

A Supply Chain Analogy for a Quantitative Course of a Finance and Accounting's MSc. Program

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ABSTRACT In a MSc. program on Finance and Accounting, a supply chain (SC) analogy is used to better integrate the learning topics on multivariate analysis and optimization-based decision making. The SC analogy was successfully applied in other MSc. courses and programs, both at national and international level, such as the triennial project on “Optimization and Decision Support Systems for Supply Chains”. Such analogy supported the design of a MSc. course addressing data-driven decision making, and the students learns are promoted through the construction of specific case studies either in Finance or Accounting subjects. Using a Problem/Project Based Learning (PBL) approach, the study cases are addressing investments planning, capacity expansion, financial risk treatment, or SC costing and accounting. This PBL approach complemented the SC analogy, in order to cope with the very intensive schedule and to promote motivation along the lecturing sessions of quantitative type .

KEYWORDS: finance, accounting, supply chains, decision making, multivariate analysis.

Introduction

International cooperation and sharing good practices are effective tools to enhance the higher education and promote innovation. This text describes the design of a quantitative-type course in a Finance and Accounting MSc. program, developed and implemented in the *Escola Superior de Tecnologia e Gestão of Instituto Politécnico de Portalegre*.

The MSc. course on Multivariate Analysis and Decision Making (MA&DM) was outlined from a SC analogy that has been also applied at European level. Attention is paid to the needs of labor market, so as to the exploitation of results from several international projects.

Through a PBL approach that both enhanced the course contents and real world applications, the SC subproblems were providing useful templates and mathematical models that were then applied in the construction of study cases. These subproblems were closely related with the students' professional environment, thus the related data and specific information were becoming available in a very straight way.

Finally, the structure of this article considers:

- In Section “International Cooperation and the SC frame-

work”, various international cooperation projects and the way they impacted the design of the MA&DM course are revisited;

- In Section “The SC analogy and the MA&DM course”, the SC-based analogy and the MA&DM course are both addressed, considering the encapsulating MSc. program on Finance and Accounting too;
- In Section “The FI&CO cases for finance and controlling”, the study cases developed by students are synoptically described; these cases are selected because they constitute good illustrations of SC subproblems, either on costing and management of human resources, on capacity expansion, or on investment planning (stocks portfolio);
- In Section “Conclusions and further developments”, the main conclusions and further developments are presented.

International Cooperation and the SC framework

International cooperation had a large impact on the development and implementation of the SC framework, so as in the approach developed for the design of the MSc. course

at hand. In this section, several cooperation projects at European level are briefly described, and so they are their attributes that were incorporated in the MA&DM course.

The Erasmus triennial project on *Optimization and Decision Support Systems for Supply Chain* was addressing MSc/PhD studies (Bruno *et al.*, 2012, 2013, and 2014). This intensive program on Optimization techniques was directed to industry-based SC and to decision support systems (DSS), being developed and implemented from 2011 to 2014. The optimization of production-distribution networks is focused, considering both material and financial fluxes, and also the reverse logistics. The lecturing sessions followed a pull strategy, beginning with distribution-related subjects, and ending with the suppliers' selection. In-between, both the planning and scheduling of production processes were addressed, along with the DSS usually found in manufacturing, petrochemical, and pharmaceutical SC, while the computational sessions were based on the IBM/ILOG environment.

In addition, on behalf of the "European Study on OR/MS Education" (OR-Operations Research; MS-Management Science), a survey was conducted amongst European universities and other higher education institutions (HEI) from June to October 2015 (Belien *et al.*, 2016a). The study purpose was to gain insight about the current state of OR/MS Education in Europe, and the relationships between HEI and the labor market organizations were also addressed: employability issues are important factors either for students' enrolment or programs accreditation. Overall, the majority of the respondents are recognizing the HEI efforts with these factors, while the perception of better tuning the contents and teaching practices to the needs of labor market is looming.

