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ESCUELA DE INGENIERIAS INDUSTRIALES

Grado en Ingeniería de Organización Industrial

3PL selección utilizando AHP en la cadena de suministro farmacéutica: el caso italiano

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TÍTULO: 3PL selection using AHP in pharmaceutical supply chain: the
            Italian case

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1. ABSTRACT

Se ha estudiado la aplicación del método Proceso Analítico Jerárquico para seleccionar el mejor 3PL en la cadena farmacéutica italiana. Los datos se obtuvieron a través de un cuestionario enviado a varias compañías farmacéuticas y los resultados fueron analizados utilizando el software 'Superdecisions'. El estudio se realizó de dos formas diferentes de acuerdo con los criterios seleccionados por las empresas: la primera con una evaluación del desempeño de 3PL de una manera objetiva y la otra de forma compatible con el juicio de las empresas para demostrar que las compañías farmacéuticas eligen de acuerdo con lo que declaran.

Los resultados fueron similares a la realidad siendo capaces de comprobar la eficacia del método AHP, aunque también se observaron diferencias y se verificaron algunas de las limitaciones de este método.

KEY WORDS:

Cadena de suministro farmacéutica, Logística Terciarizada(3PL) , Proceso Analítico Jerárquico (AHP), selección de distribuidores, Industria farmacéutica italiana.

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5. INTRODUCTION

The study was carry out in five phases: literature review about applications of AHP in the pharmaceutical chain and identification of the main criteria used to select 3PL; study of the Italian pharmaceutical companies; recollection of the information needed to apply AHP; apply AHP; conclusions

First phase: was realized using scientific search engines, Google scholar, Scopus, Web of science… using many key words; AHP, pharmaceutical chain, pharmaceutical suppliers, Italy, 3PL. One of the main objectives of this phase is understand what are the advantages and disadvantages of the analytic hierarchy process, when it can be useful and know which criteria have been used before to select 3PL in the pharmaceutical chain.

Second phase: study of the Italian pharmaceutical companies using also scientific search engines and with the help of the article Dallari F. et al 2016. The objective of that phase is understand how the Italian pharmaceutical companies work and how is the structure of the pharmaceutical chain

Third phase: analysis of the questionnaire made to different pharmaceutical companies. The objective of this phase is recollecting all the information necessary to can apply AHP.

Fourth phase: application of the AHP method, it was realized with software called "SuperDecisions", the explanation of how it works is in the Appendix

Fifth phase: compare the results given by the software and the real data and analyze the differences.

5.1. IDENTIFICATION

Título: Suppliers selection using AHP in a pharmaceutical supply chain: survey development for an Italian case

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5.2 OBJECTIVES

The main objective is to study if the method AHP is good to make decisions in the suppliers in a pharmaceutical supply chain, and if it is, to suggesthow all the actors involved in that chain could improve their selection.

AHP was applied to real data collected using a questionnaire submitted to pharmaceutical companies of the Italian supply chain. This work is structured as follow:

First some AHP applications for pharmaceutical chains are presented.

Second the effectiveness of AHP in the real cases, the advantages and disadvantages are analyzed.

Compare the results obtained with AHP with the real decisions made by the companies.

5.3 JUSTIFICATION

The outsourcing of logistics functions to 3PL service providers has now become a common practice in many industries. 3PL refers to the use of subcontracted specializedlogistics companies to perform logistics functions that can encompass the entirelogistics process or selected activities within that process and that have traditionally been performed within an organization (*Lieb et al., 1993*).

The use of 3Pl has a great impact on customer satisfaction, on logistics system performance, reduces capital investment in facilities, equipment, in information technology, has an impact on employee morale, reduces manpower cost, improves specific logistics function parameter, inventory turnover rates, on-time delivery, increases productivity that are some of the many reasons why a good selection of a 3PL in very important.

6. LITERATURE REVIEW

In this chapter it is offered a short introduction to AHP and some applications to a pharmaceutical supply chain are presented.

6.1 AHP METHOD

Analytic Hierarchy Process, developed by Saaty (1980), is a Multi-Criteria Decision Method (MCDM), it can take in account multiple objectives or criteria. With this method is possible to model the process of selection of suppliers or other levels of a pharmaceutical chain or even ranking the risks, and in general any problem that entails a lot of factors quantitative and qualitative.

AHP reduces complex decisions to a series of one-on-one comparisons.

This method has been used in complex problems with a hierarchy structure, goal, criteria (objectives, set by the decision maker), sub-criteria (sub-objectives, also set by the decision maker), and alternatives. It uses simple mathematics (calculation of the principal eigenvector) and the standard preference table.It permits the use of data, experience, insight, and intuition in a more logical manner.

It is has many applications, choice, ranking, prioritization, resource allocation, bench marketing, quality management.

In 2008 the Institute of Operations Research and Management Sciences awarded Thomas L. Saaty with INFORMS Impact Prize for his development of the AHP.

Principal steps to apply AHP are the following:determining the decision we need to make selecting the alternatives or choices and the important criteria for the decision; comparing the criteria; measuring alternatives against criteria; computing the priorities and making selection. In the appendix is developed an example using AHP.

6.2AHP IN THE PHARMACEUTICAL SUPPLY CHAIN FOR SUPPLIERS SELECTION

AHP has been used to make an analysis of suppliers in a generic pharmaceutical chain, *Enyinda, et al. 2010*. The researchers applied AHP to select the best suppliers

for a pharmaceutical company in U.S. wherea group of purchasing and supply chain managers was requested to respond to several questions. Then they developed a hierarchical model.

The criteria considered were quality, cost, service, profile of the supplier, risk, and regulatory compliance.

The results of the study were obtained using the software Expert Choice and were the following: regulatory compliance was the most important criteria, followed by quality, risk, cost, profile of the supplier and service.

AHP allowedselecting the best supplier for the company.According to Tahriri et al. (2008), "supplier selection problem has become one of the most important issues for establishing an effective supply chain system."
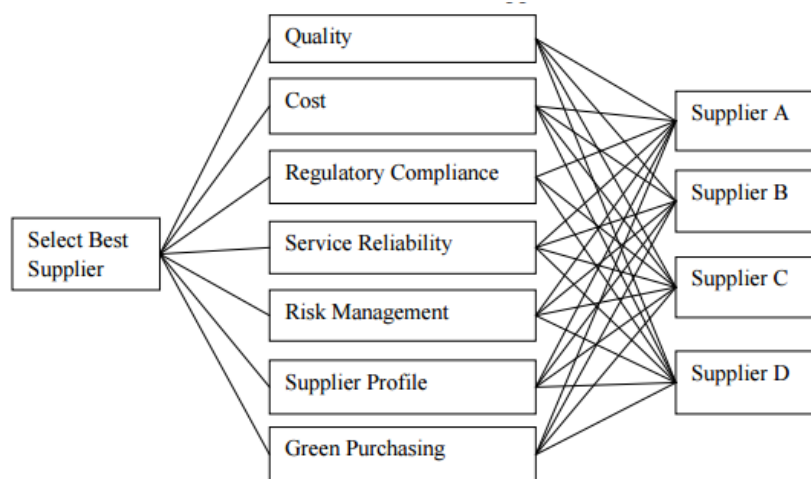
Figure 1The Hierarchical Structure for Supplier Selection*Enyinda, et al., 2010*

*Asamoah et al. 2012,*selected the best raw material suppliers of the Artemether-Lumefantrine anti-malarial drug for a pharmaceutical company in Ghana. The factors studied were quality, price and reliability/capacity. The results showed that the quality was the most important one, followed by reliability/capacity and price. They used AHP and Taylor's approximation method to rank the alternative suppliers instead of the hierarchical model. They found that the AHP method was the easiest method to find the best suppliers in a reliable and timely way.

