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THE IMPACT OF ARTIFICIAL INTELLIGENCE AND INFORMATION TECHNOLOGY ON PHILANTHROPIC ORGANIZATIONS

Case studies of non-profit and cultural associations

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1 Introduction

Connections between Artificial Intelligence (AI) and philanthropy are gaining increasing interest since the rigorous quantitative approach to the problems and the challenges in this field have been developed following the success gained in the profit sector. This chapter examines the impact of AI and Information Technology (IT) in the philanthropic context by illustrating two distinct applications in very different sub-domains. Case studies use a variety of AI and mathematical methods that precisely fit the considered problems and demonstrate either the flexibility of the tools and their adaptability or the great utility of AI and IT in the philanthropic field.

The first considered application context regards the Decision Support Systems (DSSs) for fundraising management. In the context of philanthropy, non-profit organizations (NPOs), whose main activity is fundraising (FR), have a considerable role to play (Rosso et al., 2004). FR strategies are crucial for achieving the mission and reaching the goal of the ongoing campaign (Sargeant, 2001). The Donor's role and efficient management are of great importance (Duncan, 1999). For this reason, both econometric and operational literature dealt with (potential) Donors' profiles that match some specific gift inclination (Duffy et al., 2007) to support the effectiveness of the process. Economists agree that information on potential Donors plays a crucial role in achieving the improvement of fundraising strategies (Melandri, 2004b; Nudd, 2003).

Quantitative studies in econometric and economic modeling have shown the main factors influencing individuals in their choice of giving. For example, Andreoni (2006) characterizes altruism's economic and social foundations as individuating factors such as the own community or the social network and the so-called "enlightened self-interest." These variables are also modeled by Smith and Chang (2002). Lee et al. (1999) argue that an individual tends to assume a role identity as Donor that depends on their network of social relationships. They identify several variables that can

DOI: 10.4324/9781003468615-9
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impact role identity, influence individual preferences and attitudes, and affect the utility people get from their decision about how and to what extent they donate (Cappellari et al., 2011).

In general, several factors should be considered to individuate an optimal fundraising strategy: the interests of (potential) Donors, their social network and personal profile, the operational literature and rules of thumb of the experts in the field, and the information on past campaigns. Practitioners claim that the 70%–80% success rate of a fundraising campaign is determined by choosing the appropriate target (the set of Donors to whom the strategy is addressed) and only 20%–30% from motivations and creativity (Melandri, 2004a). These factors strongly influence the gift probability, affected by individual aptitudes and economic constraints (Cappellari et al., 2011): age, instruction level, place of origin, financial situation, number of children, social network, and religious involvement. Therefore, integrating all of this information to find an optimal fundraising strategy is very complex. In this context, the need for advanced DSSs, targeted for different aims and association types, is highly felt.

The second considered domain is Financial Literacy, which is related to philanthropy through the activity of the Cultural Philanthropic Organizations. The subject of financial education is broad and varied and includes very different approaches. In the international institutional sphere (Organisation for Economic Co-operation and Development – OECD, 2011), there is a need to monitor the level of financial education of a specific population. This involves statistical aspects of sampling, the design of questionnaires, and the analysis of their results. Behavioral economics has also studied the links between personal finance choices and notions of financial education. Economic psychology also influences monetary choices and can be useful in developing financial education pathways.

On a more practical level, financial education plays a role in savers' choices of pension funds. The financialization of welfare is also analyzed in Caselli and Ruocco (2018), where the intersections between economic actors and philanthropic and financial instruments are explored in an international context, particularly in the Italian scenario, with specific reference to Social Impact Investing.

Financial literacy in the adult population is also extensively analyzed in OECD (2020). A more didactic approach is developed in Houghton Budd (2016), where specific strategies for teaching financial education are proposed, examining a concrete case study. However, financial education for children has received less attention over time. Anyway, interesting tools for a qualitative approach to financial literacy have recently been developed, such as the Europoli app, developed by the EduFin Committee, with the contribution of the European Commission.

The approach proposed and developed in this study fits into the framework of tools aimed primarily at young persons. Its originality is in analyzing contexts frequently observed in personal finance choices and visualizing them in a guided and interactive computer lab, respecting the directions of research in the didactics of financial mathematics. Each model is implemented by constructing a visualization diagram that captures the financial situation and its evolution, which is a strength of this approach. The use of computer tools, even the most advanced ones, makes it possible to graphically model quite complex situations and to make effective financial choices. This technique is particularly useful for those people who don't have specific notions of financial mathematics (Barzanti & Pezzi, 2019a, 2019b). In this context, collaboration with a philanthropic cultural organization is in development, in order to make available a high-end IT solution with the construction of a web application and increase the usability of the proposed implementation.

The chapter is organized as follows: Section 2 considers the field of fundraising management and the employment of IT. In particular, Section 2.1 overviews the most advanced DSSs, which make use of AI, soft computing techniques, and advanced mathematical methods. In contrast,

Section 2.2 describes in detail one of these systems, with a rigorous approach completed with the help of diagrams and explanatory figures. Some very recent approaches, challenges, and ongoing developments are illustrated as well. Section 3 considers the context of Financial Literacy and the need for an advanced IT tool for the financial education of children. Section 3.1 examines two recent applications in Excel. Section 3.2 shows a very recent demo of an ongoing high-end IT solution with a web application developed in collaboration with a philanthropic cultural organization. Section 4 concludes the chapter.

2 Decision support systems for fundraising management

The strategies commonly employed use the so-called giving pyramid, an operative structure that advises the fundraisers in their macro-decisions. The giving pyramid is well studied by the operational literature (Melandri, 2017). Economic literature also refers to this concept (Lange et al., 2007). Figure 7.1 shows the Donors' segmentation determined by the pyramid (a further subdivision is possible).

The Contacts constitute the ground of the pyramid, that is, the potential Donors known by the association. One goal of a loyalty campaign is to involve new people in the mission of the association by their first donation. It is essential that a Contact becomes a Donor at the first gift request (therefore, it is significant to solicit the gift in a suitable campaign for that Contact). The effectiveness of achieving the step at the first gift request makes the new Donor more prone to become a regular Donor, establishing in this way a positive drift (the Donor becomes "hot") toward a subsequent step to the second level of the pyramid.

Quantitative methods employing database (DB) technologies have been studied and developed in the pertaining literature to make these strategies more effective (Barzanti & Pieressa, 2006; Kercheville & Kercheville, 2003). The effective use of information on Donors and Contacts (i.e., potential Donors) is crucial for optimizing the resources for the campaign by selecting the most promising Donors/Contacts for the considered context.

However, tools using a classical database approach (Flory, 2001a, 2001b) are not able to elaborate the knowledge available in the econometric and operational literature as an expert in the field

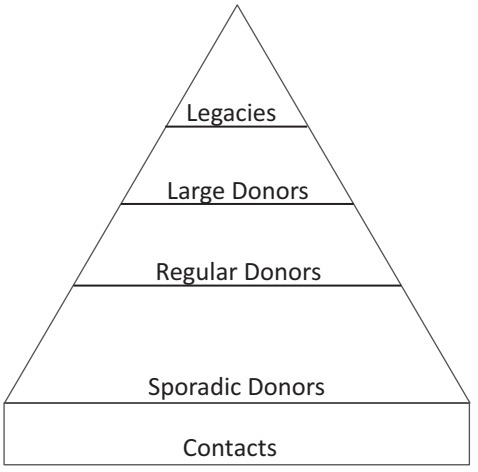

Figure 7.1 The giving pyramid. The pyramid explains the Donors' segmentation.

does (Duffy et al., 2007) and are not able to suggest suitable fundraising strategies. The problems that these systems can solve are limited by the potential of such a technology. The support to the fundraiser is limited to giving general indications about specific claims without adequately managing all data about people, integrating qualitative information with quantitative data.

For these reasons, an innovative approach was performed in this field by Barzanti et al. (2007) who introduced the use of mathematical modeling and Decision Support System (DSS) techniques to help associations to decide the kind of campaign they have to organize, which features to implement, and which Donors of the DB list must be contacted, to maximize the expected return of the campaign, satisfying time and cost constraints.

2.1 Artificial intelligence and soft computing for fundraising DSSs

The need for an advanced approach has led to comprehensive development in this field. In particular, quantitative methods have been specialized for different types of organizations. On the one hand, Barzanti et al. (2009) and Barzanti and Mastroleo (2013)(their corresponding systems are hereafter called Knowledge Fuzzy Mathematical - KFM by Barzanti et al. (2009) and Advanced Mathematical - AM by Barzanti and Mastroleo (2013)), have dealt with large-sized associations, including international ones, owing lists of millions of contributors and a powerful organizational system that requires a very sophisticated DSS.