Besides that, European cooperation is well known as a critical subject for the comparability and standardization on higher education. Miranda and Nagy (2011) presented a case of European cooperation that addressed several OR topics and the development of a learning module (*Lego on My Decision*). Beyond the basics of computational linear algebra, linear programming (LP), integer programming (IP), and the related modeling subjects, an advanced session was also prepared to deal with data uncertainty and to use multi-criteria decision-making methods.

Exploiting the results from the referred cooperation projects, several issues were crucial for the design of the MSc. course on MA&DM:

- The direct utilization in classroom of a comparable and normalized module on multi-criteria decision making, and the continuous transference of innovation between the partner countries (for example, Miranda *et al.*, 2014;

Nagy and Miranda, 2012; Nagy *et al.*, 2012).

- The curriculum development in business programs shall consider the needs of labor market, that is, the requirements of companies in the field, as well as the competitiveness and the productivity of human resources (Belien *et al.*, 2016b; Miranda, 2016).
- Within the SC framework, the evolution of technologies is allowing real time decision making, the simultaneous treatment of finance and accounting issues, and the development of optimization-based systems through the IBM/ILOG environment and the CPLEX tools (Barbosa-Póvoa *et al.*, 2016).

The SC analogy and the MA&DM course

In this section, the rationale that supports the SC analogy and the main attributes of the MA&DM course are synoptically presented. Namely, by considering that:

- Finance rules, economic priorities, and accounting regulations play a very important role in the design and implementation of industry-based SC;
- The relevance of SC topics and the complementary expertise are important attributes for the MSc. students;
- Despite the industry or economic sector, similarities occur in the optimization either of agro-industry businesses, petrochemical operations, or even in pharmaceutical networks, being also important to share modeling and solution procedures.

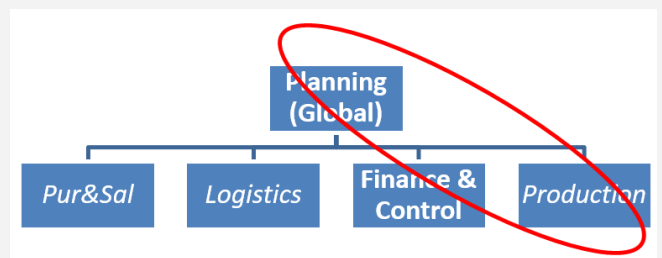


Figure 1: SC framework for the MSc. Course (Adapted from: Miranda, 2011).

In Figure 1, the first level of SC operations considered the *(Global) Planning Department* on top, heading several departments directed to *Purchases and Sales (Pur&Sal)*, *Production*, *Logistics*, and also to the *Financial Accounting and Controlling Department (FI&CO)*. In more detail:

- The *Planning Department* was mainly addressing the SC strategic activities, while it also evaluated the investments in finance products or facilities, for example in capacity expansion.
- The *FI&CO* department allowed a better approach to the

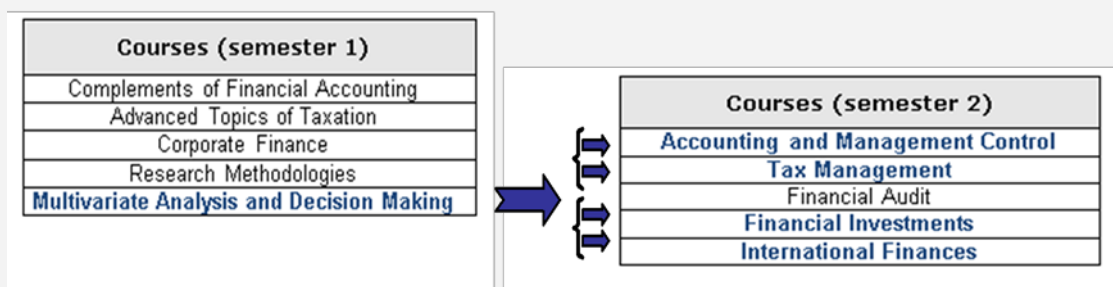


Figure 2: The MA&DM course within the Finance and Accounting MSc. program.

real world, since most of the business planning systems included modules for costing and cash flow controlling; the *FI&CO* topics promoted the practice of quantitative tools and the second semester courses were better prepared this way (Figure 2).