The main criteria use to select suppliers in general are the following:

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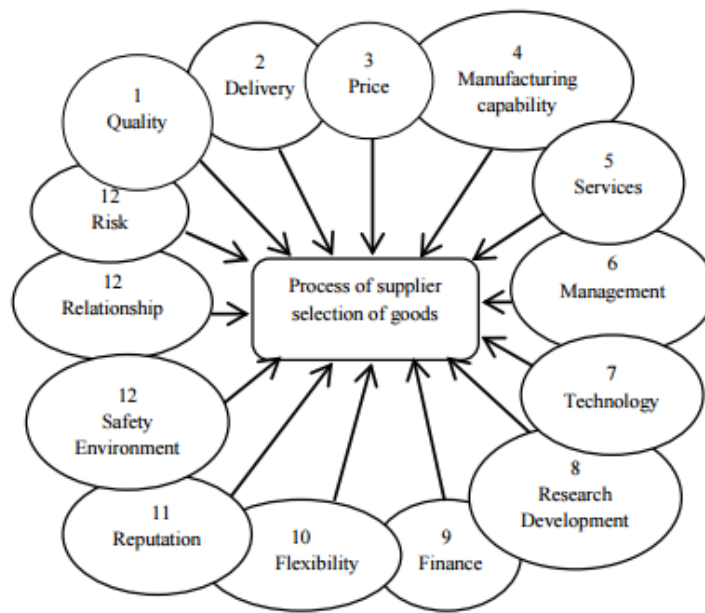
Figure 2 Criteria for supplier selection of goods
(2010)http://article.sapub.org/pdf/10.5923.j.logistics.20120103.02.pdf

They found that the ranking of the criteria was the following: quality, delivery and price, followed by manufacturing capability, services and management.

6.3. AHP IN A PHARMACEUTICAL SUPPLY CHAIN FOR RISK RANKING

Enyinda et.al 2008,in *"Modeling risk management in the pharmaceutical industry global supply chain logistics using analytic hierarchy process model"*, modeled risk management in the pharmaceutical industry global supply chain logistic using AHP. The goal of the study was to know the most important risks of outsourcing and the best strategies to follow.

It is an interesting study due to the fact that nowadays outsourcing has become a good tool to reduce cost, improve flexibility, gain a window on new technologies, the risks of doing that can be high, so they need to be analysed.

The results of the study were that the most important risk was the regulation/legislation risk, the second most important was operational risk followed by reputational risk. For alternative policy options, the most important risk mitigation was risk reduction followed by risk transfer, risk avoidance, and risk acceptance.

That study allows executives to select the appropriate measures to control pharmaceutical risks.
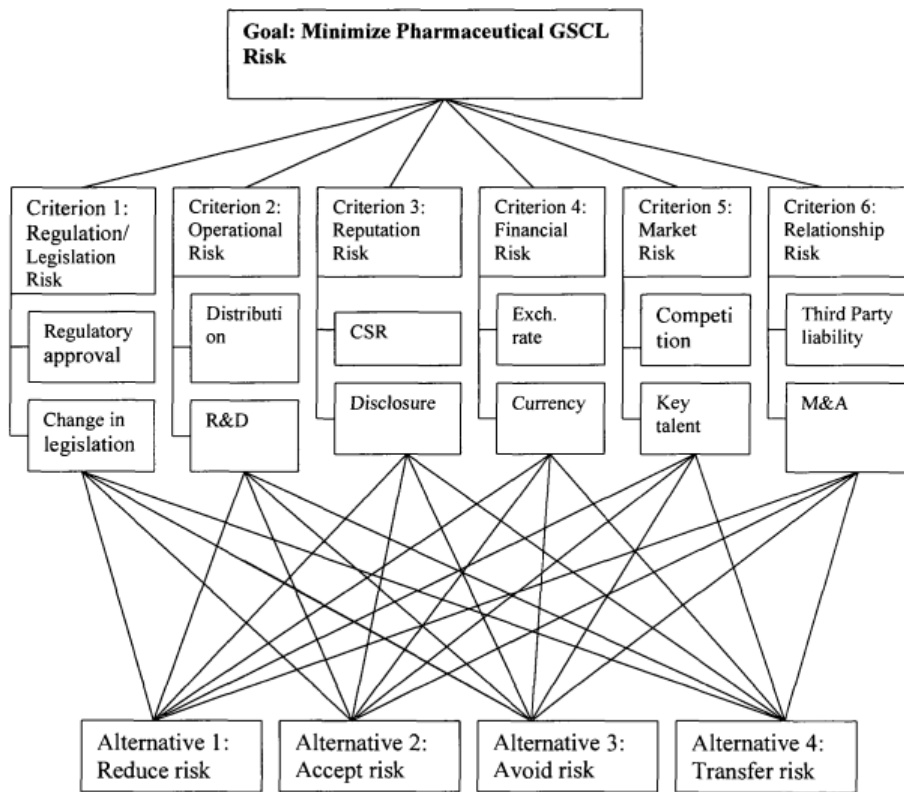
Figure 3 Hierarchy Structure Modeling of Pharmaceutical GSCL Risk... Enyinda et al. 2008

Jaberidoost,et al. 2015, made an study of the risk in a pharmaceutical supply chain in Iran using AHP and simple additive weighting (SAW). They obtained the data needed through literature review, expert opinions with an open questionnaire to try to identify risk, 16 experts, and a final questionnaire and interview with experts in which the pairwise comparison was made. The results said that the most important risk in Iran was regulation issues.

6.4 AHP TO SELECT 3PL PROVIDERS

The main criteria used to selecting 3PL providers using AHP are resumed in the work of *Kai Shiang Hsu et al.2011,* and are the following;

Related to delivery there are two main criteria; Delivery Accuracy that include speed and reliability, and Logistic Costs.

Taking in account service the most used criteria are; Just in Time(JIT) capability,it makes the system more agile and reduces inventory, lead time and cost through elimination of nonvalue-adding activities; IT capability, makes transactions faster and

transparent which mean reductions in lead time and cycle time and Information sharing, Supply-chain time compression becomes possible through current working, standardization of processes, and effective information sharing.

In relationship with reliability the criteria used are:previous experience,ability and experience in handling and managing some critical issues and uncertainties in rapidly changing customer loyalty, honesty and reputation, the dimension captures the image of the 3PL in the market and provides a good, subjective inside view into the 3PL selection process, market status, ensures continuity in services, regular updating of equipment and reflects its financial performance, customer satisfaction and reputation and scale of vendor, 3PL's ability to provide services in large area. It helps consignor to expand the business limits and provides the same quality of service and customer satisfaction.