On the other hand, Barzanti and Giove (2012) introduced Knowledge Choquet – KC, which also considers small-sized organizations and developed a DSS based only on essential information without an organized DB. This approach has been validated in the operational world by associations that test it (as documented in Barzanti & Giove, 2012; Barzanti & Mastroleo, 2013; Barzanti et al., 2009) and in the pertaining literature (Melandri, 2017; Verhaert & Van den Poel, 2012).

Medium-sized organizations are considered in Barzanti et al. (2017), Fuzzy System – FS, and Barzanti and Giove (2018), where a DSS based on a specific mathematical model and targeted for this kind of association has been created and enhanced.

More generally, a process of evolution, strengthening, and specialization of the proposed methods and algorithm has been developed. In this context, Barzanti et al. (2020) introduced the Recommended System Fuzzy – RSF, and in Barzanti et al. (2021), it was considered that one of the goals of a loyalty campaign is involving new people in the mission of the association by their first donation. In operational language, the goal is to make some Contacts going up from the ground of the giving pyramid to the first level.

The innovative approaches to fundraising are characterized by significant use of mathematical modeling, suitably implemented according to the considered purpose or the particular focus of the process. As regards the available information, associations are classified according to the existence of a structured DB and the presence in the DB of specific qualitative information of Donors' profiles (like personal interest and relationship network), in addition to the usual information on the gifts and the typical personal profile. Usually, this classification strictly depends on the organization's size. Along with the modeling approach, the methods differ in the use of advanced mathematical and statistical techniques (probability, linear algebra, utility functions, similarity measures, Choquet integral, nonparametric estimation) or soft computing and artificial intelligence (AI) techniques (fuzzy logic, knowledge-based approach). Table 7.1 summarizes the classification of the DSSs by association size and quantitative techniques employed.

KFM method is based on a knowledge approach and extensively uses Fuzzy techniques[1]; it is targeted at large-sized associations with a well-structured complete DB. AM method is an improvement of KFM, which uses Advanced Mathematical techniques instead of soft computing.

Table 7.1 Classification of the DSSs by association's size and quantitative techniques employed

	Advanced mathematical techniques	*Soft computing and AI techniques*
Large-sized associations	AM, RSF	KFM
Medium-sized associations		FS
Small-sized associations	KC	

In particular, the fuzzy evaluation of the gift probability is replaced by an entirely mathematical estimation based on the Choquet integral with rigorous upper and lower bounds. Moreover, the utility function approach allows to contemplate not only the immediate maximum expected return objective but also a long-term perspective considering the evolution of the Donor lifetime as well.

Medium-sized organizations are considered in FS. FS only uses the quantitative information of the DB to rank and select the most promising Donors for a specified campaign by a Fuzzy technique. RSF is focused on the strategic goal of involving new Donors in the association with their first gift. The Recommender system is based on a Fuzzy approach and uses a specific Similarity measure developed for this aim, starting from a general similarity formula. It is targeted at medium-sized organizations and uses quantitative and qualitative information from a medium-structured DB.

KC uses the features of the organization profile to select the best fundraising strategy. This approach is necessary when structured DB information is unavailable, and it is therefore targeted at small associations. The knowledge of one or more experts is extracted by hierarchically organizing the organization's domain and identifying a non-additive measure coupled with the Choquet integral. DSSs have been variously validated, tested, cited, and referred. In addition to the remarks above, see Moro et al. (2018) and Ruixia et al. (2010).

In general, the advantage of the DSSs targeted for large-sized organizations is the completeness of the considered process, obtained by managing both Donors and Contacts, by considering the total expected return of the campaign and by allocating an eventual budget saving. The disadvantages concern the necessity of frequent maintenance of DB and the non-immediate interaction with the system by the fundraisers, who are required to be trained on quantitative notions, particularly for AM.

Concerning medium-sized associations, FS is relatively easy to use and considers both the Donors' ranking and the total expected return, with simple management of the budget saving. Contacts are not considered, and consequently, no long-term strategy is examined. On the other hand, RSF considers the Contacts, analyzing the best method to acquire Donors from Contacts. Although the mathematics is nontrivial, the DSS use is quite simple, and the results are specific and effective.

Finally, KC is easy to use and needs no DB (and consequently no information maintenance), but the process of identification of the measure is elaborate, with the fulfillment of an articulate questionnaire by the association fundraisers. For a wide review, see Barzanti (2021).

An idea of articulating such systems is shown in Figure 7.2, where the architecture of KFM is displayed. In the first part, the feasible strategies with their Donors' targets are selected by an expected gift model and fuzzy rules in compliance with the marginal gain condition. Then, the possible Contacts selection based on fuzzy rules is performed if a budget saving occurs. Then, an articulated strategies evaluation is completed, with a dynamic estimation based on a mathematical

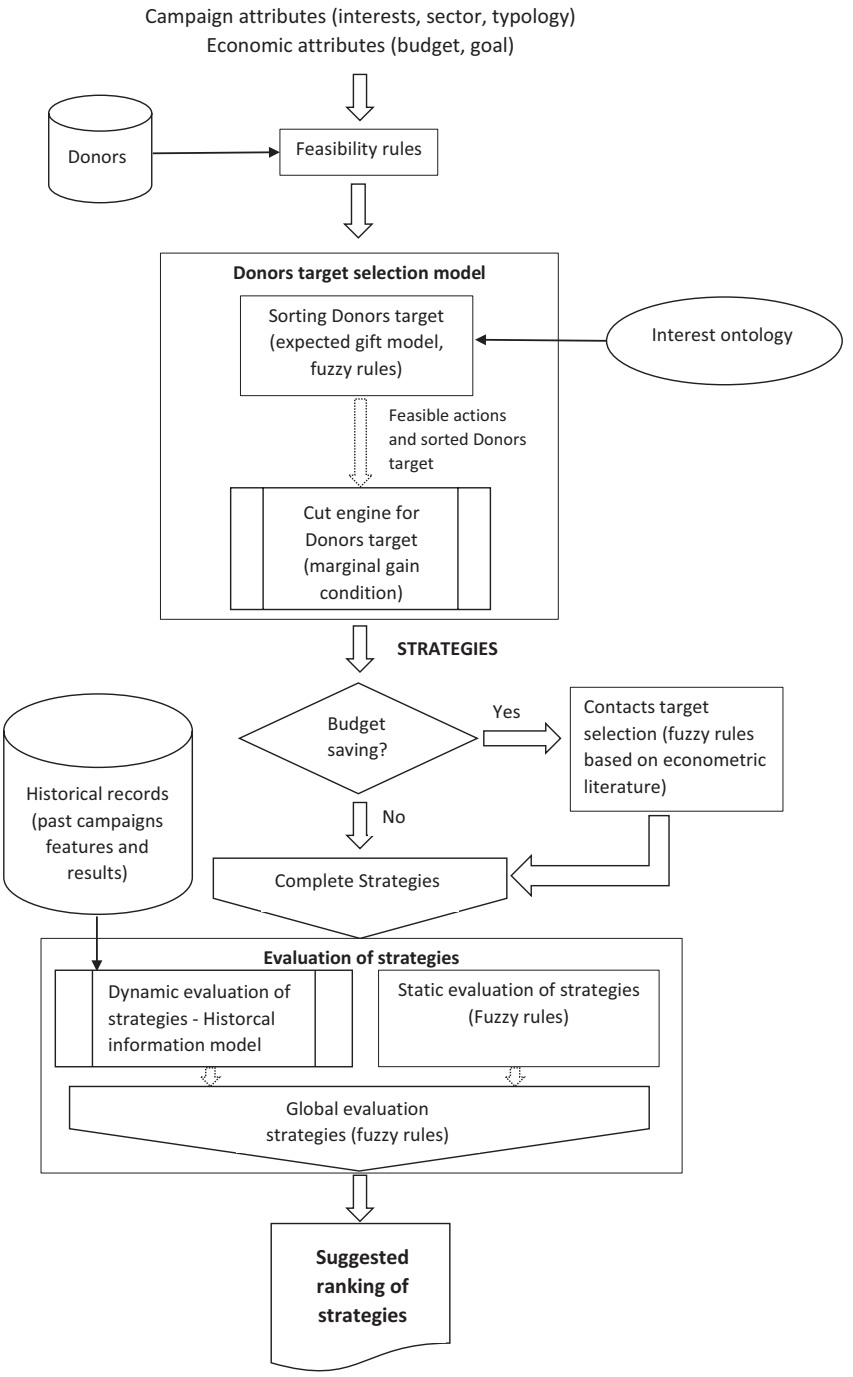

Figure 7.2 The architecture of KFM. Each part of the system is highlighted, with the explication of all the interactions.

