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www.Personal_Asset_Allocation

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Today consumers demand delivery of financial services anytime and anywhere, and their needs and desires are evolving rapidly. The World Wide Web provides a rich channel for distributing customized services to a range of clients. An Internet-based system developed by Prometeia S.r.l. for Italian banks—both traditional and e-banks—supports consumers and financial advisors in planning personal finances. The system provides advice on allocating personal assets to fund consumers' needs, such as paying for a house, children's education, retirement, or other projects. State-of-the-art models of financial engineering—based on scenario optimization—develop plans that are consistent with clients' goals, their attitudes towards risk, and the prevailing views on market performance. The system then helps clients to select off-the-shelf financial products, such as mutual funds, to create customized portfolios. Finally, it analyzes the risk of portfolios in terms that are intuitive for laypersons and monitors their performance in achieving the target goals. Four major banks use the system to support their networks of several thousand financial advisors and to reach tens of thousands of clients directly.

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During the last decade, the decline of the welfare state created consumer demand for more autonomy in managing their financial assets and changed their needs and desires. At the same time, the development of the World Wide Web created a rich channel for distributing customized financial services to satisfy investors' increased sophistication and diversity.

Prometeia S.r.l., working with university faculty, developed expertise in financial engineering. We used this expertise to design customized products for Italian consumers, and we relied on the World Wide Web to make these advances in financial engineering available to large networks of financial advisors and through them to reach an increasing client base. In addition, financial institutions reached the most sophisticated segment of the client base through the Internet, providing clients with greater autonomy and allowing financial institutions to bypass the monopoly control of financial advisors over clients. Supported by an appropriate business plan, four major Italian banks successfully deployed the Web-based system, which supports networks of several thousand financial advisors and reaches tens of thousands of consumers directly. One of the early adopters is making the system available to clients outside Italy in Europe.

Advances in financial research and financial engineering are geared towards both large institutions and individuals. Markowitz (1991) compared individual and institutional investing, concluding that realistic game-of-life simulators would include simulations of the family financial-planning process—a complex and ill-structured process—and models to optimize asset allocation for various scenarios of the family financial plan. Simulations of consumption during the life cycle abound in the economic literature (Guiso et al. 2001), although they are mostly normative models in stylized form. Optimization-based systems for retirement planning have been developed for www.financialengines.com by William Sharpe and Associates. The HOME Account Advisor of Berger and Mulvey (1998) supports further household financial needs beyond retirement planning.

In general, individuals are best suited to conduct the complex financial-planning process, perhaps assisted by financial advisors, and carry out their own simulations in the form of what-if analysis and scenario projections. In this effort, they rely on the advice of financial advisors, the demands of spouses and siblings, and the opinions of friends and relatives. Once they establish some key parameters of the family's financial plan, such as the target retirement age and income, they seek professional advice on investing their assets to reach these targets. Expertise on market trends and the availability of investment opportunities must be combined with each individual's investment style to produce a comprehensive portfolio. A support system should monitor this portfolio for its ability to reach the targets: the targets may be too ambitious, the savings may be too little, or the mutual fund may be underperforming.

The system we developed uses advances in financial engineering to optimize the financial-planning process and provides tools to support asset allocation, monitoring, and control:

— It provides strategic asset allocation by creating well-diversified portfolios in the broad asset classes and global markets.

— It provides tactical asset allocation by recommending a portfolio of mutual funds from those the financial institution offers that best matches the strategic decisions.

— It monitors and controls the portfolio, identifying the risks of underperformance vis-à-vis the targets and allowing for portfolio revisions.

Prometeia offers the system on the Web using offline and online subsystems that allow for real-time optimization, while the user interface interprets the recommendations using alternative forms that are understandable to a layperson. As Markowitz (1991, p. 7) put it, "Another challenge is to use modern computer technology to help [investors to] understand and remember what has been done." We met this challenge by using the Web and designing interfaces based on the recommendations of financial advisors and the banks' marketing departments.

A survey on changes in providing financial service triggered the Prometeia's decision to enter this new business. In collaboration with Prometeia's analysts, we designed the modules making up the Web-based personal-asset allocation system. We devised three modules to form the integrated interactive system: a personal-asset allocation module to carry out strategic decisions, a personal-rating module for tactical decisions, and a personal-risk analyzer to control and monitor risk. We built the integrated decision-support system with the help of Prometeia's information technology department, trying hard to solve technical problems due to computational and security issues. The success of the project can be ascribed to the business plan, whose key components are the development of an application-service provider and the integration of the businesses of financial product originators and distributors.

Changes in Providing Financial Services

In the last two decades, Italy has accumulated a huge public debt (more than 100 percent of the yearly GDP). After signing the Maastricht Treaty (the financial agreement subscribed to by those countries adopting the euro), the Italian government has been adopting policies to reduce social expenses.

With the consequent decline of the welfare state, individuals have become aware that their well-being and that of their families is increasingly in their own hands and decreasingly in the hands of the state. As a result, consumers demand prompt delivery of quality financial services, and they have become knowledgeable about financial products.

The numbers are telling: In the 1980s, almost 40 percent of US consumers' financial assets were in bank deposits. By 1996, bank deposits accounted for less than 20 percent of consumers' financial assets, with mutual funds, insurance, and pension funds absorbing the difference (Harker and Zenios 2000, Chapter 1). Similar trends exist in Italy. The traded financial assets of Italian households more than doubled in the six-year period from 1997 through 2002 (Prometeia S.r.L. 2001). The bulk of the increase was absorbed by mutual funds and asset management (Table 1).

The increase in traded financial assets comes with increased diversification of the Italian household portfolio, similar to that in the US a decade earlier. Between 1995 and 2000, mutual funds and equity shares grew at the expense of liquid assets and bonds

	1997	1998	1999	2000	2001	2002 (estimate)
Household total	944.853	1,427.999	1,781.996	2,124.102	2,488.154	2,877.773
Percent of household's assets	23.6	31.4	34.6	38.3	41.9	44.8
Mutual funds	368.432	720.823	920.304	1,077.360	1,237.964	1,386.519
Asset management	375.465	542.205	673.500	781.300	880.450	956.970
Life and general insurance	165.000	202.300	257.400	329.600	433.400	574.000

Table 1: The traded financial assets of Italian households more than doubled in the period 1997 through 2002, and much of the increase has been absorbed by mutual funds. (Data from *Forecast Report* (Prometeia S.r.l. 2001).)

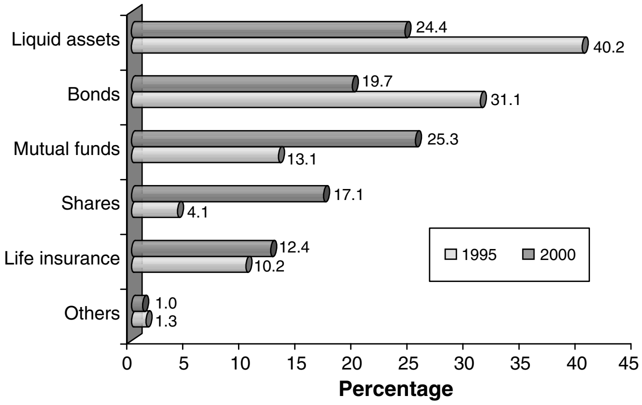


Figure 1: The evolution of Italian household portfolios shows an increase of mutual funds and equity at the expense of liquid assets and bonds.

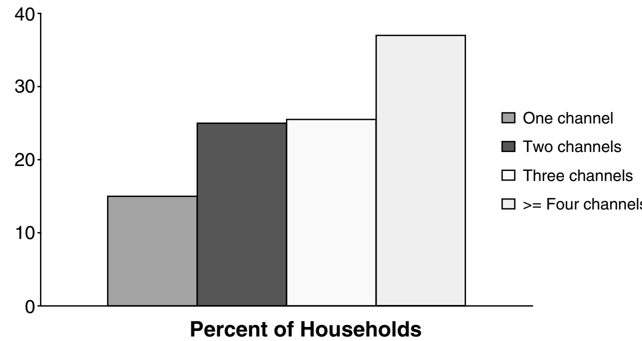


Figure 2: US households use alternative delivery channels, and the majority use four or more channels. (Data from Kennickell and Kwast 1997.)