Related to flexibility there are: flexibility in billing and payments conditions which increases goodwill between user and supplier and Flexibility in operation and delivery, which may enable the user to give customized service to the shipper, particularly in special or non-routine request

Delivery

Delivery Accuracy	Logistic Costs

Service

JIT capability	IT capability	Information sharing

Reliability

Previous experience	Honest and reputation	Market status	Scale of vendor

Flexibility

Flexibility in billing	Flexibility in operation and delivery
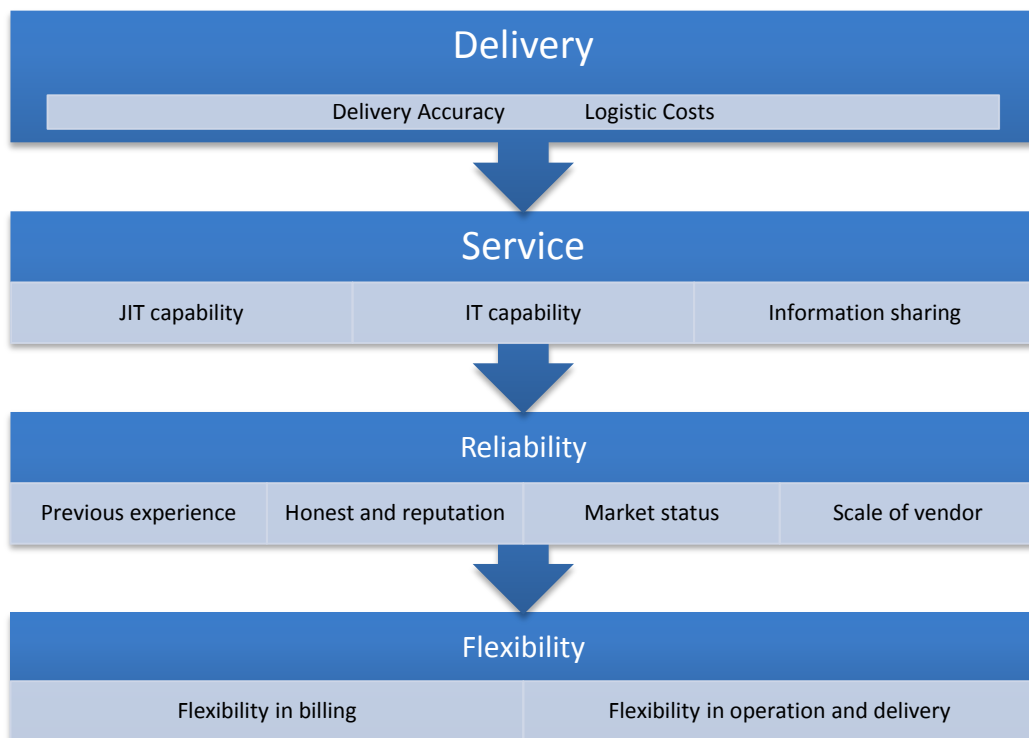
Table 1Criteria used in literature by various researchers. Kai Shiang Hsu et al.2011
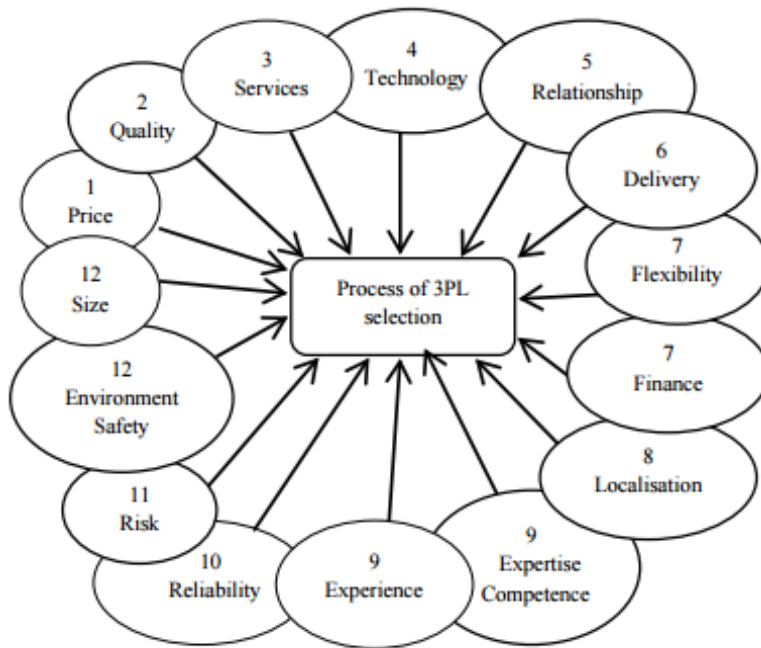
Aguezzou et al. 2010 found that the most common criteria used to select 3PL in pharmaceutical companies were price, quality, services and technology.

AHP has been used to select 3PL providers by *So et al.2006 and* five quality dimensions were studied; reliability, responsiveness, empathy, assurance and tangibles. The study was made with an empirical case study, analyzing four companies providing 3PL services in Korea. The most important factor was responsiveness, in the perception of 3PL customers.

6.5 CONCLUSIONS

Different criteria have been used to select the best 3PL, but even if they have different names they are all related, for example in one study the most important criteria is prize, that is related with logistic costs, used in another study. Quality and reliability are also correlated, and the second ones more important..

But also those factors are related with the culture of the country, for example in Korea the most important one is not price but it is responsiveness.

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6.6 ADVANTAGES AND DISADVANTAGES OF USING AHP

Agarwal et al., 2011 analyzed sixty articles from various journals and conferences from 2000 to 2011 to find out the most prominent MCDM methodology followed by researchers. The researchers studied the different MCDM approaches that have been used in the literature and then the most prominent approach was identified. The researchers discovered that even though the most widely applied methodology was Data Envelopment Analysis (DEA), mainly for its robustness, they recommended the use of the AHP to aid the researchers and decision makers in meeting the challenging task of the supplier selection problem effectively in the future.

One advantage of AHP is that it illustrates how possible changes in priority at upper levels have an effect on the priority of criteria at lower levels. Moreover, it provides the buyer with an overview of criteria, their function at the lower levels and goals as at the higher levels. A further advantage of AHP is its stability and flexibility regarding changes within and additions to the hierarchy. In addition, the method is able to rank criteria according to the needs of the buyer which also leads to more precise decisions concerning supplier selection. The main advantage of AHP is that the buyer is able to get a good picture of the supplier's performance by using the hierarchy of the criteria to evaluate them (*Omkarprasad and Kumar, 2006*).

The main advantages of this method are:

It is able to deal with qualitative factors, as well as with tangible and intangible factors, not many methods can do that.

It allows the use of data, experience, insight, and intuition.

It can have a control of the consistency with which decision-makers make their judgment.

It is a relatively simple, intuitive method.

It allows decision makers to derive ratio scale priorities (weights) instead of arbitrarily assigning the weights.

Nevertheless, that method has some critics.

The pair-wise comparison evaluation is subjective and there is not an exact rule to make the conversion from verbal to numeric scale.