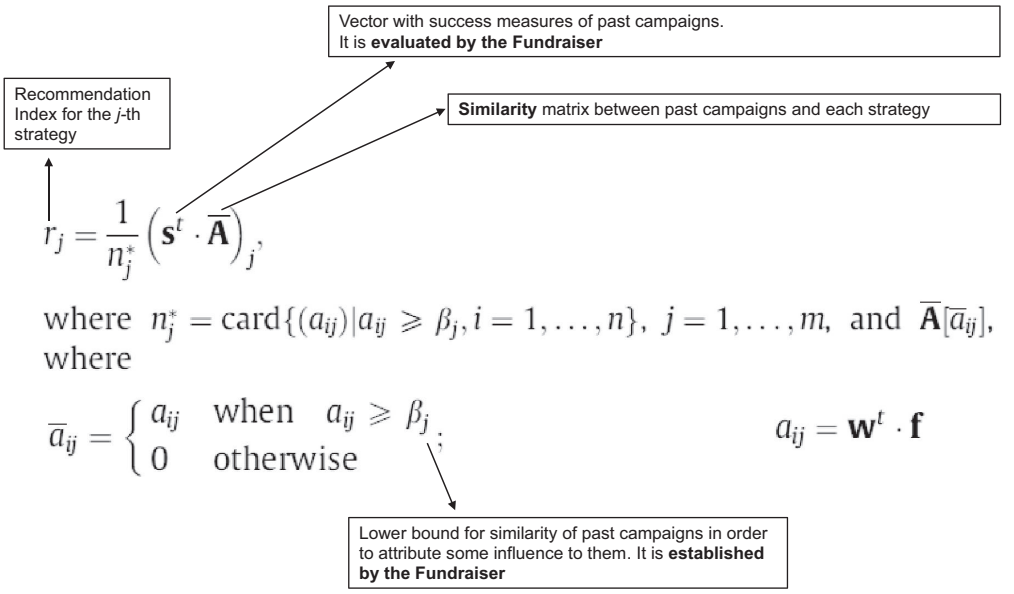

Figure 7.3 The mathematical model of dynamic evaluation of strategies in KFM. In this linear algebra model, "card" denotes the cardinality (i.e., the number of elements) of the considered set.

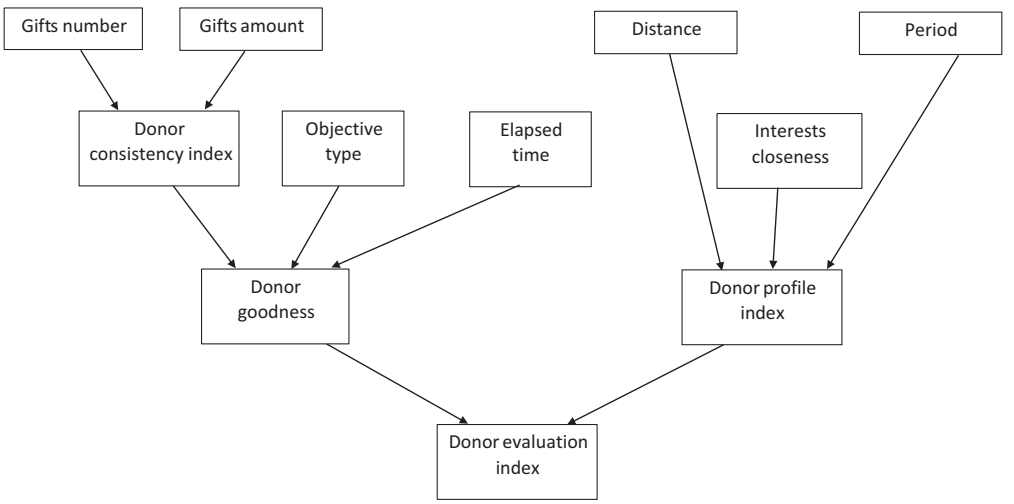

Figure 7.4 Fuzzy evaluation of the gift probability in KFM. The fuzzy structure of the variables is shown.

model (Figure 7.3) and a static fuzzy model. The global evaluation of the strategies produces their ranking. Figure 7.4 shows the details of the fuzzy evaluation of the gift probability.

2.2 Case study: the system FS

FS is developed for medium-sized associations and uses fuzzy techniques to maximize the global return of a campaign. As for the data, it uses the classical quantitative information of Donors (i.e.,

gift amount, recency, and frequency). Data is organized in a simulated DB constructed from experts' knowledge based on a realistic composition of a set of Donors.[2] The Donors' segmentation was determined following the giving pyramid. A set of 30,000 Donors is considered, and about 400,000 gift requests are collected. In the set, about 6% are Large Donors, 19% are Regular, and are further subdivided into "stable" (SRD) and "dynamic" (DRD). The remaining 75% are Sporadic Donors; about 25% made only one donation (OSD), and the rest made more than one donation (MSD). Legacies are not present in the considered sample.

Concerning the gift history, the DB includes the number of donations for each Donor; the gift amount for each donation (measured in thousands of euros); the elapsed time or recency, that is, the number of units of time since the last donation (measured in semesters); the number of past gift requests, including those in which the donation was not subsequently made. Other personal profile variables collected are risk aversion, measured as numbers of insurance policies signed by the Donor; education, subdivided into four categories: Master and Ph.D., Bachelor, High School, other/lower school level; age and number of children; wealth, measured in thousands of euros.

Tables 7.2 and 7.3 report a synthesis of the data collected in the DB. Table 7.2 illustrates the segmentation of the Donors population in the Giving Pyramid related to some characteristics: the minimum and maximum Donation amounts are shown. Large Donors have high gift amounts, Regular Donors from low to medium gift amounts and from medium to high frequency, whereas the Sporadic ones are characterized by low amount and frequency.

Only 10% of the Large Donors have "low wealth," and the percentage increases respectively to about 40% for Regular and 70% to Sporadic Donors. In the last column, the percentage of Donors who subscribed to at least one insurance contract is reported; this is a commonly used measure of the risk aversion of a person.

In addition, Table 7.3 shows some statistics of Donors' profile characteristics and gift history.

Table 7.2 Some Donors' characteristics with respect to their segmentation

Donors	*Min D. amount*	*Max D. amount*	*Low wealth (%)*	*Ins. policies ≥1 (%)*
Large	300	1,000	10	65
Regular (DRD)	100	500	40	65
Regular (SRD)	50	400	40	65
Sporadic (MSD)	30	100	70	35
Sporadic (OSD)	10	50	70	35

Table 7.3 Statistics regarding Donors' profiles

	Min	*Max*	*Mean*	*Std. Dev.*
Gifts' number	1	28	6.40	5.20
Elapsed time	0	119	94.72	25.76
Amount	20	1,000	133.65	158.20
Wealth	10	1,000	398.47	310.17
Risk aversion	0	5	1.07	1.67
Age	18	89	53.43	20.85
Childrens' number	0	3	1.50	1.12

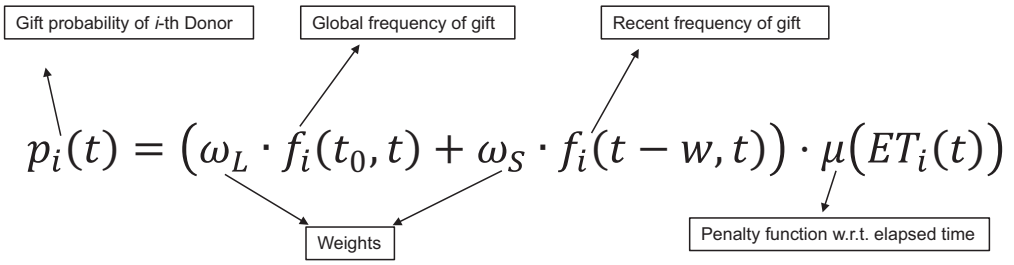

Figure 7.5 Evaluation of the gift probability in FS. The role of each mathematical object of the evaluation is explicated.

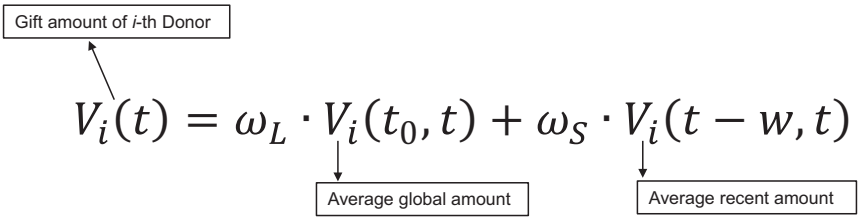

Figure 7.6 Evaluation of the amount in FS. The role of each mathematical object of the evaluation is explicated.

The system implements a model, whose key points are the particularly in-depth estimation of the giving probability (Figures 7.5 and 7.6) and the amount (Figure 7.6) expected from each Donor and the fuzzification process (Figure 7.7).

The two values $f(p)$ and $g(V)$ are subsequently aggregated using a suitable aggregation operator. In this case, the choice of a conservative strategy suggests the adoption of the MIN operator.