(Figure 1). By 2003, one third of the total revenues of the Italian banking industry came from asset-management services.

These statistics reveal the *outcome* of changes in consumers' behavior. What changes caused this new pattern of investment? The annual *Household Savings Outlook* (*Osservatorio sui Risparmi delle Famiglie*) (Eurisko-Prometeia S.r.l. 2001) provides insights. First, the traditional distinction between the delegation of asset management to a pension fund board or to the directors of an insurance firm by most consumers and the autonomy maintained by wealthy investors in managing assets no longer appears valid. Ordinary investors exhibit both attitudes.

Second, the trend is towards greater autonomy and towards innovative instruments (Figure 1). The group of Italian households classified in the Eurisko-Prometeia survey as "innovators" grew steadily from 6.7 percent in 1991 to 22.6 percent by 2001. Each percentage point increase added a further 200,000 households to this category. In 2003, this segment numbered 4.3 million households. Households in this category adopt a professional approach to finance. They are able—or at least feel they are able—to manage their financial affairs, and they rely on integrated channels, using online information and conducting business by phone.

Third, an analysis of the influence of quantitative variables on the savings habits of households shows that awareness of financial indicators and, in particular, of the performance of managed assets, is influencing household behavior. Older investors are more aware of such indicators than younger investors. The analysts performing the Eurisko-Prometeia survey also predict that the trend towards increased diversification of assets under management will continue unabated during the next three years. The investors' favorites are insurance and portfolio management. However, the survey was conducted just prior to worldwide bull markets stalling, so any projections can be questioned.

Investors changed their attitudes towards innovative products; they also changed their attitudes towards delivery channels. Data from a survey of households in the US (Kennickell and Kwast 1997) show that consumers want more than one delivery channel. While visiting a bank branch remains predominant, many US households use alternative channels, such as phone, electronic transfer, ATMs, and PC-banking (Figure 2). Italian households follow this trend, although with some delay. In 2000, only 16 percent of Italians surveyed could recognize online brands. By 2003, this number had grown to 56 percent. Brand recognition has been followed by use of the new channels (Figure 3).

As the demand side of financial services changed, the supply side changed as well (Harker and Zenios 2000). Technology and the Internet are gaining importance in finance and investing. Many companies offer research, advice, brokerage operations, and other important financial data on the Internet. By browsing the Web, anyone can obtain security prices, company and market news, and retirement plan consultants. Web sites are designed so that even financial novices can decide which mutual fund to purchase, whether to surrender their life insurance, or to sell or buy a given stock. The Web investor has the autonomy to decide what is important and what is not, much as the institutional investor has for years. The value added by the Internet consists of spreading financial information and allowing people to act immediately based on the news they have just downloaded.

The market for direct distribution of financial products through the Web is, however, a niche market. Compared to traditional channels, it is modest in terms of shares traded. For instance, it is estimated that in Italy only 500,000 investors out of 12 million potential users rely on the Web for trading (Eurisko-Prometeia S.r.l. 2001). This is consistent with

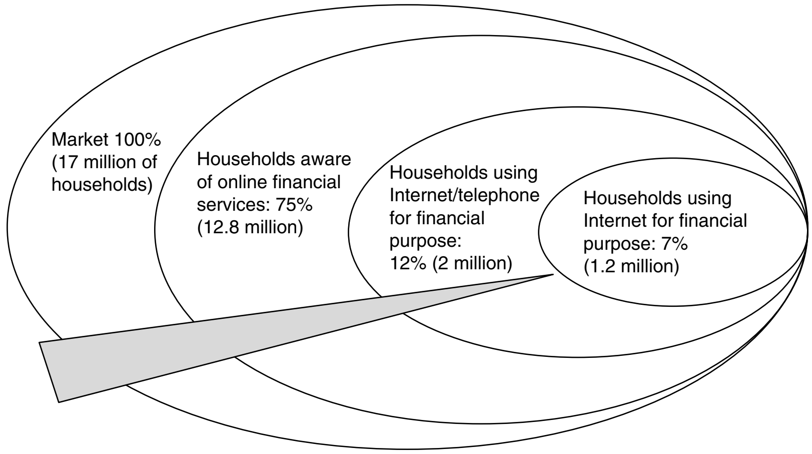


Figure 3: Italian households are changing their financial attitudes and exploiting new channels. A survey reveals that more that 19 percent of Italian households use the Internet and the telephone for financial purposes. (Data from *Household Savings Outlook* (Eurisko-Prometeia S.r.l. 2001).)

another change: Financial services have changed from handling product sales pure and simple to actively managing customers' financial-planning expectations and needs. In this field, the Internet has considerable potential as a facilitator. It is one more channel firms can use to manage the relationships they have established with customers through the traditional channels of banks, agencies, and advisors. Financial institutions try to provide multichannel support (Figure 2).

The shift towards multichannel distribution is caused by pull and push forces. The pull is coming from the changing demands of consumers, especially the young. The push is coming from suppliers of financial services using the Web to reach a wide client base.

They use the Web to reach customers and to support financial advisors, their internal clients. This support leads to customer loyalty towards advisors and creates disincentives for advisors thinking of switching firms (Roth and Jackson 1995). In addition, Web-based services give firms a channel of communication with customers that is not controlled by the network of financial advisors.

These last points are key considerations. Their advisors are valuable assets for financial service providers. Firms need to serve them well but also need to loosen their tight grip on the clients. Broker Stephen Sawtelle made front-page news in *The Wall Street Journal Europe* (August 29, 2001) when he left Wadell and Reed and clashed with the firm for control of his 2,800 clients. Sawtelle was eventually allowed to keep 2,600 of his clients, and an arbitration panel ruled that the firm had to pay \$27.6 million in damages to its former broker. Wadell and Reed could not have avoided his departure by supporting him with a Web-based system. It fired him for "personality conflicts." (Incidentally, it had informed him just seven days earlier that "your distinguished service to your clients and our company is immeasurable.") However, the 2,800 clients would have been more autonomous had they managed their assets directly, and the ensuing battle for their control would have been less disruptive.

Prometeia was positioned to perceive the changes in financial services in Italy and to suggest a strategic course of action. Prometeia provides consulting services to industrial companies, insurance companies, banks, and government agencies in Italy. To support its activities, Prometeia carries out an annual survey of Italian households in collaboration with Eurisko, and they summarize the results in a report titled *Osservatorio sui Risparmi delle Famiglie* (*Household Savings Outlook*) Eurisko-Prometeia S.r.l. (2001). This survey captured early changes in customer attitudes and demands and provided us with the first piece of the puzzle.

The financial research and consulting area of Prometeia focuses on two main topics: financial institutions' strategies and industrial planning, and the design and implementation of an integrated decision support system (assets and liabilities management, market and credit-risk management, profitability analysis, and capital budgeting). Prometeia is market leader in these areas in Italy with more than 50 business partners, including all the major Italian banks. Through its consulting activities, Prometeia realized its needed innovative products to support client demands and realized the potential role of the Web as a facilitator. This provided the second piece of the puzzle.

The link that brought the pieces together was the expertise Prometeia acquired in financial engineering by collaborating with the Hermes Center on Computational Finance and Economics at the University of Cyprus. We had developed scenario-optimization models for managing insurance policies with guarantees (Consiglio et al. 2000, 2001). Scenario optimization models can be used to customize products for individual investors in the context of game-of-life simulations. The Web would provide the interface, and the clients would retain full control of their own game-of-life simulations. The overall concept appealed to e-banks and to traditional banks seeking to improve their support of their financial advisors and to provide additional services to their clients.