Watson and Freeling (1982) discussed that the questions put to the decision-makers in order to know their priorities were useless and   meaningless.

Some researchers believe that the AHP method can be imprecise because sometimes there is an uncertainty in the opinion of the experts and therefore when one does the pair-wise comparison and assigns coefficients to them making decisions not reliable. That is why sometimes instead of using AHP it is used AHP fuzzy, the fuzzy version with linguistic variables to assess the weights for each decision maker.

Khorasani et al., 201 applied AHP fuzzy to find the best suppliers in a pharmaceutical manufacturing company. The results of the study were that cost, quality, organization of supplier, services, and technical skills of supplier are the principals criteria to choose a suppliers.

The main disadvantage of this method is the use of subjective inputs; once you change that the ranking changes, so you cannot have a unique solution. Furthermore if more than one person is working with this method, different opinions about the weight of each criterion can complicate it.

7. THE ITALIAN PHARMACEUTICAL SUPPLY CHAIN

7.1 INTRODUCTION

The pharmaceutical sector is really important in Italy due to its role in economy, employment and in society, being one of the most important sectors. There are around of 180 businesses that create 28, 7 millions of euros, more of 70% it is refers to the exportations.

In their activity they do not also have to take in account the benefits, as in a normal business, they also have to take care about the "Health protection", which all the entire chain is responsible for. That is the reason why to analyze the efficiency of the pharmaceutical chain you need to make a relation between the costs and also the level of the service that they cover.

7.2 SUPPLY CHAIN

The main actors in the pharmaceutical supply chain are pharmaceutical companies, depositories and dealer, transporters, intermediate distributors (wholesalers), pharmacies, drugstores, hospitals and nursing homes.
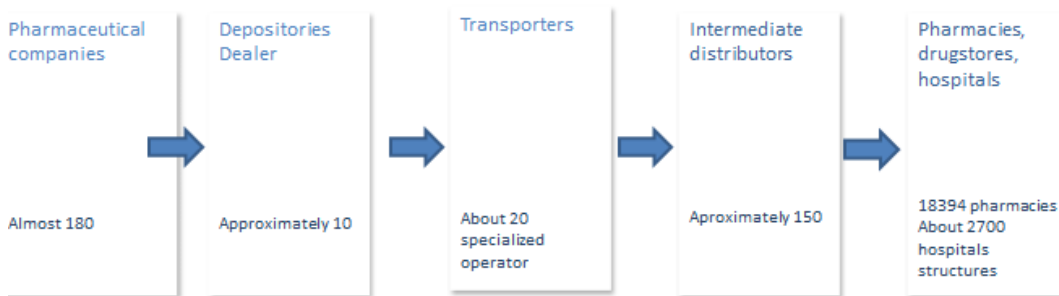
Figure 5Actors in the supply chain in Italy

Pharmaceutical companies

The first part of the chain is constituted by the pharmaceutical companies They have the mainly production located in northern Italy and Lazio. The market is highly concentrated with established leaders and composed almost exclusively by multinational companies.

In Italy there are about 180 pharmaceutical companies and some pharmaceutical of reduced size operating as sub-suppliers

The pharmaceutical companies are required to comply with "good manufacturing practice" they constitute a set of principles and guidelines that help to ensure the safety, effectiveness and quality in the production processes of the medicaments.

Figure 6 Localization of pharmaceutical companies in Italy Report: *Pharma Supply Chain. Source: elaborazioni C-Log sudatiMinisterodella Salute.*

Depositories and dealers

The depositories are logistics operators who are the responsible for the storage and distribution of medicines, providing a range of services such as warehousing, transportation, pharmaceutical workshop (packing, re-packing, cancellations...). A pharmaceutical company can served to one or more depositaries, depending on the strategy that they follow.

The distribution can be in two ways:

- Direct distribution: the medicine goes directly from depositories to pharmacies or hospitals; usually a minimal quantity is required.
- Intermediate distribution: wholesales buy to the depositories the medicine that afterwards goes to pharmacies and hospitals.

There are 12 depositories approximately in Italy with a high concentration which covers almost the whole market. The warehouses of the depositories are located mainly in two logistics districts, the most important one in Lombardy and the second one in Lazio.

Depositories and dealer carry out the same activity, but the last one also support the credit risk toward its customers.

They, as well as intermediate distributors and transporters, are subject to compliance with the "Good distribution practices" that is now in phase of implementation in Italy.

Intermediate distributors

Intermediate distributors are traders whose primary business is logistic. They buy the property of the goods and, consequently, the business risk. There are different types:

- Private wholesalers, they have one or more stores or distribution centers,they cover almost the complete national territory.
- Cooperatives of pharmacists, with one or more deposits, they cover provincialor regional territory.
- Structures distribution of community pharmacies that besides supplyingtheir pharmacies, also provide the supply of other centers (private or not).

The wholesalers market is also characterized by a high degree of concentration, in which there are national leaders like Comifar Distribution (part of the Phoenix Group, which owns the highest market share in Europe) and Alliance Healthcare, and also some with a regional coverage (e.g. Unique, Unifarm, etc.).

Transportation

The transportation of medications is 99% by road but there is also a maritime routes between the islands (where the vehicles are loaded onto ships) and sometimes the transportation is also by air, for high value products or urgent.
There is one leader in national transportation, 3PL 3 and dozens of companies are present in the specialized market with a limited coverage of the territory, usually regional.

Delivered point

The delivered points are pharmacies, facilities, hospitals, nursing homes and structures Social-Health Territorial.

There are currently about 18,000 pharmacies in Italy, split between private and public pharmacies. Because of the huge number of products on the market and the impossibility of having all medicinal products in stock, they need wholesales (usually 3 or 4), which could realize 4 deliveries per day. The pharmacies also can buy directly from the depositories.

According with the Ministry of Health there are approximately 2,650 hospitals also split between private and public hospitals.

The distribution of the medicament

The distribution of medicaments is responsible for supplying more than 18,000 pharmacies and about 2,650 hospitals in the area. And it must be able to reach all the delivery points in a timely manner, regardless of the location, so as to serve the patient with the right product, in the right amount and in the shortest possible time.

Once the medications reach the depositories, there are three distribution channels through which the delivery points are supplied:

1. Pharmacy (direct to pharmacy): the depositary directly supplies the public pharmacies and private. It occurs as a result of direct orders by pharmacies, generally in with a minimum order.
2. Hospital: the depositary directly supplies the hospitals of the national territory, hospitals, Social-Health Territorial structures, nursing homes, clinics, prisons, etc. By region, purchases by facilities hospitals are more or less centralized, as happens in Campania (through the company SoReSa) or Tuscany, respectively through So.Re.Sa. companies (Regional Company for Healthcare) and ESTAR (Ente Regional Technical Administrative Support).
3. Intermediate distribution: the depositary supplies the wholesalers and cooperatives, which acquire ownership of the goods and distribute them to pharmacies and facilities health.

The intermediate distribution helps significantly to promote efficiency in the supply chain both upstream and downstream. On the one hand, operating in a systematic and capillary way, with deliveries just in time, allows pharmaceutical

companies a continuous control of the dynamic of the market and the adaptation of the production to them. On the other hand the benefits of the pharmacies are higher with an intermediate distribution because they can reduce to the minimum the working capital (inventory stock) not able with direct delivery.