Summarizing, for each Donor in the DB, represented by the ordered couple $(p_i(t), V_i(t))$, a score is computed, as in (7.1):

$$Score_i = MIN\left\{f\left(p_i(t)\right), g\left(V_i(t)\right)\right\} \tag{7.1}$$

The Donors are ordered using the values $Score_i$, and $D = \{d_{(1)}, d_{(2)}, \ldots, d_{(n)}\}$ is the ordered list of all the Donors with $Score_i > 0$ ($N \leq M$), i.e., $\{d_{(1)} \leq d_{(2)} \leq \cdots \leq d_{(n)}\}$. U_{cost} is the cost for a request and $K_{MAX} = INT\,(Budget/U_{cost})$ is the maximum request number given the available *Budget*. The system proposes to the decision-maker (DM) the first K^* Donors in the ordered list, with $K^* = MIN\left\{K_{MAX}, N\right\}$. An estimation of the total gain *TG* is computed through the expected values of the first K^* expected gifts, see (7.2):

$$TG\left(K^*\right) = \sum_{i=1}^{K^*} p_i(t) \cdot V_i(t) \tag{7.2}$$

The System computes the total average score

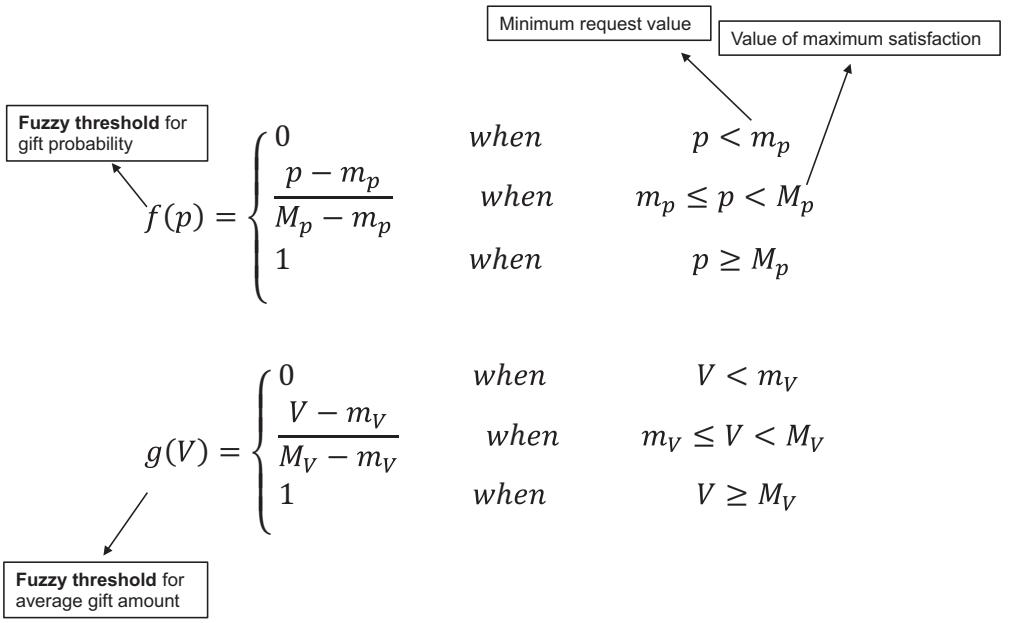

Figure 7.7 The fuzzification process in FS. The mathematical process implemented by the fuzzy system is specified.

$$TScore\left(K^*\right) = \frac{1}{K^*}\sum_{i=1}^{K^*} Score_i$$

as well.

If $TG - Budget \ge G$ the target is reached. Anywise, if the average score is low and the expected total gain is satisfactory, the DM can decide to decrease the value of K^* and the system recomputes $TG(K^*)$ and $TScore(K^*)$ until a good compromise is reached.

An ongoing development in this framework regards the parametric statistical approach in the evaluation of $p_i(t)$ and $V_i(t)$ on the basis of Barzanti and Nardon (2022), with the aim to individuate a complete distribution estimation of these quantities and therefore a lower and an upper bound of the total return of the campaign. Another challenge can be the employment of a nonlinear fuzzification process, instead of the formulas applied in Figure 7.7, with the aim to capture pessimistic or optimistic evaluations of the Fundraiser. With respect to the gift probability, the fuzzification formula becomes like in (7.3), with $k>0$, where $0<k<1$ denotes optimism and $k>1$ pessimism.

$$f\left(p\right) = \begin{cases} 0 & when \;\; p < m_p \\ \left(\dfrac{p - m_p}{M_p - m_p}\right)^k & when \;\; m_p \le p < M_p \\ 1 & when \;\; p \ge M_p \end{cases} \tag{7.3}$$

From an operational point of view, some challenges regard the interaction between Fundraiser and DSS, in terms either of the use of the software and interpretation of its results or the appropriate setting of the parameters to incorporate his/her own valuations and fine-tune the system. The key point is to make the Fundraiser confident with the software in order to use it appropriately as an instrument that can be personalized on the basis of the objectives and the professional evaluations.

As for the implementation of the system, the tool is designed in Visual Basic, using SQL language on a MS Access DB. The graphical interface allows the DM to set up the Campaign Parameters (*Target*, *Budget,* and *Unit Cost*), the Algorithm Parameters (*omega L*, *omega S*, *Time Horizon,* and *Time Window*), the Preliminary Selection Parameters (*Robustness*, *Frequency*, and *Average Past Gift*), as also the Elapsed Time Thresholds (*Min Elapsed Time*, *Max Elapsed Time*). Fuzzy aggregation parameters are also set by the indication of the bound of both thresholds (*Min Probability*, *Max Probability*, *Min Expected Value*, *Max Expected Value*). Figure 7.8 shows the whole interface.

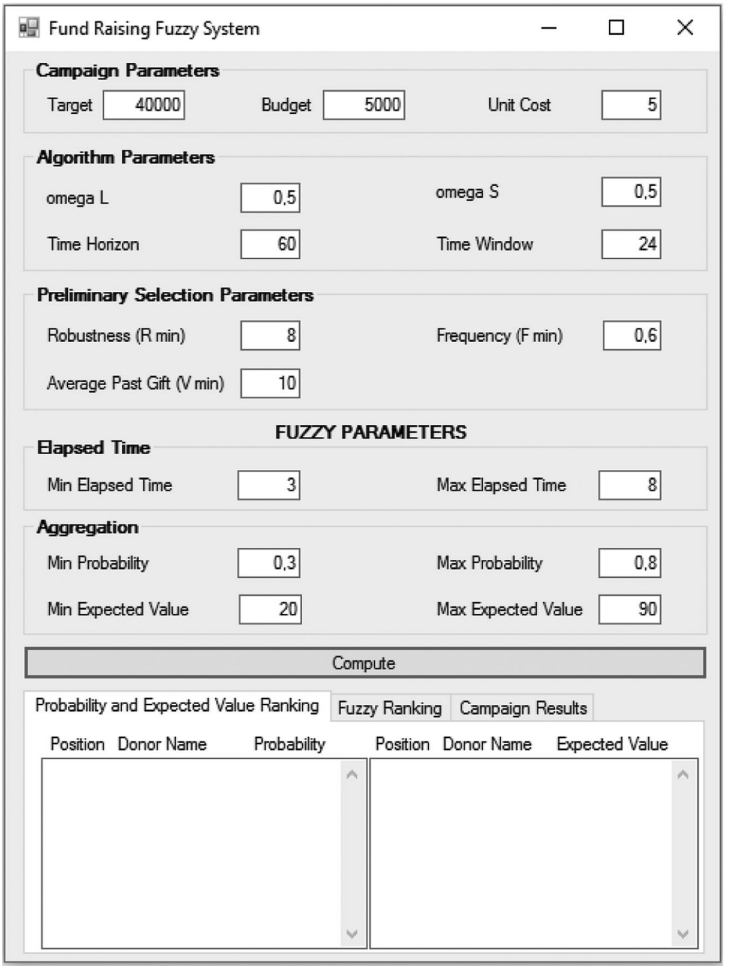

Figure 7.8 Graphical user interface. The interaction mask between the system and the user is shown. In particular, the input parameters are classified by their meaning.

Notice that the results are widely described. First, a synthesis of the ranking by probability and expected value is presented (the Probability and Expected Value Ranking Tab). Then, the ranking obtained by the fuzzy algorithm is shown (the Fuzzy Ranking Tab), as well as the synthetic indicators for the campaign results (Campaign Results).

The Campaign Parameters are typical of a medium-sized organization; the Technical Ones are determined based on the function of the characteristics of the DB and the preliminary choices of the DM. The results of the first ranking phase (gift value and probability estimation) are presented in Figure 7.9.

In this case, after the preliminary selection, the considered Donors decreased from 30,000 to about 6,900. Consider that the DM can choose how deep to explore each single ranking. This gives a general idea of the features of data with respect to the ranking criteria. In this case, the selected step is 300 for the Probability and 600 for the Expected Value. The fuzzy aggregation implementing the algorithm (Donors' selection) is shown in Figure 7.10.

The global results of the Campaign (Expected Campaign Value), with the Total Average Score, are presented in Figure 7.11.