The Design of a Web-Based Personal-Asset Allocation System

Individuals must plan for a variety of financial goals: buying a house, a car, or other tangibles; financing children's educations; saving for retirement; and covering health-care and other insurance. The typical family focuses on these goals at different stages in their lives. Newlyweds are concerned with purchasing homes, young parents, with their children's education, and middle-aged couples, with their retirement. Some personal-asset allocation systems (for example, Berger and Mulvey's 1998 HOME Account Advisor) advocate an integrative approach to financial planning that takes into account all of these targets. Others (for example, Sharpe's www.financialengines.com) focus on a single problem, for example, retirement planning.

While conceptually the integrative approach has advantages, in practice it is unwieldy and perhaps inadvisable. Beyond the computational and algorithmic problems in optimizing an integrative financial plan, end-users could have several objections. First, the information requirements are very high, and clients are reluctant to reveal their complete financial particulars to an investment advisor or to a single financial institution. The silo approach to risk management, in which individual departments develop strategies for their own areas, prevailed in banks, and it is alive and well in personal financial planning. Individuals tend to segment their problems instead of taking an integrative view, and various needs take priority over time. The silo approach, however, can produce suboptimal results (Berger and Mulvey 1998).

Specialized systems that focus on a single goal, such as retirement, place manageable demands on users, and they obtain expert advice on allocating assets to solve well-specified, significant problems. Perhaps the best known Web-based service provider in this category is www.financialengines.com, which serves a wide client base.

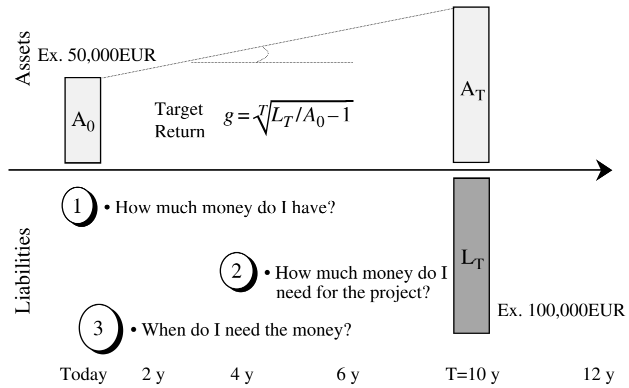


Figure 4: The system determines the growth rate after the customers input the target, initial investment, time span, and savings.

The system of personal financial tools (PFTs) that we developed provides support for all of the goals a typical family faces but does so by segmenting the family's planning problem into distinct subgoals. The family specifies the financial-planning problem by indicating the time horizon of the project (T), the target goal (L_T), and the current asset availability (A_0). This information is sufficient for calculating the target return that the individual expects (g) (Figure 4). The system of PFTs will then help the user to structure an asset allocation consistent with this target return and the client's attitude towards risk revealed by answers to the online questionnaire.

For each user-specified goal, the PFTs provide three interactive modules: a personal-asset allocation, a personal rating, and a personal-risk analyzer.

—The personal-asset allocation determines the *strategic* allocation of assets based on sectors or broad market indices.

—The personal rating provides a data warehouse of financial indicators and a ratings of mutual funds to help users to pick assets tactically, recommending specific investment vehicles, such as particular equity mutual funds.

—The personal-risk analyzer measures the portfolio risk and monitors the portfolio performance in achieving the target goals.

These three tools form part of an integrated interactive system that allows users to carry out game-of-life simulations, addressing both strategic and tactical issues. The personal-risk analyzer provides a control module to ensure that the strategy developed and its execution will meet the targets.

Strategic Decisions: The Personal-Asset Allocation Tool

The first step in devising a strategic plan is to elicit the client's goals and preferences. The financial advisor asks clients to specify their targets, their planning horizons, and the availability of funds. They must also reveal their attitudes towards risk, which are difficult to ascertain by direct questioning. Every institution we dealt with has a questionnaire developed in house that financial advisors use to establish clients' tolerance of risk. Using a short series of questions, advisors classify clients in five categories of risk takers: *prudente*, *moderato*, *equilibrato*, *dinamico*, and *aggressivo*. They infer the risk tolerance of their customers from their answers to questionnaires designed to investigate clients' risk tolerance. While we could not obtain complete information on those proprietary systems, typical questions are the following: "What is your knowledge about financial markets?"; "In which assets have you invested so far? (a) Government bonds; (b) Stock; (c) A portfolio of stocks and bonds; (d) Short-term instruments like BOTs (Italian T-Bills), bank accounts, and CCTs (Italian floating rate notes); and "With which of the following terms are you familiar?: (a) Value-at-risk; (b) Benchmark index; (c) The difference between stock and bonds." A software program weights the responses to such questions to provide customers with weights between 0 and 100 and maps these weights into the five risk categories. The literature on assessing risk preferences is vast, and it is grounded on the theoretical results of various researchers (Kagel and Roth 1995; Kahneman and Tversky 1979, 1981).

A scenario-optimization model specifies an asset-allocation plan that meets the client's target using the available funds and that is consistent with the client's risk profile. The model takes a target-first view. The asset allocation is such that getting to the final target is the primary concern. Any surplus obtained must be saved to back any subsequent shortfalls. The investor is averse to having a deficit *viz-á-viz* the target at the horizon. A suitable objective function for our investor is the piecewise linear

$$\text{maximize} \quad \mathscr{E}[U_T] - \lambda \mathscr{E}[D_T]. \tag{1}$$

Here $\mathscr{E}$ denotes expectations, and U_T and D_T are the upside and downside, respectively, of the terminal wealth against the target, representing surplus and deficit at maturity. λ is a weight indicating risk aversion (high for $\lambda = 8$, low for $\lambda = 3$, and neutral for $\lambda = 0$).

We employ a simple approach for generating scenarios using only the available data without any mathematical modeling by bootstrapping a set of historical records. Each scenario is a sample of returns on the assets obtained by sampling returns observed in the past. We select dates from the available historical records randomly, and for each date in the sample, we read the returns of all asset classes realized during the previous month. These samples are scenarios of monthly returns. To generate scenarios of returns for a long horizon—say 10 years—we sample 120 monthly returns from different points in time. The compounded return of the sampled series is one scenario of the 10-year return. We repeat the process to generate the desired number of scenarios for the 10-year period. With this approach, we preserve the correlations among asset classes.

The asset classes are determined according to the Morgan Stanley and JP Morgan classifications; they consider three generic asset classes, stocks, bonds, and cash, which are aggregated into broad sectors such as EMU (European Monetary Union) and ex-EMU. In particular, we used the following asset classes (listed with their DataStream code in brackets): North American stocks (MSNAMR), Pacific stocks (MSPACF), emerging-market stocks (MSEMGK), EMU stocks (MSEMUI), ex-EMU stocks (MSEXEM), North American bonds (JPMUSU), Pacific bonds (JPMJPU), EMU bonds (JAGALL), ex-EMU bonds (JPMUKU), emerging-market bonds (JPMPTOT), and cash (JPEC3M). Figure 5 shows the benchmark asset classes and their historical performance.

We based our scenario-generation method on the premise that history repeats itself. While this may be true in the long run, using historical series starting from the 1990s to bootstrap scenarios for the early part of 2000 will lead to very optimistic forecasts. In the PFTs system, we intentionally leave the scenario-generation method unspecified. We describe one example to illustrate the system, but users provide their own estimates. We provide pointers to other Web-based services that specialize in market forecasts so that users will have access to the relevant expertise.

The optimization model will specify an asset-allocation decision that is consistent with the investor's risk preference and the projected scenarios. While we take a target-first view, we cannot guarantee that the goals will be met under all circumstances. The goals may be too ambitious, the available savings may be too low, or the prospective returns on the assets not high enough. We analyze results of scenario optimization to ascertain whether the recommended decision meets the goals (Figure 6).

Four courses of action are available to clients who are not comfortable with the probability of success—or lack of it—of a given plan. These options are available through the interactive Web-based system. First, the client can increase savings; the model estimates the amount needed to increase the probability of success, either as lump sum or as periodic increments. Second, the client can trim the goals, for instance, by shelving plans for a swimming pool. Third, the client can delay the project. In the last two cases, the system gives the client enough information to make an informed decision. As the client trims goals or delays the project, the probability of success increases.