The following figure illustrates the scale of physical flows in the distribution chain:
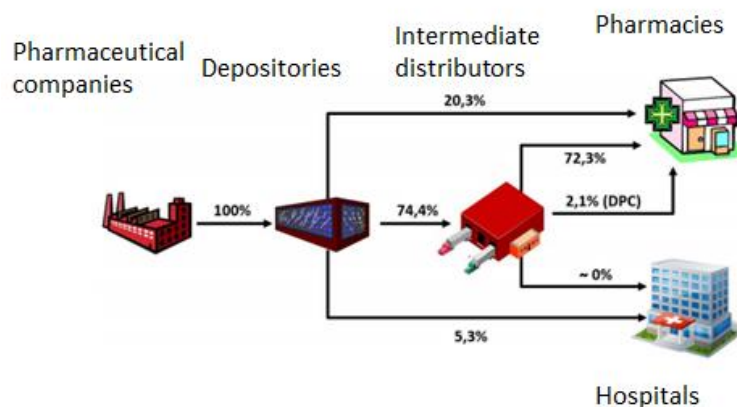
Figure 7 Percentage of flows along distribution channels, 2014. Source: Dallari. F et al 2016.

In recent years, the direct channel to pharmacies from pharmaceutical companies has increased. The reasons are attribute on the one hand to the constant supply of generic medicaments (a lower value), that make the leading pharmaceutical companies get closer with the pharmacies. And on the other hand, pharmacies can have bigger discounts if the order directly from manufacturer, with a huge volume of purchases.

7.3 DISTRIBUTION MODELS

The distribution models has been suffering significant changes over the years, in the 80s the dealer was an important part of the supply chain, which typically did storage activities, support and sales and was paid by pharmaceutical companies through a percentage of the price of the pack.

Since the 90s the pharmaceutical industry has faced continual price declines of the medicaments, a rising cost of the inputs, the increasing of the competitiveness and the evolution of the legislation. Due to those facts, the efficiency of the

distribution chain has started to be very important; the figure of the dealer was gradually replaced by the depositary that does not acquire ownership of the goods.

In the actual distribution model the pharmaceutical companies provide to 1, 2 or 3 deposits, managed by one or more logistics operators.
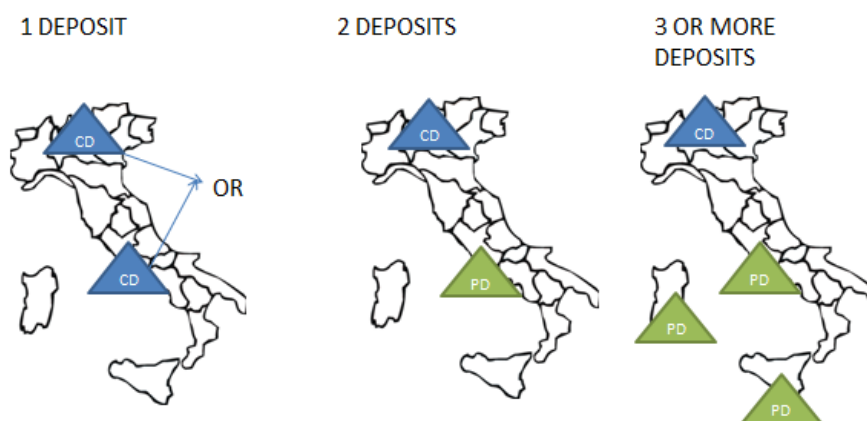
Figure 8 Distribution models in the pharmaceutical supply chain.

CD: Central Deposit

PD: PeripheralDeposit

One deposit; usually the deposit is located in Lombardy region, or, in rarer cases, in central Italy. The solution allows supply delivery points in a time between 24 and 72 hours.

Two deposits; there is a central depot that supplies northern Italy, part of the center and Sardania (maritime transport along the route Genoa-Olbia/ Porto Torres), while a peripheral deposit covers the remaining part of central Italy and the south. For both sites, the time to delivery oscillate between 24 and 48 hours. From the central depot pass all flows from the production plant, part of which are intended to supply the peripheral warehouse.

Three or more deposits; the difference between having two deposits is that one of the peripheral deposit is located in Sardania or Sicily. Also in that case the delivery time fluctuate between 24 and 48 hours.

7.4 3PL IN THE PHARMACEUTICAL ITALIAN CHAIN

Services offered

The range of services offered by depositaries is very wide and, in addition to traditional activities storage/distribution, provides complementary services, for example:

Pharmaceutical workshop: labeling, packaging, changing the package text.

Traceability of products and individual packs.

Credit management: billing and debt collection.

Marketing activities: call center, telemarketing, and market research.

The level of integration with the pharmaceutical company is usually high.

Relationship between pharmaceutical companies and depositaries

Pharmaceutical companies hire 3PL expecting having some of those services:

Receipt of the products, included the control of goods received, dealing with non-conformity goods, performance evaluation.

Storage of products.

Preparation of orders; receiving orders, preparation deliveries, repacking, control.

Transporting goods to stores or customers.

Additional services; relabeling, change price.

In the monitoring of products in stock, the customer prepares inventories "programmed", for which there are generally defined bonus/penalty based on based on how many products there are.

The 3PL interfaces with the customer through the information system, on which there are data of KPI, constantly loaded, of customer complaints, monitoring of inventory and shipments.

In relation with transportation, the parties shall agree on the procedures and deadlines, it can be two scenarios:

- 3PL has totally freedom of choice about the method of transportation; the performance is evaluated in programed meetings where the customer has the possibility of taking a corrective action.

- 3PL and customer agree in the methods of transportation; in that case the pharmaceutical company has the control of that phase. That method has starting of being more common in the majority of pharmaceutical companies used it as another way of monitoring.

The duration of the contracts between 3PL and pharmaceutical companies ranges from 1 to 5 years, which is a reflection of the strategic followed by the pharmaceutical company.

In some case, the services offered by the depositaries are treated as commodities, with a periodical evaluation and can lead to the change of operator. It is not uncommon to find a pharmaceutical company working with two different depositaries.

In other cases the relationship is considered strategic, partnership, both parties improve the performance through joint plans and investment in a long term (at least 5 years)

The pharmaceutical company evaluate the performance of the 3PL through KPI, that evaluation concerns various outsourced activities. Some examples of KPIs:

Delivery On Time
Inventory Value Accuracy
Order Cycle Time
Quality Delivered On Time
Picking Accuracy
Replenishment Accuracy
Shipment Lead Time
Temperature Deviations

For each service parameter is defining a reference through which the penalties or bonus are calculated.

8. SURVEY DEVELOPMENT

In this study it has been used a questionnaire developed by the researchers of *UniversitàCattaneo-LIUC*for the pharmaceutical supply chain in Italy: pharmaceutical companies and the most representative logistics operators, in terms of market presence. The answer gave by the companies were reported in an anonymous form. A description of the questionnaire is presented;

Pharmaceutical companies were asked concrete questions; the satisfaction with the 3PL if they responding properly to the needs (current and projected); how likely is the increase of the volumes delivered by 3PL at expense of the intermediate distribution in a scale from 1(unlikely) to 10 (very sure); what are the trends and opportunities that impact more on logistics and distribution in Italy (consolidation of 3PL, international acquisition of 3PL, vertical integration of 3PL); what are the services to be strengthened by the currently 3PL operating in Italy for a better service.