The target is well achieved, with a satisfactory average score. The whole budget is used as specified by the algorithm. However, suppose the DM wants to decrease the considered Donor number to slightly increase the Average Score, thus maintaining the goal of reaching the Target; in that case, there is the possibility to recompute the Campaign Results with the new Donor number

Probability and Expected Value Ranking | Fuzzy Ranking | Campaign Results

Position	Donor Name	Probability	Position	Donor Name	Expected Value
1	D 19897	95,00%	1	D 2073	121
301	D 8631	72,50%	601	D 11744	96
601	D 9469	63,33%	1201	D 21409	89
901	D 28938	55,00%	1801	D 27044	86
1201	D 15463	44,32%	2401	D 22234	82
1501	D 26357	35,00%	3001	D 24209	79
1801	D 5628	26,79%	3601	D 19807	77
2101	D 27163	17,50%	4201	D 16882	74
2401	D 23715	13,94%	4801	D 26472	72

Figure 7.9 First ranking phase. The expected gift probability and amount are computed for each Donor.

Probability and Expected Value Ranking | Fuzzy Ranking | Campaign Results

Position	Donor Name	*f(p)*	*g(V)*	***Score***
1	D 2834	1,00	1,00	1,00
51	D 9605	1,00	0,95	0,95
101	D 18362	0,87	0,96	0,87
151	D 5678	1,00	0,82	0,82
201	D 26650	1,00	0,79	0,79
251	D 6007	1,00	0,76	0,76
301	D 10401	1,00	0,73	0,73
351	D 20076	0,70	0,89	0,70
401	D 3802	1,00	0,68	0,68

Figure 7.10 Fuzzy aggregation and whole ranking. The score of each Donor is computed.

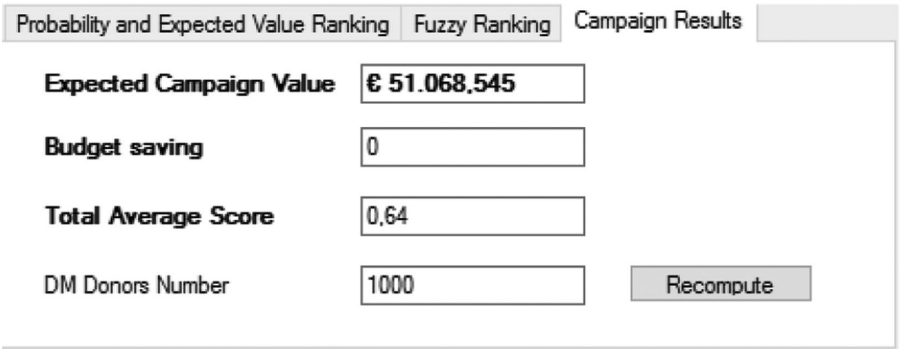

Figure 7.11 Campaign results. The expected total return of the campaign and the robustness of the result are calculated.

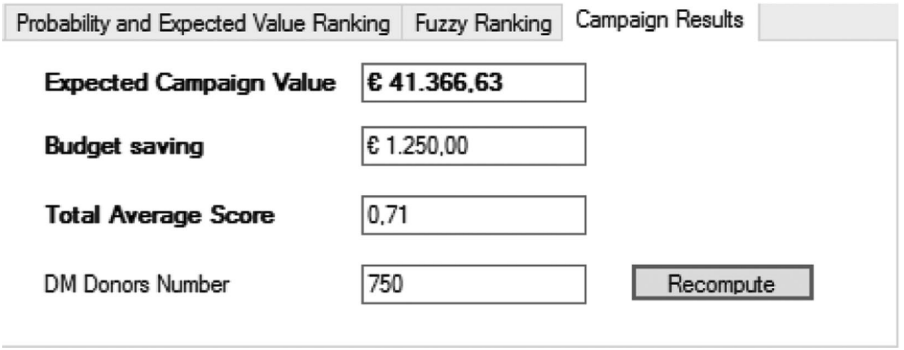

Figure 7.12 Campaign results with budget saving. The robustness of the result is enhanced.

through the parameter DM Num Donors and the Recompute function. In this way a budget saving is also obtained, which will be added to the Expected Campaign Value. Figure 7.12 shows the results with 750 Donors.

3 The use of information technology in financial literacy

The subject of financial education is broad and varied and includes very different approaches. In the international institutional sphere (OECD, 2011), the level of financial education of a specific population needs to be monitored. It involves statistical aspects of sampling, design of questionnaires, and results analysis. Financial education programs are then classified in a five-tier framework concerning needs, accountability, fine-tuning, micro impacts, and macro impacts, to overcome difficulties in their evaluation (O'Connel, 2009). Behavioral economics has also examined the links between personal finance choices and notions of financial education. Economic psychology also influences financial choices and can, therefore, be helpful in developing financial education pathways. More practically, financial education may influence savers' behavior when choosing pension funds.

The phenomenon of the financialization of Welfare is also analyzed in Caselli and Ruocco (2018), where the intersections between economic actors and philanthropic and financial tools

are analyzed in an international context, mainly in the Italian scenario, with particular reference to Social Impact Investing. Opening new spaces for investment in social policies presents challenges in governance, responsibility, public finance, and incentives for the non-profit sector. Philanthropic associations, mainly banking foundations, support a wide range of social policy actions carried out by third-sector organizations through non-refundable grants. These third-sector organizations often partner with each other or local administrations. In this context, the phenomenon of impact finance is essential between philanthropic action and the creation and management of financial assets based on goods and/or services dedicated to fulfilling fundamental social rights.

Financial literacy in the adult population is also extensively analyzed by OECD (2020); starting from the assumption endorsed by G20 leaders, financial literacy is one of the essential ingredients for the financial empowerment of individuals and the overall stability of the financial system; a comprehensive study with descriptive statistical tools is developed in 26 countries. The study provides financial literacy information that go beyond knowledge, covering aspects of financial behavior and attitudes. In the Italian context, in Cucinelli et al. (2019), the three indicators defining the financial literacy index are taken into account and analyzed using multilevel regression statistical methods of OCSE – Financial Attitude Index (FAI), Financial Knowledge Index (FKI), and Financial Behavior Index (FBI) whose dynamics depend on the region. A more didactic approach is developed in Houghton Budd (2016), where specific strategies for teaching financial education are proposed through the analysis of real case studies.

Financial education for children and young persons has received less attention over time. In Rinaldi and Todesco (2012), research is developed concerning possible gender differences in terms of economic socialization patterns and, consequently, of financial literacy and attitude to money. The study – focused on the adolescent population of 1,635 students in Northern Italy – was carried out using statistical methods through ad hoc questionnaires. It emerged that although there is a gender difference regarding attitude to money, there is no difference compared to financial literacy. Interesting tools for a qualitative approach to financial literacy have recently been developed, such as the Europoli app, developed by the EduFin Committee, with the contribution of the European Commission.

The purpose is to educate young people about financial education through play, coming into contact with the world of finance and financial instruments. The app leads young people into a virtual world where they are invited to realize how to earn and manage money. They interact with parents, bank counselors, and teachers who show them how to manage money-related activities through games and challenges such as first savings, house purchase, child support, and retirement. Day-to-day account management, investments, financial management of contingencies, and procurement planning are some topics examined. There is also a first approach to insurance, banking, and social security instruments. A synthesis of the state of the art can be found in Lusardi (2019).

The approach proposed and developed in this study fits into the framework of tools aimed primarily at young people. However, adult users can usefully adopt it. Its originality consists in reproducing in a guided and interactive digital lab real contests frequently observed when making one's financial choices, thus respecting the guides of research in the didactics of financial mathematics (Barzanti & Pezzi, 2019a, 2019b).

The use of digital tools, even the most advanced ones, allows not only the graphic modeling of quite complex situations but also the achievement of an effective financial choice even in the absence of specific notions of financial mathematics. The interactive environment *unloads* all calculations to the Excel worksheet, bypassing all technical issues (Barzanti & Benvenuti, 2023) and

following the development of a quantitative approach aimed at financial choices in a concrete operational stage: a guided lab is implemented to solve personal finance problems and to suggest the most appropriate decisions in various contexts, depending on the financial variables involved. This ambitious goal may be reached by using digital and automatic calculation tools, which are also used to make access to the lab easier.

3.1 An interactive Excel financial lab with the use of graphic modeling

The following examples concretely show how the use of Excel provides solutions to complex problems in financial economics, even where specific notions of financial mathematics are not present, as demonstrated by the *Goal Seek* function used in the first example and the use of well-selected financial functions within the broader context of the second example, where a quite complex personal finance problem is solved in an evolving scenario. Both examples are focused on methodological and financial literacy aspects, while the technical approach is ensured by using Excel. In this way, students, appropriately guided in the computer lab, can understand step by step the different phases of problem-solving. The examples were proposed to students and validated in specific teaching lessons cooperating with high schools.