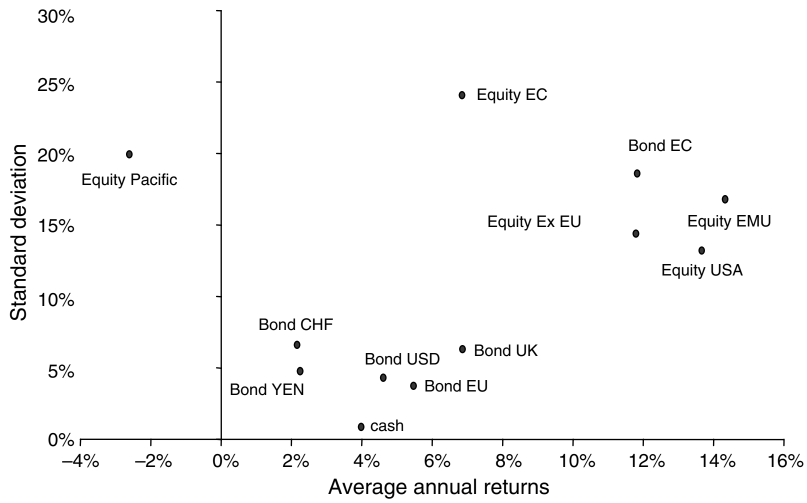


Figure 5: Performance of the benchmark asset classes during 1988–2000.

A final alternative is to go for aggressive portfolios with higher expected returns and higher volatility. The resulting increase in the probability of success would be accompanied by an increase in the magnitude of the potential shortfall.

Tactical Decisions: The Personal Rating Tool

Once the investor decides on a strategic asset allocation, he or she must decide on a specific portfolio. The personal rating tool provides a menu of mutual funds the institution sells that are appropriate to the client's strategic plan. The menu includes ratings and other information about the funds' performance.

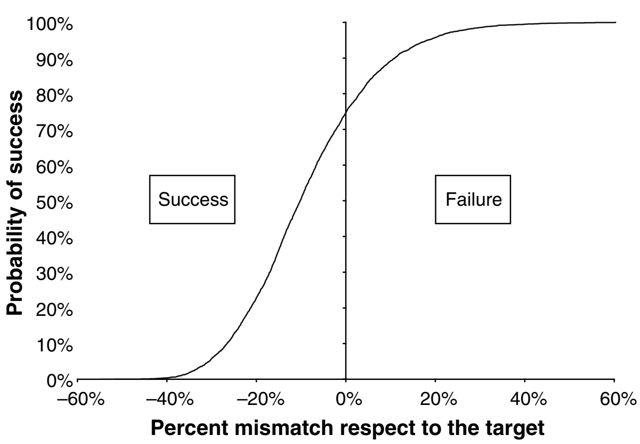


Figure 6: We illustrate the results of a typical simulation and analysis of the probability of success. For this example, the probability of success is 75 percent. There is a 25 percent chance that the targets will not be met in the next six years. This may be acceptable to the user if the project under consideration is building the family vacation home but may be unacceptable if it concerns children's education or retirement.

The multitude of mutual funds pushes financial institutions to provide personal rating tools.

Customers want personal rating tools to help them to choose funds that meet their strategic asset allocations, creating pull forces.

Control: The Personal Risk Analyzer

With the personal risk analyzer, clients can monitor the risks of their portfolios given their targets at the *strategic* and *tactical* levels. When the strategic asset allocation tool and the tactical asset allocation tool perform as planned, the investor is on the way to meeting the goals within the time horizon. When the tactical portfolio fails, the client must examine the performance of individual fund managers and drop underperformers. A failure of the strategic portfolio indicates a general change in economic conditions

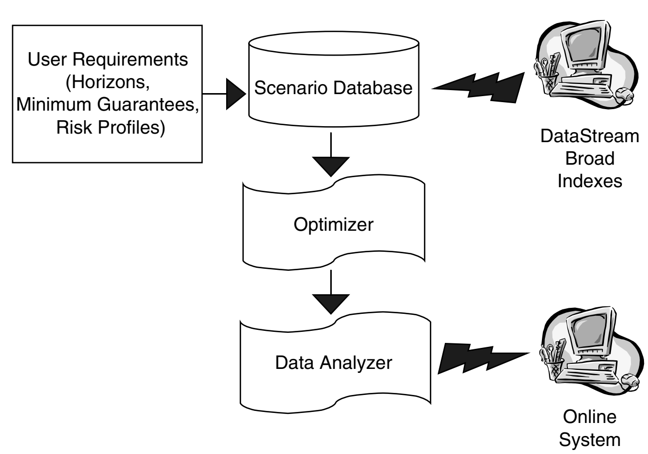


Figure 7: In the off-line system, we run the optimization model every month for several combinations of risk profiles, horizons, and target portfolio growth rates.

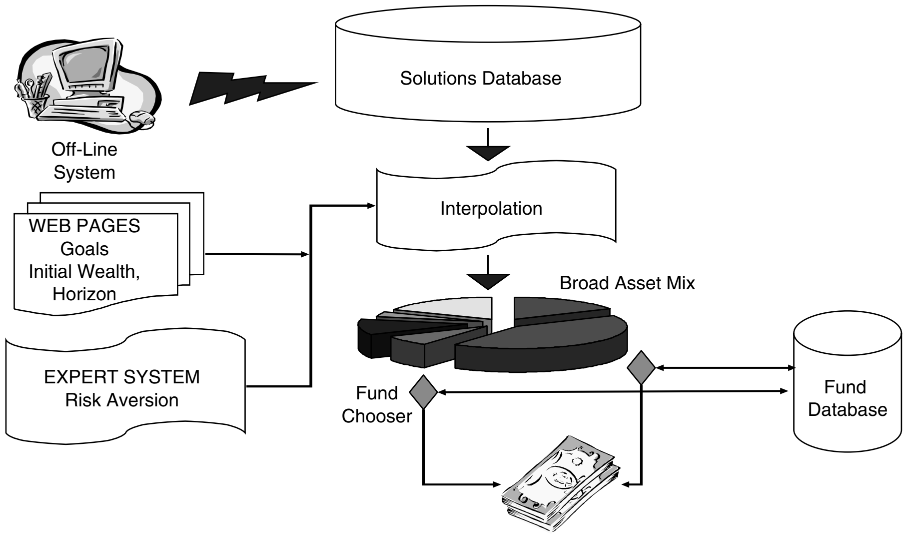


Figure 8: Using the online system, the investor interacts through the Web pages, and the system maps the data entered onto the solution database and matches them with specific mutual funds from the fund database.