SURVEY

Company profile

The first part is defining the company profile; in which the companies are divided by the product sold in Italy (ethical, OTC, other type) and storage temperature, and also subdivided by the canal distributive they use, depositary->pharmacy, depositary->hospital, depositary->wholesaler, depositary->other, Wholesaler->pharmacy, wholesaler->hospital.

Supply chain configuration

They have to describe the flow in the pharmaceutical supply chain, telling the provinces served and the area geographical, name of the logistics operator, warehouse role (central, peripheral or dedicated), channel served(H,W,F), type of stock(p. pallet), stream out(packs/ year) and if there is automation within stores.

Also they have toquantify the flow, numbers of delivered points served, average of orders per week, average of lines per order,average number of items per order line, %returns and complaints, when they serve to pharmacies, hospitals and wholesaler.

Logistic service

They were asked to put evidence the aspect more important for them in order to select the providers, giving 1 to the criteria less important and 7 to the most important. The criteria are competence, brand/reputation of the supplier, presence

on the national territory, quality in the relationship between customer-supplier, customer care/assistance, capacity to offer value-added services and market share/references in the sector.

Also they had to order from 1 to 5 the criteria used to evaluate the service given by the provider between costs,quality / reliability, price / quality, customization, innovative solutions and to select which 3PL offer which service. The types of possible services given are: deposit, pharmaceutical office, storage, distribution (room tº), distribution (tº controlled), order management (order entry, checking and validation), launch new products with automatic transmission, customer service (call center), other value-added services (deposit account, home delivery, etc.)
They also have to classify the relevance of these services between very important, important, less important, and not important:

About the contract, they were asked about the duration with the 3PL, warning time (in case of cancellation), and frequency of renewal contract / launch tender.
Selection of the KPI used for monitoring the logistics-distribution process, the types or KPI can be Yes-No, MALUS, and they are: on-time delivery (on time) normal –ordinary, on-time delivery (on time) - urgent orders, delivery accuracy, completeness order (% rows processed)damage during transport, errors in processing orders (picking), damages in stock, inventory misalignment, incidence of returns (%), incidence of rejected (%), other (specify)

They also had to specify who monitors the KPI if the 3PL or the pharmaceutical company, and an extract of the formula use for calculate the KPI.

INTERESTING ANSWERS

In general, the pharmaceutical companies are very satisfied with the 3PL service they hired, given to them a mark between 8 and 10. An argument of that good mark is because they have made a good partnership between the companies, ex: SECURITY project where they made a risk mapping, common security service on transport etc., with this synergy they are able to share costs.

The three trends and opportunities that impact more on logistics and distribution in Italian are consolidation of 3PL, international acquisition of 3PL, vertical integration of 3PL doing for 3PL 4 and 3PL 3.

3PL 5 is the only really good supplier in the cold chain; they took the US patents that are able to maintain the temperature 2°- 8° degrees stable. If a drug goes below zero, it could crystallize and this is something dangerous.

The services to be strengthened by 3PL currently operating in Italy are improving the speed of deliveries to South Italy, without provision of stock.

TABLES USED TO APPLY AHP

Criteria	Relevance
Competence	
Brand/reputation of the supplier	
Presence in the national territory	
Quality in the relationship between customer-supplier	
Customer care/assistance	
Capacity to offer value-added services	
Market share/references in the sector	

Table 2 Table used to apply AHP 1

Service	Very important	Important	Less important	Not important
Deposit				
Pharmaceutical office				
Storage, distribution(room t°)				
Distribution(t° controlled)				
Order management (order entry, checking and validation)				
Launch new products with automatic transmission				
Customer service (call center)				

Other value-added services (deposit account, home delivery, etc.)				

Table 3 Table used to apply AHP 2

	3PL
Deposit	
Pharmaceutical office	
Distribution(8-25ºC)	
Distribution (2-8 ºC)	
Order management (order entry, checking and validation)	
Launch new products with automatic transmission	
Customer service (call center)	
Other value-added services (deposit account, home delivery, etc.)	

Table 4 Table used to apply AHP 3

COMPARISON OF THE CRITERIA USED WITH THE CRITERIA CONSIDERED IN THE PAPER Kai Shiang Hsu et al.2011

The criteria that are going to be used to develop the AHP model are: competence, brand/reputation of the supplier, presence in the national territory, quality in the relationship between customer-supplier, customer care/assistance, capacity to offer value-added services and market share/references in the sector.

The criteria that we used in our first analysis are similar to the criteria found in the literature and the comparison is showed in the following table:

Criteria used	Criteria found
Competence	Reliability/ Services. Price
Brand/reputation of the supplier	Reputation, pre experience
Presence in the national territory	Location
Quality in the relationship between customer-supplier	Relationship/quality
Customer care/assistance	Information sharing
Capacity to offer value-added services	Market status

Market share/references in the sector	Scale of vendor/size

Figure 9 Comparison of the criteria found in papers and .the criteria used.

Competences are the abilities, commitments, knowledge and skills that have the 3PL. The competences can be measure like the range of services that are able to offer with accuracy and reliability. It also depends on the price; one company is more competent if it provides the same services than others are able to offer but it is cheaper.

Brand is defined as a toolbox of marketing and communication methods that help to distinguish a company from competitors and create a lasting impression in the minds of customers. If they have a good reputation and pre-experience the company will have more chances of being hired.

The presence in the national territory influencesthe selection of a 3PL. Having a good location in different parts of Italy is essential to make better relationships with the pharmacies, hospitals and pharmaceutical companies.

Quality in the relationship between customer-supplier could be measure with the certifications and the good practice they do.

Customer service is the provision of service to customers before, during and after a purchase. To have a good customer service, the company has to share the information with the customer and the customer gives a feedback.

Capacity of offering added services is important to differentiate themselves from other companies. It is not the most important criterion, but it can determinate the market status of a business.

Market share is the percentage of a market accounted by a specific entity; it depends on the scale of vendor and on the size of the company.

9. ANALYSIS OF DATA AVAILABLE USING AHP

We are going to apply AHP in two different ways.

1. In this option, we are going to rank the 3PL, comparing the criteria in an objective way. The final ranking will be compared with the real choices of the pharmaceutical companies. Using the answers given in the table 1 we can build the first level AHP. In the second level we have to compare 3PL against the criteria, for this we do not need the questionnaire but objective data that can be obtained from the websites of the 3PL.

2. The main objective of that option is to verify if the pharmaceutical companies havechosen their 3PL in accordance to what they declare. In this case the answer given in the table 2 are used to build the first level AHP, and the answer given in the table 3 to build the second level.

Option 1:

To apply Superdecision software to implement AHP, the first thing to do is the definition of the problem and determination of the goal that in this case is :*"The selection of the best supplier for an Italian pharmaceutical company"*.