3.1.1 Problem 1

It is a typical economic aspect example listed among financial literacy problems: The price of a good results from the balance between supply and demand. In other words, price determination relates to its supply and demand, as it follows specific market rules. In particular, the demand curve, a decreasing function, and the supply curve, an increasing function, describe the quantities demanded and offered of a good according to its price. The economic theory ensures that the balance price is where supply and demand coincide, that is why it is necessary to find the matching point of the two functions (i.e., the zero of their difference). We consider the following problem, where the demand and supply functions of a particular good (expressed in millions of units), as a function of its price, are respectively:

$$d(p) = 15e^{(-p-2)}, \quad s(p) = 6ln(p+1)$$

We determine the break-even price (in hundreds of euros) of the good and its quantity traded on the market.

The functions considered (exponential, in this case negative, and logarithmic), typical in the representation of economic processes, show nonlinear or transcendent trends and the resulting equation can be efficiently solved using Newton's method (Barzanti & Benvenuti, 2023).

In this case, however, we proceeded using Excel (*Goal Seek* tool), which interactively implements Newton's method as mentioned above.

We must solve the following equation:

$$15e^{(-p-2)} - 6ln(p+1) = 0$$

to find the value of the variable p at the intersection of the two curves, as shown in Figure 7.13.

We set the problem in an Excel worksheet and use the *Goal Seek* simulation tool, which can be found in the Data menu, *What if Analysis* > *Goal Seek* icon. We must now set up the tool: the first cell must contain the references of the target function (C5), 0 must be entered in the second

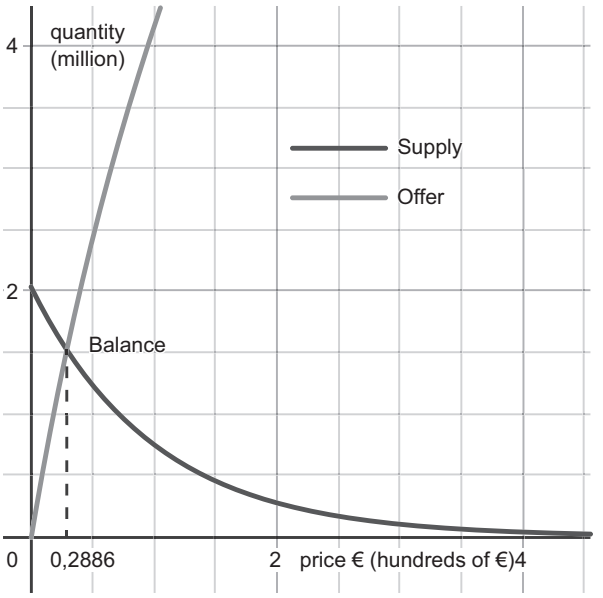

Figure 7.13 Supply and demand quantities as a function of price. The equilibrium point is shown.

cell as we want the target function to be equal to 0, and in the third cell its reference (C6) must be entered, in order to obtain the price value that will lead the supply and demand functions into balance, as shown in Figure 7.14.

Once OK is clicked, overwriting in cells C5 and C6 the results obtained from the processing, *Goal Seek* will return a balance price value (€ 28.86), corresponding to a quantity of traded goods of 1.5212 million units as shown in Figure 7.15. We can observe that in cell C5, just as in the Current Value of *Goal Seek*, an approximate result of zero is obtained due to the numerical nature of the method.

In this way, Excel can bypass the direct, specific, and analytical knowledge of Newton's method and allows for solving a macroeconomic problem related to Financial Literacy using software that requires this numerical method. Therefore, a young student without specific quantitative knowledge of this subject can easily understand the problem and its solving strategy.

3.1.2 Problem 2

It offers the possibility of dealing with a personal finance problem. It is quite a complex problem evolving, and once again, it can be successfully solved using Excel without an in-depth knowledge of specific financial mathematics notions. Consider the following problem:

As rent for her garage, Samantha will receive regular advance annual installments of €2,000 each for five years. These sums will be invested in a deposit account that initially yields a yearly compound interest rate of $i = 3.70\%$.

a If after two years, when the third installment is paid, the compound annual interest rate rises to 4%, what will be the amount available at the end of the fifth year?

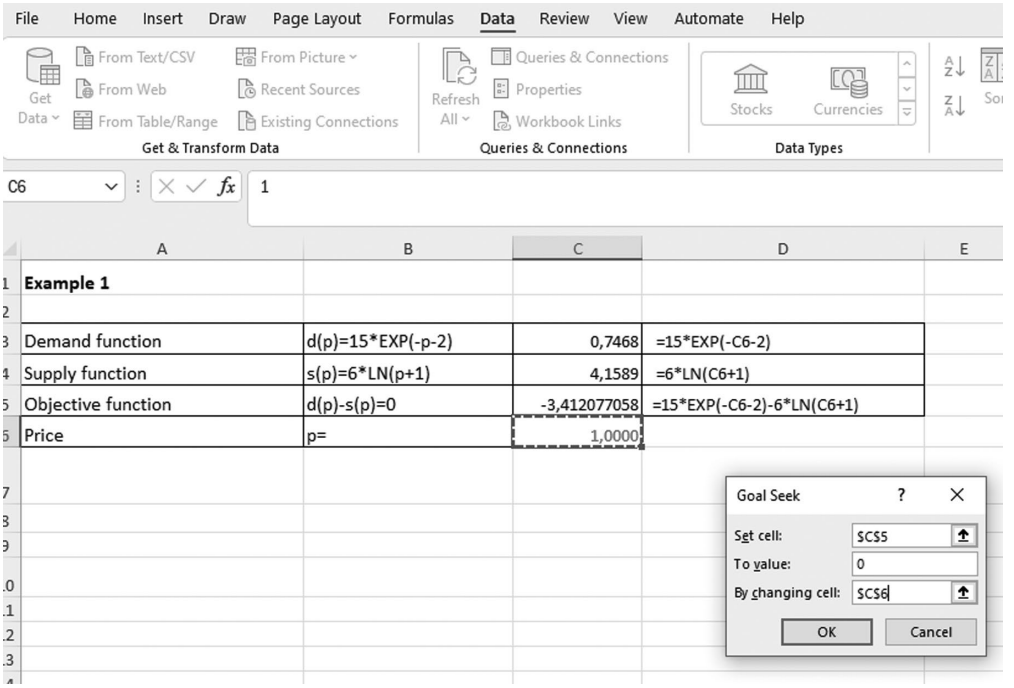

Figure 7.14 Implementation of *Problem 1* in Excel with the *Goal Seek* tool.

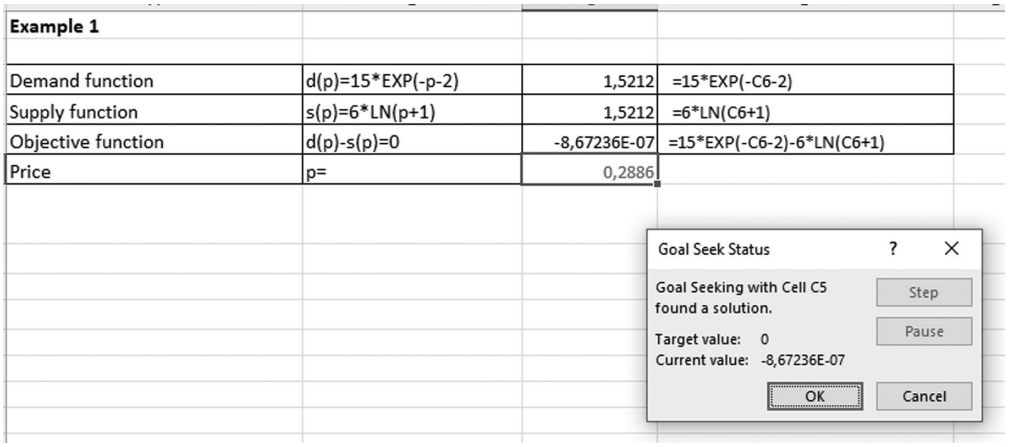

Figure 7.15 Solving *Problem 1* using the *Goal Seek* tool.

b After 2.5 years, the bank proposes Samantha to disinvest up to €5,000 from her deposit account and invest it in a new product providing a higher yield (4.50%). Since Samantha decides to accept the transaction for the maximum amount allowed (€5,000), what overall amount will she get at the end of the five years, considering that the remaining sum is left in her deposit account?