The majority of the courses in the second semester of the MSc. program in Finance and Accounting were requiring the subjects lectured in the MA&DM course. Indeed, the tools and methods addressed in this quantitative course were supporting the subsequent courses in Accounting and Management Control, Tax Management, Financial Investments, and International Finances (Figure 2).

The MA&DM course integrated two modules, one addressing *Multivariate Analysis* (MA) and the other *Decision Making* (DM), being their main contents:

- MA - Organization and treatment of multivariate data; forecasting; hypothesis testing with multivariate data; and multivariate linear regression.
- DM - Decision theory; game theory; multi-criteria decision making, and robust optimization.

Furthermore, the reader can find additional information about the SC-related analogy in the open literature (Miranda, 2011 and 2010), while the integration of various OR-based courses in Bachelor and MSc. Management programs is being prepared (Miranda, 2016).

A PBL approach is complementing the SC analogy presented in this section, in a way to better deal with the intensive schedule: 4 hours in each lecturing session. Thereafter, a set of typical SC subproblems were presented, they were prepared to be used as template and LP/IP mathematical models were provided as default models. These open procedures are supporting the subsequent developments in the students' case studies.

The FI&CO cases for finance and controlling

In current Section, illustrative cases focusing on decision

making under uncertainty and aiming at specific finance and accounting issues, within the related *FI&CO* department, are described. The students' motivation was promoted, since learning experiences directly related with the *FI&CO* context were treated. This approach helped students to cope with their own professional issues, while spurring motivation during the learn activities.

Beyond the finance controlling activities to ensure liquidity and working capital, the *FI&CO Department* also dealt with the SC activities' funding. The description of some specific study cases on human resources, capacity expansion, and on investment planning, follows in the text.

[HR] The Human Resources Costing and Management

To take full advantage of the available resources in an organization, optimizing the resources utilization by controlling and reducing costs, and by increasing efficiency is essential. The HR case was directed to the management of human resources, with the objective of minimizing their costs through linear programming (LP), and forecasting was used for scenarios simulation.

The methodologies were developed within the Systems Theory, aiming at the optimization of the company's resources and the application of forecast methods for the appreciation of the most probable scenarios. A LP-based DSS directed to the costing and management of human resources was developed, with the objective of minimizing the total labor cost. Because this case involved human resources, an additional difficulty arose: the optimal solution required variables integrality, being this obstacle to be over-passed by IP modeling.

The first objective was met with a solution with 16 internal operators, 4,695 overtime-hours and 10 external operators presented a total cost of € 351,145. Thereafter, the application of forecast methods for the entire economic year conducted to a second solution that would have an extra cost of € 12,159.40. For the same time horizon, the introduction of

additional qualitative parameters indicated a third optimal solution with 15 internal operators, 4,541 overtime and 10 external operators, with a total cost of € 341,222: this was the lowest cost of the three solutions. During the sensitivity analysis, some limitations were taken into account:

- The operators' productivity may vary for several reasons, such as new working methods or new technologies/tools, or even alterations on the work type;
- The evolution of labor costs can be different from the expected trend;
- The workload forecast cannot be verified in some scenarios.

Some of these limitations were curbed with the proper utilization of the forecast methods: their usage was closely related with the error; thus, the right selection of the forecast method was a key issue to reduce the error level. Finally, the integration of LP/IP and forecast methods allowed a better control of the human resources: by driving the analysis, enabling optional choices, or even by repositioning management rules leading to lower costs. Finally, the evaluation of the existing limitations, the continuous monitoring, and subsequent revisions were required too.