The second step is to insert a hierarchy of objects:the goal in the top level, the selection criteria in the intermediate levels and a list of possible 3PL (alternatives), in the lowest level.
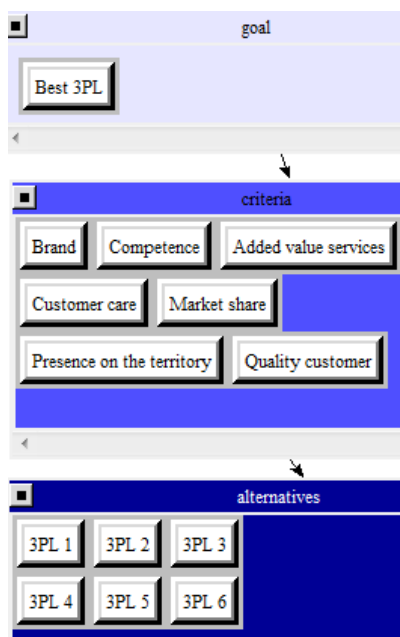
Figure 10Hierarchy Structure of Suppliers in a Pharmaceutical Supply Chain Option 1

First we need to compare the criteria pair-wise and to do that we are going to use the standard table which has been created by experienced researchers in AHP and it has been proved to be good for comparing the alternatives.The number and words of the standard preference table are based on empirical research over 25 years.

Numerical rating	Definition of Verbal Scale	Explanation
9	Extremely preferred	An element is favored by at least an order of magnitude
8	Very strongly to extremely	
7	Very strongly preferred	An element is very strongly dominant
6	Strongly to very strongly	
5	Strongly preferred	An element is strongly favored
4	Moderately to strongly	
3	Moderately preferred	Experience and judgment favour one element over another
2	Equally to moderately	
1	Equally preferred	Two elements contribute equally

Table 5 The AHP Pair-wise Comparison Values or Scale of Preference between two Elements

2,4,6,8 are used only to represent compromise between the preferences listed above or used to compromise between two judgments, so we will try to avoid using them.

The answers needed to make the comparisons in the first level are the ones given in the table 1 and are the following:

Criteria	Relevance
Competence	1
Brand/reputation of the supplier	2
Presence in the national territory	7
Quality in the relationship between customer-supplier	4
Customer care/assistance	5

Capacity to offer value-added services	6
Market share/references in the sector	3

Table 6 Option 1: Importance of each criterion for the company 1

Criteria	Relevance
Competence	1
Brand/reputation of the supplier	2
Presence in the national territory	7
Quality in the relationship between customer-supplier	4
Customer care/assistance	5
Capacity to offer value-added services	6
Market share/references in the sector	3

Table 7 Option 1: Importance of each criterion for the company 2

Criteria	Relevance
Competence	1
Brand/reputation of the supplier	2
Presence in the national territory	7
Quality in the relationship between customer-supplier	4
Customer care/assistance	5
Capacity to offer value-added services	6
Market share/references in the sector	3

Table 8 Option 1: Importance of each criterion for the company 3

We have to take in account that a 7 means that is the less important and a 1, the most important.

In order to assign a single value for the relevance of each criterion, , we take the average on the answers given by the different companies:

Criteria	Relevance
Competence	1
Brand/reputation of the supplier	3.33
Presence in the national territory	7

Quality in the relationship between customer-supplier	2.66
Customer care/assistance	5
Capacity to offer value-added services	4.33
Market share/references in the sector	4.66

Table 9 Option 1: Average of the importance of each criterion.

Then, to perform a pair-wise comparison of two criteria, we are going to subtract these two numbers and applying the following rule:

If the difference x is	The value of the pair-wise comparison is:
0<x<0.5	1
0.5<x<1.5	3
1.5<x<3	5
3<x<4.5	7
4.5<x<6	9

Table 10 Option 1: Rule to make comparisons in the first level

The table 11 is given in input to the Superdecision software and the following ranking of the selection criteria is obtained:

	Brand	Competence	Customer care	Market share	Presence territory	Quality customer
Added value	3	7	3	1	5	5
Brand		5	5	3	7	3
Competence			7	7	9	5
Customer care				3	5	5
Market share					5	5
Presence territory						7

Table 11 Option 1: Comparison between the criteria.

The meaning of the table is the following: a number en black for example 3 in added value means that added value is 3 times more important than customer sales; a number in red stands for 1/x, it means that brand is 3 times more important than added value.

Inconsistency: 0.09814		
Added val~		0.06481
Brand		0.13208
Competence		0.45958
Customer ~		0.04096
Market sh~		0.06481
Presence ~		0.01989
Quality c~		0.21786

Figure 11 Option 1 Importance of each criterion.

We can see that the most important criterion is competence, and the difference with the others is pretty big, followed by quality in the relationship between customer-supplier because it allows creating fundamental synergies.

Brand and markets share are the next criteria more important.

Customer care and capacity to offer added value service seem not to be a relevant criterion of selection since, almost all the 3PL are able to offer the same services.

The presence on the territory is the less important factor, because for some pharmaceuticals companies is not useful to have the same type of product divided in different warehouse, and they don't mind having everything in only one central warehouse even they prefer it.

It is important to check the consistency of the comparisons in every step. The inconsistency of the matrix is less than 0.1 so is acceptable.

Now we have to compare the different 3PL in respect to each criterion.

Presence on the territory

To quantify the presence on the territory we are going to take in account the number of platforms they have in Italy.

3PL	Number of platforms
3PL 1	6
3PL 2	2
3PL 3	8
3PL 5	10
3PL 4	5

3PL 6	3

Table 12 Option 1 Criterion: Presence in the territory 3PL

Using the following rule to assign numbers in each comparison:

Difference	Final number
0	1
0<x<2	3
2<x<4	5
4<x<6	7
6<x<8	9

Table 13 Option 1 Criterion: Presence in the territory 3PL. Rule.

	3PL 4	3PL 3	3PL 2	3PL 5	3PL 6
3PL 1	3	5	7	7	5
3PL 4		5	5	7	5
3PL 3			9	3	7
3PL 2				9	3
3PL 5					9

Table 14 Option 1 Pair-wise comparison for presence in the territory 3PL

With that rule we had an inconsistency more than 0,1 that is not acceptable to apply AHP, so we have to change the criterion to assign the numbers and introduce also the numbers 2,4,6 and 9. The new rule is the following

Difference	Final number
0	1
1	2
2	3
3	4
4	5
5	6
6	7
7	8
8	9

Table 15 Option 1 Criterion: Presence on the territory 3PL. Rule Part 2

	3PL 4	3PL 3	3PL 2	3PL 5	3PL 6
3PL 1	2	3	5	5	4
3PL 4		4	4	6	3
3PL 3			7	3	5
3PL 2				9	2
3PL 5					8

Table 16 Option 1 Pair-wise comparison for presence in the territory 3PLPart 2

Figure 12 Option 1 Inconsistency of the Pair-wise comparison for presence in the territory

3PL 5 is the 3PL are the ones with more presence on the Italian territory, followed by 3PL 3, 3PL 1, 3PL 4, 3PL 6 and 3PL 2.