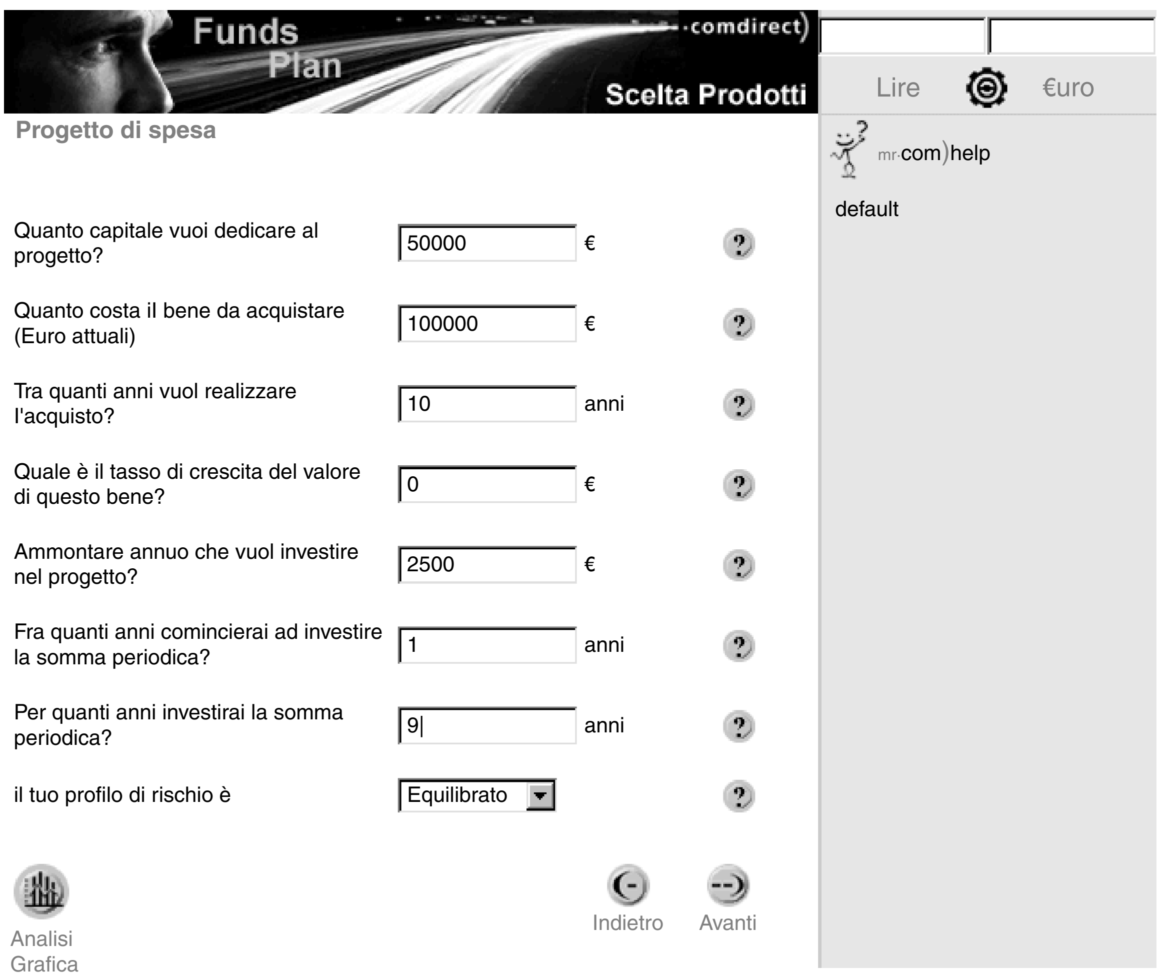


Figure 9: We show the Lorenzos' personal financial requirements for purchasing a retirement home that has a current market value of 100,000€.

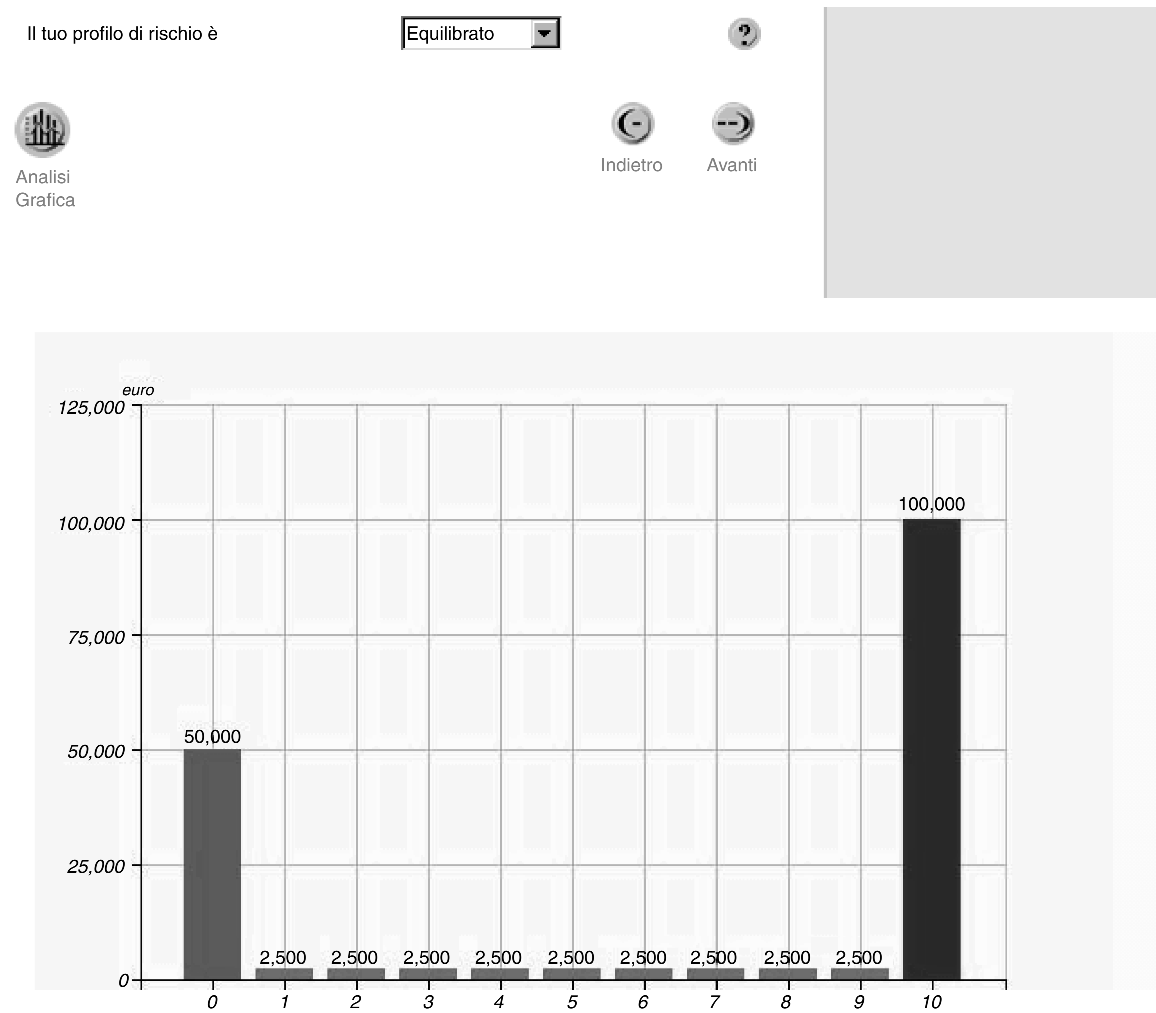


Figure 10: We show the Lorenzos' Web page and their cashflow specifications.

that threatens the investor's plans and calls for an increase in savings, a cut in targets, or acceptance of delay in meeting goals.

The Integrated Decision-Support System

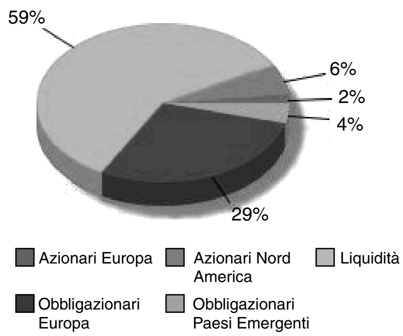
The system combines an off-line module that runs the optimization and an online module that customizes products. The off-line module exploits the fact that large segments of the population are homogeneous, so that we can optimize for a range of planning horizons, financial targets, and risk preferences. We then customize a plan for an individual by extrapolating from the pool of optimized plans.

We run the scenario optimization model off line and store the results in a solution database (Figure 7). The online system (Figure 8) interacts with the user and, for a given risk profile, horizon, and final goal, interpolates the optimal portfolio from the available solutions in the database.

The customer accesses the online system through a set of Web pages. An expert system analyzes the user's inquiry, maps the risk profile to the proper risk-aversion parameter, and then calculates the minimum growth rate. It passes these data on to the interpolation module that consults the off-line system through the database of solutions and determines the strategic asset allocation that is close to the client's requirements. It then maps the broad asset allocation to a set of mutual funds the investor can buy. A fund chooser shows a set of mutual funds the institution sells from the broad asset classes the optimizer chose. Each institution maintains a database of available funds.