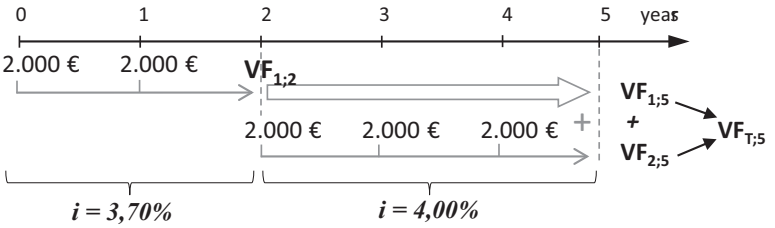

Figure 7.16 Model of *Problem 2*, point (a). The graphical model facilitates the resolution.

c Calculate the global investment rate, considering both the rate change after two years and the disinvestment and further reinvestment of €5,000 after 2.5 years.

d If the disinvestment and reinvestment of €5,000 generated trading commissions, what would be the highest amount Samantha could afford to consider the investment operations still profitable compared to her deposit account yield?

3.1.2 Solution

a The problem model is described in Figure 7.16, where the first two installments at the rate i = 3.70% and the subsequent ones at the rate i = 4.00% are highlighted.

With the proper use of the Excel worksheet, the student can try to solve the financial problem by setting up calculations using the financial formulas (*FV* and *SUM*) available in the software, as shown in Figure 7.17.

Note that $FV_{i;k}$ refers to the future value of the ith annuity at time k; e.g., $FV_{1,2}$ represents the future value of annuity 1 at time two years. A proper use of Excel allows calculating the future value $FV_{T;5}$ after five years (€ 11.254,19), as shown in cell B10.

b At this point, a new investment proposal may occur. The model of the problem, which now considers the new scenario arising from the bank's proposal, is described in Figure 7.18.

Although the new model is more complex compared to (a), it may be easily managed by methodically following the graphical scheme step by step until the final solution is determined through the calculations of the intermediate future values and then of the final future value, by properly applying the yield rates for each financial operation obtained from the disaggregation of the whole problem (Figure 7.19).

The nontrivial articulation of the problem is because the new investment opportunity is proposed at a time outside the original schedule, generating on the computational side the resolution of three sub-problems (solved in cells B23, B24, and B25, respectively) and leading to the final result of $FV_{T;5}$ = €11.311,71 (cell B26), also using *ad hoc* methods, due to the specificity of the problem and the Excel functions (*FV* and *SUM*) that are correctly activated.

c The model for calculating the overall investment rate is shown in Figure 7.20.

Note how neither the rate change at the two-year period nor the disinvestment and reinvestment of €5,000 at the 2.5-year period are shown in the model since these events do not directly affect the calculation of the overall rate (in particular, with the disinvestment and reinvestment on €5,000 calculation the entire amount available at that time is still kept invested): the only indirect influence visible in the model is the final future value, which includes the effects of both operations.

1	**REPLY a)**		
2	Installment	€ 2.000	
3	Initial compound annual rate	3,70%	
4	New annual compound rate	4,00%	
5	Annuity duration 3,7% rate (years)	2	
6	Annuity duration 4% rate (years)	3	
7	$FV_{1;2}$ = Annuity future value 1 (to 2 years)	€ 4.224,74	*=FV(B3;B5;-B2;;1)*
8	$FV_{1;5}$ = Annuity future value 1 (to 5 years)	€ 4.752,26	*=B7*(1+B4)^B6*
9	$FV_{2;5}$ = Annuity future value 2 (to 5 years)	€ 6.492,93	*=FV(B4;B6;-B2;;1)*
10	**$FV_{T;5}$ = Total future valute (to 5 anni)**	**€ 11.245,18**	*=SUM(B8:B9)*
11			

Figure 7.17 Solving *Problem 2*, point (a) using Excel. Use of Excel functions *FV* and *SUM* is highlighted.

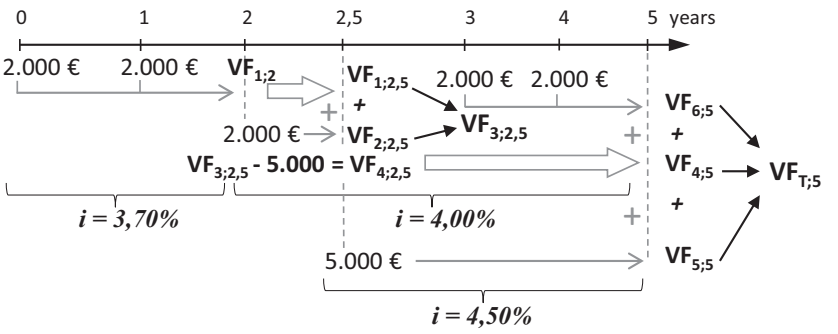

Figure 7.18 Evolution of the model in relation to a new investment opportunity. The graphical model is very effective to capture financial changes.

Figure 7.21 shows the problem setup and the Excel function *RATE* needed to determine the solution, exhibited in cell B32.

The problem resolution proposed in Figure 7.21 is only one of the hypotheses that the Excel sheet offers; the same result could be achieved using the *Goal Seek* tool, as in *Problem 1*, by constructing the Discounted Cash Flow (DCF) function and seeking the value that resets the function to zero. The math solution, obtained through Newton's method, is implemented in this case by the interactive *Goal Seek* tool, which again allows seeking the solution in a rapid way.

d At this point, the economic operator has to decide because the new investment opportunity (which is supposed to be more profitable) has generated additional costs.

To calculate the maximum value of the expenses that Samantha could accept to decide to disinvest and reinvest €5,000, it is necessary to compute the threshold value that makes the two investment options equivalent. In other words, we need to calculate the amount of the expenses that, once subtracted from the €5,000 investment, still generate the same future value as if €5,000 were left in Samantha's deposit account, as shown in Figure 7.22 The variable E_{max} refers to the maximum expense Samantha can afford.

Figure 7.23 shows the Excel solution, where E_{max} = 59.59 €.

12	**REPLY b)**		
13	Installment	€ 2,000	
14	New investment amount	€ 5,000	
15	Start annual compound rate	3.70%	
16	New annual compound rate	4.00%	
17	New investment c.annual rate	4.50%	
18	$FV_{1;2}$ = Annuity future value (first two installments)	€ 4,224.74	***=FV(B15;2;-B13;;1)***
19	$FV_{1;2,5}$ = Annuity future value 1 (to 2,5 years)	€ 4,308.40	***=B18*(1+B16)^0,5***
20	$FV_{2;2,5}$ = Future value 3ª installment (to 2,5 years)	€ 2,039.61	***=B13*(1+B16)^0,5***
21	$FV_{3;2,5}$ = Total future value (to 2,5 years)	€ 6,348.01	***=SUM(B19:B20)***
22	$FV_{4;2,5}$ = Residual (to 2,5 years)	€ 1,348.01	***=B21-B14***
23	$FV_{4;5}$ = Residual future value (to 5 years)	€ 1,486.88	***=B22*(1+B16)^2,5***
24	$FV_{5;5}$ = New invest. Future value (to 5 years)	€ 5,581.63	***=B14*(1+B15)^2,5***
25	$FV_{6;5}$ = Annuity future value 2 (to 5 years)	€ 4,243.20	***=FV(B16;2;-B13;;1)***
26	**$FV_{T;5}$ = Total future value (to 5 years)**	**€ 11,311.71**	***=SUM(B23:B25)***
27			

Figure 7.19 Solving *Problem 2*, point (b) using Excel. Use of Excel functions *FV* and *SUM* is highlighted.

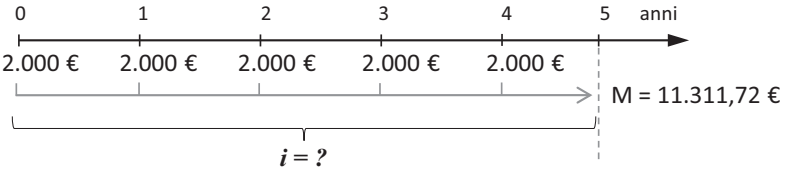

Figure 7.20 Model for overall interest rate computation. The graphical model highlights the meaning of the Internal Rate of Return (IRR).

28	**REPLY c)**		
29	$FV_{T;5}$ = Total future value	€ 11.311,71	*=B26*
30	Installment	€ 2.000	
31	Installment number	5	
32	***i*** **= Global annual compound rate**	**4,137%**	*=RATE(B31;-B30;;B29;1)*
33			

Figure 7.21 Solving *Problem 2*, point (c) using Excel. The use of the Excel function *RATE* is highlighted.

In conclusion, the new investment opportunity for Samantha is convenient if expenses are below the threshold value of €59.59.

Figure 7.24 shows the whole Excel problem-solving sheet in its steps.

3.2 Case study: developing a high-end web application for the Excel Lab

To further enhance the importance of Financial Literacy in the cultural portfolio of young students, mainly when they are not familiar with Excel or only have basic knowledge, an alternative,

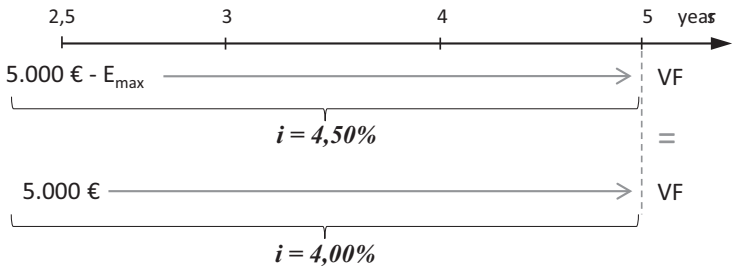

Figure 7.22 Modeling of the decision problem. The graphical model is very effective in showing the choice variable.

