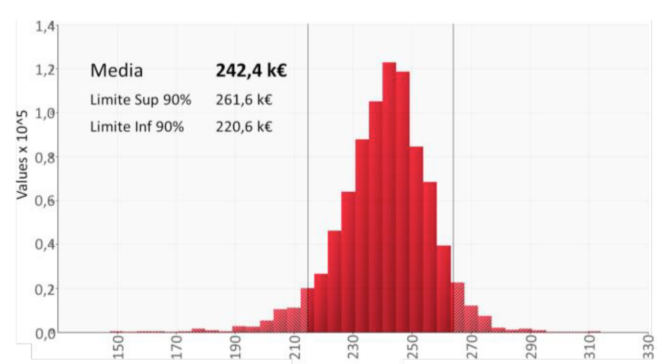

Fig. 9. Probability distribution of the annual differential cost ($cashflow_0$) between the as-is and to-be model.

Even in the worst-case scenario simulated by software, the annual differential cost between models is about 150k€, consequently the ratio $I_0/Cashflow_0$ is equal to 1.1 and in accordance with Fig. 4 the PbP is about one year with a discount rate of 5%. From the knowledge of the PDF of the differential cost, it was possible to obtain an estimate with a confidence interval of 90% of the NPV in the periods after the investment with the results shown in Fig. 10:

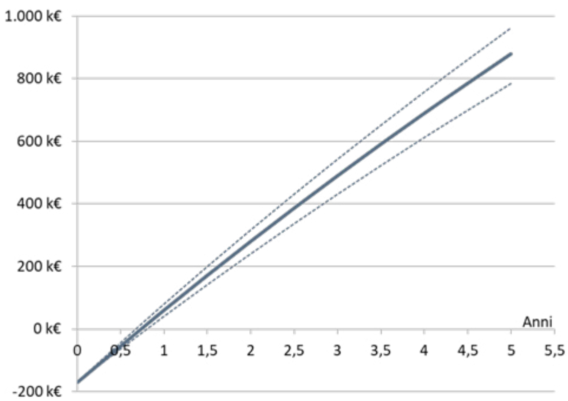

Fig. 10. Net Present Value curve of the investment proposal with CI=90%. The 5-year NPV is between 785k€ and 963k€ and the PbP is between 8 and 9 months with a 90% CI.

As is clear from the interval estimate of investment valuation indices, and replying the RQ3, the implementation of the 3PL logistics model is highly profitable and so replying the RQ1, the logistic model described in the previous chapter should be the right one to be adopted. Choosing the right 3PL provider plays a key role in the economic success of the model adopted for several technical and economic reasons. Replying the RQ2 the logistic suppliers will have to guarantee delivery times shorter than the business planning horizon to be able to deliver spare parts to the right picking-point when needed. Moreover, it must have space requirement compliant with most part of the materials used for maintenance to manage them through the 3PL model. As far as only economic reasons are concerned, it is necessary to choose the supplier who has the best compromise between the number of picking points in the territory, which is directly proportional to the reduction of the first trip itineraries for the maintainers, and the cost of shipping. In our case, the evaluated 3PL suppliers have small differences in terms of cost and quality of service, while as far as the number of picking points is concerned, the selected provider, with 8724 post offices in Italy is by far the best 3PL partner for the implementation of the logistics model. Part of the saving of the 3PL model is due to the elimination of activity "c" (see Fig. 5), which, as described in the introduction, is not yet present in some of the utilities (see Fig. 2). For this reason, it would be interesting to carry out the same type of study for such utilities and assess whether the model would also be convenient in such case. Just to have an idea, from a simple analysis of the present case study, removing the “c” activity among the costs of the as-is model, the Cashflow is reduced to about 105k€ and keeping unchanged "r" leads to a PbP of less than 2 years and NPV of about 220k€ at 5 years, therefore still advantageous. Another limitation of this study is the use of a single case study, which does not allow the results obtained to be generalised. The main purpose of the study was to provide a complete and valuable procedure for the feasibility study of the 3PL logistic model for utilities. In conclusion in further studies, it would be therefore interesting to formalize analytically the problem of choosing the right 3PL supplier, as well as its application to other case studies.

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