The Case of Mr. Lorenzo

Consider the case of Mr. Lorenzo, who is a typical head of an Italian household, aged 55, with two children well into their own careers. He and Mrs. Lorenzo have a wealthy retirement plan based on a combination of private savings and a generous Italian social



Asset Allocation Consigliata		
	%	€
Azioni	**8,10%**	**4050,00**
Azionari Europa	1,80%	900,00
Azionari Nord America	6,30%	3150,00
Azionari Pacifico	0,00%	0,00
Azionari Paesi Emergenti	0,00%	0,00
Obbligazioni	**33,10%**	**16550,00**
Obbligazionari Europa	28,80%	14400,00
Obbligazionari Nord America	0,00%	0,00
Obbligazionari Paesi Emergenti	4,30%	2150,00
Obbligazionari Yen	0,00%	0,00
Liquidità	**58,80%**	**29400,00**

	Asset Allocation Realizzata		Scostamenti		
	%	€	%	€	X
Fondi Azionari	**0,00%**	**0,00**	**0,00%**	**0,00**	
Fondi Obbligazionari	**0,00%**	**0,00**	**0,00%**	**0,00**	
Fondi Monetari	**0,00%**	**0,00**	**0,00%**	**0,00**	
TOTALE	**0,00%**	**0,00**			☒

Figure 11: This Web page shows the proportional asset allocation the system recommends (left) and the assets the Lorenzos bought. Because they have not yet followed the system's recommendations and have bought nothing, the entries on the right are zero.

security system. With the prospective decline of social security support by the state, the Lorenzos plan to buy a house in the Italian Alps to serve as their vacation home and eventually as a retirement home or as an asset to sell to supplement their retirement income.

The Lorenzos have available 50,000 euros and expect to invest an additional 2,500 euros per year over the next decade to buy a home currently valued at 100,000 euros (Figures 9 and 10). They assume the standard inflation rate of two percent for housing and wish to invest in a balanced portfolio. They have a medium appetite for risky investments.

The system recommends a portfolio (Figure 11) with a probability of success that is marginally over 55 percent, as the success thermometer shows (Figure 12). This means that their plan is little better than flipping a coin. They could delay retirement by an additional couple of years, but the probability of meeting their goals after 12 years, instead of 10, is only 57 percent.

They could increase their annual savings, but they are reluctant to forego consumption over the next decade to buy a retirement home. Opting for a more aggressive portfolio is another alternative. Developing a plan for a 12-year horizon, maintaining the 2,500 euros per year contribution, and building a portfolio characterized as *aggressivo* improves the probability of success to 80 percent. Because their essential retirement needs are covered—pension, health care, and a fully paid house in the city—the Lorenzos decide, with some nudging from their children, that the proposed plan is sound.

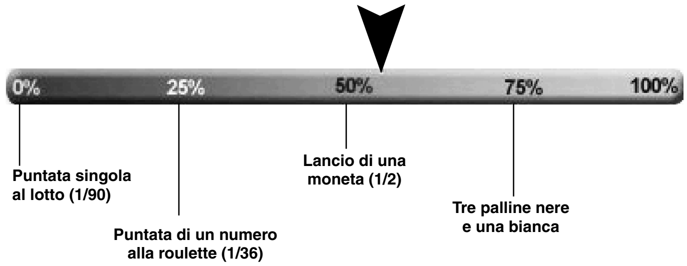
To build the portfolio the Lorenzos need the personal rating tool. They need to convert the optimal asset allocation the system recommended into specific funds. They are unwilling to put any money into emerging market bonds ("Obbligazioni paesi emergenti"). ("If I have not visited the country, I am not buying its government bonds" declared Mr. Lorenzo.) They end up with a portfolio heavy on US bonds and light on bonds in emerging markets (Figure 13).

Business Plan for the Deployment of the System

Developing the scenario optimization model and the concept of the Web-based service was important, but the system's success depended on two characteristics

Probabilità di successo

Qui va inserito il testo sopra il termometro



Qui va inserito il testo tra il termometro e la tabella

		Strategia 1	Strategia 2	
Probabilità di successo		Capitale Iniziale da investire	Capitale Iniziale da investire	Risparmio annuo da aggiungere
23,10%	Molto bassa	22131,16		
25,20%	Molto bassa	24188,46		
27,90%	Molto bassa	26458,10		
31,30%	Bassa	28964,21		
36,20%	Bassa	31733,91		
41,70%	Bassa	34797,73		
45,10%	Bassa	38190,10		
48,10%	Bassa	41949,80		
51,20%	Mediocre	46120,66		
55,50%	**Mediocre**	**50000,00**	**50000,00**	**0**

Figure 12: This Web page displays the probability that the proposed plan will meet the Lorenzos' goals. The thermometer indicates a probability of success equal to flipping a coin (lancio di una moneta).

of the business plan:

(1) We focused on developing an application service provider. Prometeia staff, working closely with client institutions and the academic consultants, designed a turnkey system that relies on the off-line optimization model and custom-made online systems to support the idiosyncratic needs of each institution.

The off-line system is the generic engine box, which is identical for all applications. We customized the input data and the user interface. Input data concern primarily the types of products the institution offers, which are already part of its business strategy. Some institutions may also wish to convey their views on market trends to their clients in specifying scenarios. Usually they rely on market expectations from other sources. The information required from consumers is also custom-made for each application, driven by the market segment to which the customer belongs. Similarly, we have the user interface on the sellers' core businesses, which their marketing departments understand very well.

The client institutions need no expertise in financial engineering or in Web-based services. However, we adhered to their performance specifications. Much as someone buying a new car can be satisfied with a particular automobile without knowing anything about the complex electronic controls running the engine, so Prometeia's clients were satisfied with the services the Web-based system and the personal financial tools provided without understanding the advanced technology behind the user interface.

(2) We viewed the Web-based system as designed for *business to business for consumers.* Two types of businesses provide financial services: businesses that originate products, such as investment banks, and businesses that distribute products, such as retail banks, financial advisors, and brokers. The system