34	**REPLY d)**		
35	Annual compound rate deposit securities	4,00%	
36	New investment compound annual rate	4,50%	
37	Invested capital	€ 5.000	
38	Investment duration (years)	2,5	
39	**E_{max} = Maximum expense**	**€ 59,59**	*=B37*(1-((1+B35)/(1+B36))^B38)*
40			

Figure 7.23 Solving *Problem 2*, point (d) using Excel.

innovative, and high-level easy-to-use solution was developed in collaboration with *Nuova Civiltà delle Macchine* (NCdM), a philanthropic association with cultural and social promotion aims.

The association aims to promote, enhance, and disseminate scientific and humanistic culture, spread awareness, and promote the development of relations between the experts in these studies, facilitating their cooperation at local, regional, national, and international levels. Its priorities are training teachers and students and ongoing training of adults. To this end, the association carries out educational research and experimentation projects with the cooperation of the education system to achieve a coherent integration with training, upskilling, and cultural promotion activities. Therefore, the successful collaboration and efforts to spread the culture of financial literacy, primarily among young students, allowed matching each other's knowledge to reach a wider audience of young people.

The proposed solution allows the user to easily learn through direct training on the job and through effective self-learning. Questions propose closed answers; in case of a wrong selection, a comment will be shown to help the user understand why and orient him to the correct answer.

Starting from the solution given by Excel in *Problem 2* (Figure 7.24), we used the XML meta-language, a marker or tag language able to create real instructions for the representation of data by a digital support, in order to edit a shared syntax readable by both man and machine. The MFCompile.exe program (created by Claudio Ricci, NCdM) generates, after inputs (Excel and XML), an HTML file executable from the Web, which is, in fact, a high-level problem-solving solution allowing a wide range of students to enter the world of Financial Literacy easily.

This executable program also solves any kind of problem by easily building the corresponding web/IT solution. When requested by a PC's browser (Chrome, Edge, Firefox, Safari), the problem page is displayed in about three seconds. In addition to the text, it contains the input elements for interacting and the control logic associated with the elements, so it can check the exact answer to a question and/or make suggestions. Input elements can be taken from the associated Excel sheet.

File Home Insert Draw Page Layout Formulas Data Review

E14

	A	B	C
1	**REPLY a)**		
2	Installment	€ 2.000	
3	Initial compound annual rate	3,70%	
4	New annual compound rate	4,00%	
5	Annuity duration 3,7% rate (years)	2	
6	Annuity duration 4% rate (years)	3	
7	$FV_{1;2}$ = Annuity future value 1 (to 2 years)	€ 4.224,74	*=FV(B3;B5;-B2;;1)*
8	$FV_{1;5}$ = Annuity future value 1 (to 5 years)	€ 4.752,26	*=B7*(1+B4)^B6*
9	$FV_{2;5}$ = Annuity future value 2 (to 5 years)	€ 6.492,93	*=FV(B4;B6;-B2;;1)*
10	**$FV_{T;5}$ = Total future valute (to 5 anni)**	**€ 11.245,18**	*=SUM(B8:B9)*
11			
12	**REPLY b)**		
13	Installment	€ 2.000	
14	New investment amount	€ 5.000	
15	Start annual compound rate	3,70%	
16	New annual compound rate	4,00%	
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18	$FV_{1;2}$ = Annuity future value (first two installments)	€ 4.224,74	*=FV(B15;2;-B13;;1)*
19	$FV_{1;2,5}$ = Annuity future value 1 (to 2,5 years)	€ 4.308,40	*=B18*(1+B16)^0,5*
20	$FV_{2;2,5}$ = Future value 3ª installment (to 2,5 years)	€ 2.039,61	*=B13*(1+B16)^0,5*
21	$FV_{3;2,5}$ = Total future value (to 2,5 years)	€ 6.348,01	*=SUM(B19:B20)*
22	$FV_{4;2,5}$ = Residual (to 2,5 years)	€ 1.348,01	*=B21-B14*
23	$FV_{4;5}$ = Residual future value (to 5 years)	€ 1.486,88	*=B22*(1+B16)^2,5*
24	$FV_{5;5}$ = New invest. Future value (to 5 years)	€ 5.581,63	*=B14*(1+B15)^2,5*
25	$FV_{6;5}$ = Annuity future value 2 (to 5 years)	€ 4.243,20	*=FV(B16;2;-B13;;1)*
26	**$FV_{T;5}$ = Total future value (to 5 years)**	**€ 11.311,71**	*=SUM(B23:B25)*
27			
28	**REPLY c)**		
29	$FV_{T;5}$ = Total future value	€ 11.311,71	*=B26*
30	Installment	€ 2.000	
31	Installment number	5	
32	***i*** **= Global annual compound rate**	**4,137%**	*=RATE(B31;-B30;;B29;1)*
33			
34	**REPLY d)**		
35	Annual compound rate deposit securities	4,00%	
36	New investment compound annual rate	4,50%	
37	Invested capital	€ 5.000	
38	Investment duration (years)	2,5	
39	**E_{max} = Maximum expense**	**€ 59,59**	*=B37*(1-((1+B35)/(1+B36))^B38)*
40			

Figure 7.24 The overall solution of *Problem 2*. An overview of the whole Problem's resolution is given.

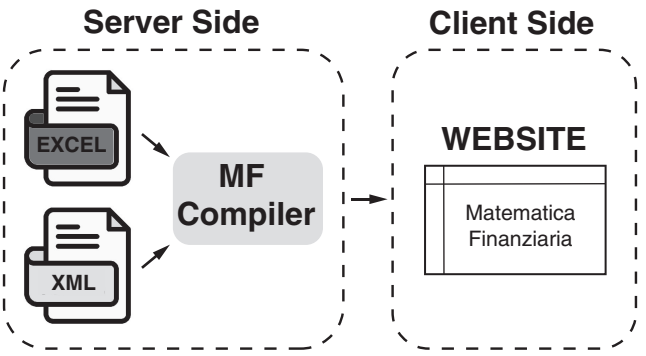

Figure 7.25 Interaction model between the involved software programs. Structure of the Demo Web Interactive Financial Lab.

Each problem, always enclosed in a single web page, is subdivided into sections containing one or more rows with text, images, buttons, or interaction objects such as a text box, radio button, checkbox, and combo-box (drop-down list).

The proposed version is a software demo developed in Italian (see Figure 7.25) and shows the interaction model between the inputs and the compilation program to generate web dialogue pages that the final user can easily operate.

Implementing a first pilot in an Italian high school made it possible to validate the proposed approach and the trial software as an effective tool to facilitate students' learning of Financial Literacy skills and knowledge.

The short-term goal is to develop a fully operative version of the software enriched with several applications offering a reasonably comprehensive overview of Financial Literacy. The next step will see the internationalization of the application and the possibility of disseminating its use to a broader audience of students.

In this way, youngsters can find answers to the most common Financial Literacy problems simply and effectively, either through traditional school learning or by using the most modern self-learning tools.

4 Conclusion

The impact of Artificial Intelligence and Information Technology in Philanthropic Organizations has been investigated, with particular reference to two specific contexts, with the illustration of case studies.

The most advanced DSSs for fundraising management for non-profit organizations have been overviewed, with some mention of ongoing developments. Furthermore, a specific DSS for medium-sized organizations has been illustrated, by the rigorous mathematical modeling approach and the explanation for non-technical readers through visualization diagrams and numerical results.

Philanthropic Cultural Organizations have been considered through their activity of Financial Literacy, in particular to youngsters. A very recent Information Technology approach has been investigated, with the presentation of a visualization diagram modeling method and the development of an interactive Excel Lab. In this context, an ongoing collaboration with the organization *Nuova Civiltà delle Macchine* (NCdM) produced a high-end web application for the Excel Lab, which has been analyzed.

These applications showed either the flexibility of the tools and their adaptability or the great utility of Artificial Intelligence and Information Technology in the philanthropic field.

Acknowledgments

We would like to thank Dr. Claudio Ricci for computational assistance and Eng. Roberto Camporesi, President of the Philanthropic Cultural Organization NCdM, for his collaboration.

Notes

1 Fuzzy Logic Systems produce acceptable but definite output in response to incomplete, ambiguous, distorted, or inaccurate (fuzzy) input. See, e.g., Czabanski et al. (2017) for further reading.
2 The DB has been fine-tuned in collaboration with ASSIF (the Italian fundraiser association) and Philanthropy Centro Studi, a research center of non-profit, fundraising, and social responsibility operative in the University of Bologna.

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