[CE] The Capacity Expansion case of an Accounting Services Company

The services industry still is in continuous evolution, with customers demanding each time innovative approaches, higher level of quality, and smaller costs. The services companies were launching new services, improving management procedures, and capacitating collaborators. It was thus crucial to use the available resources at full capacity, optimizing the productivity index, and controlling costs, while at the same time profits were to be maximized.

The CE case aimed at the resources optimization of an accounting company, using LP with the objective of profit maximization. For this, the opening of a branch-office in a new location was studied, and the main activity was to provide accounting and fiscal organization services in the new market. A set of strategic information that made possible to direct the selection of customers in the intended market is presented to the company managers, while several scenarios were appreciated.

- The opening of a branch-office in a neighbor city has been proposed, due to the economic growth in that location and the related market opportunity. The management team concluded that the investment breakpoint required a minimum of 40 customers, in order to save the financial profitability and to ensure the quality and

prestige of the company services.

- In order to maximize profit and assuming enough customers in such location, the management team needed to evaluate the local market, the customer types, in order to direct the customers' search and to increase market share. A detailed study on the costs and the resources needed to fulfill the accounting services of the 40 customers was thus developed.
- The management team proposed the diversification of accounting services by customer type, in a way to allocate staff costs and to ensure the economic and financial balance of the company. The analysis is based on data already available, for instance, 40 was the upper-limit on the number of customers.
- However, other necessity arose during the months of April and May, when another service related with the individual tax applications was to be provided. The workload of existing collaborators and the service requirements for private customers were balanced in face of the amount to charge for such service (€ 25).

[IP] The Investment Planning case in Stocks Market Portfolio

The IP case aimed at the planning of an equity portfolio by investing in the stock market located in three important financial cities, with the aim of maximizing the return on the invested capital (€ 500,000.00).

- The companies were listed on the stock markets of the three financial cities, being the related stock indexes also considered.
- The companies under analysis were the 15 most quoted of each one of the three indexes, at the date when the study kicked-off. The rationale was quite straightforward: selecting the companies whose stock prices are higher and with higher market value, probably these would be the companies with lower investment risk and higher expected return.
- The *Weight-Average Cost of Capital* (WACC) for the selected companies was the main objective, while partial considerations on the investment return, the profitability of each company stock, and the risk reduction were also evaluated. Other finance indicators for this analysis were the *Dividend Yield*, *1-Year Return*, *Price-Earning Ratio*, and the *Earnings-Per-Share*, since these indicators are usually relevant in the final investment decisions.

Complementary to the existing investment models, the investor needed to analyze the portfolio elements in terms of the indicators set, namely, analyzing the portfolio risk

against the market volatility, or the existence of other external variables. So, before the final investment decision, the sensitivity analysis concerning the market risk (e.g., the β index) was to be done.

By incorporating multivariable linear regression procedures, the investor was aware of the key indicators impacting each company stock, this way reducing the risk of investment losses. The investor was allowed to change the equity portfolio at any time, since stocks are highly liquid assets, that way easily tradable and reinvested.

Conclusions and further developments

HEI shall develop efforts to both fill the prospects of students and the labor market needs, and to provide good education services concerning real world applications. A MA&DM course is addressing decision making on uncertain environment, the multi-criteria decision methods require multivariate data, being the optimization and multivariate analysis tools connected through a PBL approach.

The PBL approach was computer-based and IBM/ILOG tools were providing a strong connection with the course contents and allowing real data treatment. In this way, the existing SC subproblems and the library of LP/IP models were used to promote the development of student-centered study cases.

The study cases were originated from the students' professional domain, the related data and the background information was directly available. Several cases are presented in this text, and the SC analogy permitted a higher level of students' involvement with the Finance and Accounting topics.

In general, the course results were very good, and so it is the students' perception about the MA&DM course. The quantitative competences needed in later phases of the MSc. program were addressed here in this course, and the development of digital materials, as open and online course materials, is still under consideration.

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