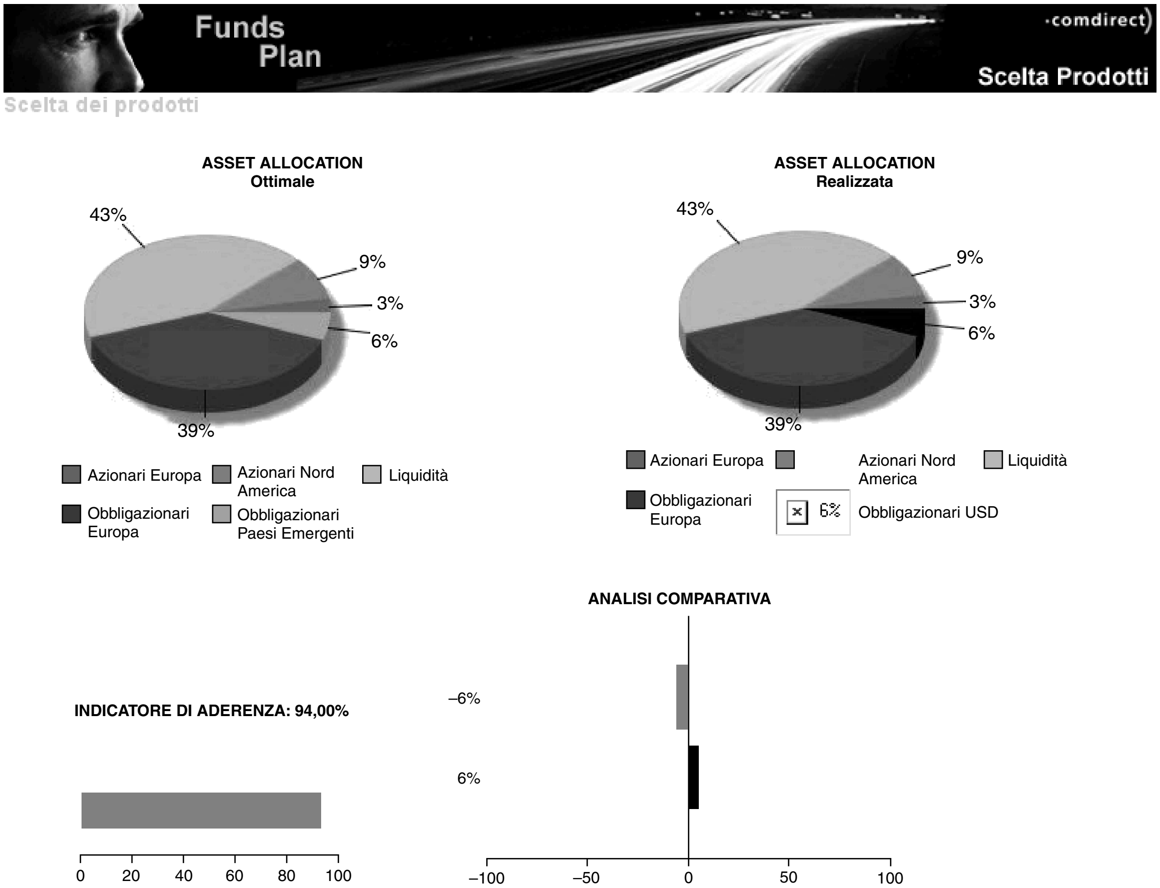


Figure 13: The Lorenzos' final portfolio has a higher probability of success than the earlier portfolio. The pie charts show the composition of the portfolio recommended by the system (left) and that of the portfolio they bought (right).

integrated the process from origination to distribution. Distributors can gain direct access to several product originators, and they can use the system to develop their own products. Product originators can also reach financial advisors working for distributors.

Our system integrates the existing service chain—originator-distributor-consumer—and creates alternative links at no extra cost (for example, originator-consumer, multiple originators-distributor) that may suit different market segments.

In our business plan, we viewed our system as one more channel for delivering services to add to the existing channels. Consumers often rely on more than one delivery channel (Figure 2). Both originators and distributors can get the same results with traditional delivery channels, but they can extend their reach by using the rich Web-based channel. For example, product originators can reach consumers directly without intermediaries.

Our system combining technology and business plans adds value at two levels. At a *basic level*, it provides consumers with advice on allocating personal assets. At an *advanced level*, it helps financial advisors to serve their clients, designing customized portfolios and dealing with product originators. Depending on the business plan of the client institution, the system would add value at one or both levels.

User www.ComDirect.it

www.Comdirect.com advertises itself as "Europe's leading online broker." It was created in 1995 as a direct banking subsidiary of Commerzbank AG to offer clients a complete range of direct brokerage services. Within five years, ComDirect became one of Europe's leading online brokers with the most heavily frequented financial Web site and over 631,000 clients as if June 30, 2001 (over 595,000 of them direct brokerage clients). ComDirect offers a range of information and analysis tools to help clients in their direct trading. Clients order via the Internet based on information provided by ComDirect or other providers. In the first trimester of 2000, clients placed about 8 million orders through 60 million visits to the company's site. ComDirect offers services

Asset Allocation Consigliata

	%	€
Azioni	**12,00%**	**6000,00**
Azionari Europa	2,80%	1400,00
Azionari Nord America	9,20%	4600,00
Azionari Pacifico	0,00%	0,00
Azionari Paesi Emergenti	0,00%	0,00
Obbligazioni	**44,80%**	**22400,00**
Obbligazionari Europa	38,90%	19450,00
Obbligazionari Nord America	0,00%	0,00
Obbligazionari Paesi Emergenti	5,90%	2950,00
Obbligazionari Yen	0,00%	0,00
Liquidità	**43,20%**	**21600,00**
Liquidità	43,20%	21600,00
TOTALE	**100,00%**	**50000,00**

Asset Allocation Realizzata / **Scostamenti**

	%	€	%	€	X
Fondi Azionari	**12,00%**	**6000,00**	**0,00%**	**0,00**	
Azionari Europa	2,80%	1400,00	0,00%	0,00	
EUROPEAN EQITY FUND 'A'	2,80%	1400,00			☐ C
Azionari Nord America	9,20%	4600,00	0,00%	0,00	
US REAL EST. SECURITIES 'A'	5,20%	2600,00			☐ C
US LEADING STOCK FUND	4,00%	2000,00			☐ C
Fondi Obbligazionari	**44,80%**	**22400,00**	**0,00%**	**0,00**	
Obbligazionari Europa	38,90%	19450,00	0,00%	0,00	
EURO BOND ACC 'B'	10,00%	5000,00			☐ C
SHORT MATURITY EURO BOND 'A'	8,90%	4450,00			☐ C
SWISS BOND FUND	20,00%	10000,00			☐ C
Obbligazionari USD	5,90%	2950,00	+100,00%	+2950,00	
US BOND FUND 'A'	5,90%	2950,00			☐ C
Fondi Monetari	**43,20%**	**21600,00**	**0,00%**	**0,00**	
Liquidità	43,20%	21600,00	0,00%	0,00	
EURO CASH FUND	20,00%	10000,00			☐ C
DOLLAR CASH FUND	20,00%	10000,00			☐ C
SWISS FRANC CASH FUND	3,20%	1600,00			☐ C
TOTALE	**100,00%**	**50000,00**			☒

Indietro Salva Piano Elimina Fondi Stampa Piano

Figure 14: This screen shows the specific funds that the Lorenzos bought. For instance, they took further liberties in splitting their cash assets among US dollars, euros, and Swiss francs.

through dot com subsidiaries operating in Austria, France, Germany, Italy, and the UK, each conforming to its local market and regulations.

The Italian subsidiary, www.Comdirect.it, was established in 1999 and is considered one of the major virtual banks in Italy seeking to exploit niche channels for innovator clients. It also seeks to acquire financial expertise and related competencies without infringing on the bank's main business, which is sales. Indeed the parent organization, ComDirect, advertises a complete range of direct brokerage services "with the exception of customer advice." The Italian division is positioned as the leading innovator for ComDirect, and in this capacity, it seeks to offer advisory tools and to exploit the Web with the new technologies of financial engineering. It used its personal financial tools to support a client base of 10,000 during its first year of operation.

Other Users

The second user is a subsidiary of one of the oldest and largest banks in Italy, a bank founded during the Italian renaissance in the 1400s. The subsidiary employs 1,500 financial advisors to support tens of thousands of clients in planning their personal investments. This bank uses the Web-based system at the basic level, adding one more channel for delivering services to its clients. It also uses the system to help its financial advisors gain access to product originators.

When a bank uses the system for both basic and advanced support, we must ensure that the advisors' recommendations are consistent with the system's. To do this, we specify the Web-based system's operations carefully so that its recommendations are consistent with the advisors' general recommendations. The bank's managers also encourage advisors to use the system to learn about new products and market outlooks, and to pinpoint any inconsistencies before consumers notice them and lose confidence in the advice they receive.

The third user is a new virtual bank that adopted the system as part of its core business and made it an integral part of the services it offers. The bank believes that virtual banking should not focus only on providing traditional banking services electronically but should offer new services in a seamless environment.

The Web-based personal-asset-allocation system provides a service most retail banks do not offer that integrates electronic banking naturally. The bank uses the Web-based system at the basic level.

The fourth user is a private bank serving a small number of individuals of high net wealth. It uses the system for advanced support of financial advisors, enhancing their access to product originators. To serve their sophisticated clients, the financial advisors need advanced support to design custom-made products as clients' needs and market conditions change. The system also enhances the advisors' working environment and improves the already excellent retention rates that this institution enjoys and its clients expect.

Conclusions

We developed a successful application on the Web for providing financial services. The system plays a double role, bringing advanced financial engineering techniques to individual investors and enhancing the capabilities of traditional banks and e-banks.

We achieved acceptance of the system only after overcoming several obstacles: Deploying the system required significant organizational resources. It altered the traditional role of financial advisors, which was to sell but not to offer advice. It decreased the efficiency of financial advisors, who had to spend more time with clients custom-designing portfolios than they would have selling off-the-shelf products. It undermined the firm's contacts with clients. We eventually overcame, addressed, or sidestepped these obstacles, either because of features of the technology or commitments on the part of client firms' top management. Innovators should keep in mind the obstacles that new technologies often encounter.

Appendix: The Mathematics of the Model

Here we give an overview of the model. Denote by T the final period of the investor's horizon and with $t = 0, 1, 2, \ldots, T$, discrete points in time from today ($t = 0$) until T. Given an initial endowment A_0 and final target liability L_T, we denote by A_T the terminal assets that are expected to cover the liability L_T. The growth rate needed to yield adequate A_T is given by

$$g = \left(\frac{L_T}{A_0}\right)^{(1/T)} - 1. \qquad (2)$$

The growth rate g can be viewed as a minimum guarantee on the rate of return on the initial endowment. Our primary objective is to deliver the final assets A_T to cover the investor's liabilities. For this reason, we build our model in such a way that any deficit is always covered by cash infusion, that is, increased savings on the part of the investor, and any surplus is taken out of the portfolio to back future possible downside deviations from the minimum guarantee. With this modeling construct, we can advise the client whether sufficient savings are available to meet the goals, whether additional savings may be required and the goals be downgraded, or whether more ambitious goals could be met with the same or reduced savings.

Uncertainty in the financial markets is captured in the form of a discrete set of scenarios denoted by $\Omega \doteq \{1, 2, \ldots, N\}$.

The investor chooses a portfolio from the universe of available assets $\mathcal{U}$. The returns of such instruments during the period $t-1$ to t are denoted by r_{it}^l for each $i \in \mathcal{U}$ and $l \in \Omega$.

To take into account price appreciation, we couple the minimum guarantee rate g to scenarios of inflation rates, i_t^l. The *real* minimum guarantee rate is given by

$$g_t^l = g + i_t^l. \qquad (3)$$

Our initial endowment A_0 is allocated to assets in proportion x_i such that

$$\sum_{i=1}^{m} x_i = 1 \qquad (4)$$

and $x_i \geq 0$. The dynamics of the portfolio value are given by

$$R_{Pt}^l = \sum_{i=1}^{m} x_i r_{it}^l \quad \text{for } t = 1, 2, \ldots, T \quad \text{and for all } l \in \Omega. \qquad (5)$$

In our model, the liability plays the role of a target that must be matched in each period by our asset portfolio to guarantee that at the end of the planning period the final goal is fulfilled. The liability must grow at the rate given by g_t^l,

$$L_t^l = L_{t-1}^l(1 + g_t^l) \quad \text{for } t = 1, 2, \ldots, T \text{ and for all } l \in \Omega, \qquad (6)$$

where $L_0 = 1$.

The main modeling issue is the perfect matching in each period of assets and liabilities. To guarantee it, we must infuse money every time a downside occurs. With the same argument, we reduce the current level of the portfolio value when an upside is experienced; thus we have

$$A_t^l = L_t^l \quad \text{for } t = 1, 2, \ldots, T \text{ and for all } l \in \Omega. \qquad (7)$$

Given that equality (7) holds, the amount of capital to cover the deficit is given by

$$d_t^s = \max[-(R_{Pt}^l - g_t^l), 0]L_{t-1}^l \quad \text{for } t = 1, 2, \ldots, T \text{ and for all } l \in \Omega. \qquad (8)$$

Note that d_t^s depends only on the current mismatch between the portfolio rate of return and the growth rate times the liability level at the previous period.

The same logic applies to the surplus definition,

$$u_t^s = \max[(R_{Pt}^l - g_t^l), 0]L_{t-1}^l \quad \text{for } t = 1, 2, \ldots, T \text{ and for all } l \in \Omega. \quad (9)$$

The dynamics of the total deficit and total surplus are defined, respectively, as

$$D_t^s = D_{t-1}^l(1 + r_{ft}^l) + d_t^l \quad \text{for } t = 1, 2, \ldots, T \text{ and for all } l \in \Omega, \quad (10)$$

$$U_t^s = U_{t-1}^l(1 + r_{ft}^l) + u_t^l \quad \text{for } t = 1, 2, \ldots, T \text{ and for all } l \in \Omega, \quad (11)$$

where r_{ft}^l is the short rate at t under scenario l.

In view of (7), the dynamics of the assets are given by

$$A_t^l = A_{t-1}^l(1 + R_{Pt}^l) - u_t^l + d_t^l \quad \text{for } t = 1, 2, \ldots, T \text{ and for all } l \in \Omega. \quad (12)$$

The max operator in (8) and (9) introduces a discontinuity in the model. To circumvent this problem, we introduce gap variables ϵ_t^{+l} and ϵ_t^{-l} to measure the portfolio excess return over the growth rate and the shortfall below the growth rate, respectively. They satisfy

$$\alpha R_{Pt}^l - g_t^l = \epsilon_t^{+l} - \epsilon_t^{-l} \quad \text{for } t = 1, 2, \ldots, T \text{ and for all } l \in \Omega, \quad (13)$$

$$\epsilon_t^{+l} \geq 0, \quad \epsilon_t^{-l} \geq 0 \quad \text{for } t = 1, 2, \ldots, T \text{ and for all } l \in \Omega. \quad (14)$$

Only one of these gap variables can be nonzero at any given time and under a given scenario. The dynamics for the value of the deficit and surplus are modified as follows:

$$d_t^l = \epsilon_t^{-l} L_{t-1}^l \quad \text{for } t = 1, 2, \ldots, T \text{ and for all } l \in \Omega, \quad (15)$$

$$u_t^l = \epsilon_t^{+l} L_{t-1}^l \quad \text{for } t = 1, 2, \ldots, T \text{ and for all } l \in \Omega. \quad (16)$$

The optimal portfolio is chosen in such a way as to maximize the expected value of the final surplus and minimize the expected value of the final deficit. The risk-aversion parameter, λ, weights differently the importance of the expected deficit: the higher λ, the more sensitive is the investor to losses. In symbols we have

$$\underset{x}{\text{maximize}} \quad \mathscr{E}[U_T^l] - \lambda \mathscr{E}[D_T^l]. \quad (17)$$

All the constraints are linear except the expression for A_t^l, which does not enter into the optimization model. Before we formulate the linear-programming model, we can simplify some of the equalities to reduce the dimension of the constraints. We can determine the expressions for U_T^l and D_T^l analytically (Consiglio et al. 2002) and substitute the relations obtained in the objective function. The linear-programming model becomes

$$\text{maximize} \quad \frac{1}{N} \sum_{l \in \Omega} \sum_{t=1}^{T} [(\epsilon_t^{+l} - \lambda \epsilon_t^{-l}) \Phi^l(t, T) \Psi^l(t)] \quad (18)$$

$$\text{subject to} \quad \sum_{i=1}^{m} x_i = 1, \quad (19)$$

$$\alpha R_{Pt}^l - g_t^l = \epsilon_t^{+l} - \epsilon_t^{-l} \quad \text{for } t = 1, 2, \ldots, T \text{ and for all } l \in \Omega, \quad (20)$$

$$R_{Pt}^l = \sum_{i=1}^{m} x_i r_{it}^l \quad \text{for } t = 1, 2, \ldots, T \text{ and for all } l \in \Omega, \quad (21)$$

where

$$\Phi^l(t, T) = \prod_{\tau=t+1}^{T} (1 + r_{ft}^l), \quad (22)$$

$$\Psi^l(t) = \prod_{\tau=1}^{t-1} (1 + g_t^l), \quad (23)$$

with boundary conditions $\Phi^l(T, T) = 1$ and $\Psi^l(1) = 1$.

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