Now the inconsistency is less than 0.1 and then is acceptable

Competence

The competence is considered as depend on the number of services they can offer; deposit,pharmaceutical office, storage, distribution (room t°), distribution (t° controlled), order management (order entry, checking and validation), launch new products with automatic transmission…

That criterion is subjective; you can't compare one against another with a math rule. Therefore, we are going to rank the six 3PLs taking into account all the services they offer (1 is the best, 7 the least competent).

3PL	Competence
3PL 1	3
3PL 2	4
3PL 3	2
3PL 5	6
3PL 4	1
3PL 6	5

Table 17 Option 1 Criterion: Competence

Using the following rule to assign numbers in each comparison:

Difference	Final number
1	3
2	5
3	5
4	7
5	9

Table 18 Option 1 Criterion: Competence. Rule

The pair-wise comparison is given in Table 19.

	3PL 4	3PL 3	3PL 2	3PL 5	3PL 6
3PL 1	5	3	3	5	5
3PL 4		3	5	9	7
3PL 3			5	7	5
3PL 2				5	3
3PL 5					3

Table 19 Option 1 1 Pair-wise comparison for Competence

Applying SuperDecision Software to Table 19 we obtain:

Figure 13 Option 1 Inconsistency of the Pair-wise comparison for Competence

The 3PL with more competence is 3PL 4, being 3PL 5 the last one.

The inconsistency is acceptable

Quality customer/vendor:

To quantify the quality customer/vendor we are going to take in account the number of certifications they have. And also to make another difference between them we are going to put the option of others that includes every criteria to measure quality different than certifications like Management System Policy

3PL	Certifications	Other
3PL 1	3	
3PL 2	5	
3PL 3	1	
3PL 5	1	
3PL 4	0	
3PL 6	1	Management System Health and Safety in the Workplace Management System Policy Management System Security

Table 20Option 1 Criterion: quality customer/vendor

Using the following rule to assign numbers in each comparison:

Difference	Final number
0	1

44

1	3
2	5
3	7
<3	9

Table 21Option 1 Criterion: quality customer/vendor. Rule

Also if the difference is 0, but any of them has something in "Others", the final number will be 3.

	3PL 4	3PL 3	3PL 2	3PL 5	3PL 6
3PL 1	7	5	5	5	5
3PL 4		3	9	3	3
3PL 3			9	1	3
3PL 2				9	9
3PL 5					3

Table 22Option 1 Pair-wise comparison for quality customer/vendor.

Inconsistency: 0.08130	
3PL 1	0.22638
3PL 2	0.55793
3PL 3	0.04929
3PL 4	0.02846
3PL 5	0.04929
3PL 6	0.08866

Table 23 Option 1 Inconsistency of the Pair-wise comparison for quality customer/vendor

3PL 2 is the 3PL with more quality customer/vendor because it has 5 certifications.

The inconsistency is less than 0.1 so is acceptable.

Customer service

The presence of customer service is going to be with yes/no answers, yes if they have customer service and no if they don't have it.

3PL	Customer service
3PL 1	Yes
3PL 2	Yes
3PL 3	Yes
3PL 5	Yes
3PL 4	Yes
3PL 6	Yes

Figure 14 Criterion: customer service

All of the 3PL have presence of customer care, therefore we don't need to include that criterion in the model because we can't use it to rank the 3PL because all of them have the same number. If we decide to use would be in that way.

	3PL 4	3PL 3	3PL 2	3PL 5	3PL 6
3PL 1	1	1	1	1	1
3PL 4		1	1	1	1
3PL 3			1	1	1
3PL 2				1	1
3PL 5					1

Table 24 Option 1 Pair-wise comparison for customer service

Figure 15 Option 11 Inconsistency of the Pair-wise comparison for customer service

All of them have the same importance in the criterion customer service.

Brand

To quantify the brand of the 3PL we are going to use the occurrence of the name in Internet in the last two years, using Google Trends

3PL	Max occurrence of the name in Internet in the last two years
3PL 1	26
3PL 2	14
3PL 3	<10
3PL 5	36
3PL 4	100
3PL 6	49

Table 25Option 1 Criterion: brand. Fount: Google trends

Using the following rule to assign numbers in each comparison:

Difference	Final number
<10	1
<30	3
<50	5
<70	7
>70	9

Table 26 Option 1 Criterion: Brand. Rule

	3PL 4	3PL 3	3PL 2	3PL 5	3PL 6
3PL 1	9	3	3	3	3
3PL 4		9	9	7	5
3PL 3			1	3	5
3PL 2				3	3
3PL 5					3

Table 27 Option 1 Pair-wise comparison for Brand

Figure 16 Option 11 Inconsistency of the Pair-wise comparison for Brand

3PL 4 is the most popular among the 3PL that is also because is a big company and it is not only dedicated to pharmaceutical companies, it also works with fashion, technology, aerospace… companies so it is normal that 3PL 4 is the most know company.

Checking the inconsistency we see that is less than 0.1 so it is acceptable.

Ability to offer added-value services

3PL	Ability to offer added-value services?
3PL 1	Yes
3PL 2	Yes
3PL 3	Yes
3PL 5	Yes
3PL 4	Yes
3PL 6	Yes

Figure 17Criterion: Ability to offer added-value services

All of the 3PL have the ability to offer added-value services, so we can't decide which the best 3PL is using only that criterion because the pair-wise comparison would be the following:

	3PL 4	3PL 3	3PL 2	3PL 5	3PL 6
3PL 1	1	1	1	1	1
3PL 4		1	1	1	1
3PL 3			1	1	1
3PL 2				1	1
3PL 5					1

Table 28 Option 1 Pair-wise comparison for ability to offer added-value services

Figure 1829 Option 1 Inconsistency of the Pair-wise comparison for ability to offer added-value services

All of them have the same importance in the criterion ability to offer added values services.

Market share / reference in the sector

To quantify this criterion we are going to us the sales volume found in database AIDA (Extend) at the library:

3PL	Sales volume (thousands/year)
3PL 1	47.605
3PL 2	17.066
3PL 3	71.279
3PL 5	10.030
3PL 4	252.423
3PL 6	13.102

Table 30 Option 1 Criterion: market share

Using the following rule to assign numbers in each comparison:

Difference	Final number
X<10.000	1
10.000<x<30.000	3
30.000<x<50.000	5
50.000<x<200.000	7
200.000<x	9

Table 31 Option 1 Criterion Market Sales. Rule

	3PL 4	3PL 3	3PL 2	3PL 5	3PL 6
3PL 1	9	3	5	5	5
3PL 4		7	9	9	9
3PL 3			7	7	7
3PL 2				1	1
3PL 5					1

Table 32 Option 1 Pair-wise comparison for Market Sales

Inconsistency: 0.08972	
3PL 1	0.11198
3PL 2	0.03271
3PL 3	0.19913
3PL 4	0.59075
3PL 5	0.03271
3PL 6	0.03271

Figure 19 Option 1 Inconsistency of Market Sales

3PL 4 is a big company so it is not strange that it has more sales volume than the others with a great difference.

Inconsistency is acceptable.

We have found the information for each 3PL on their official website online.

Analysis of the results

Name	Graphic	Ideals	Normals	Raw
3PL 1		0.443021	0.151897	0.075949
3PL 2		0.541054	0.185509	0.092755
3PL 3		0.491644	0.168568	0.084284
3PL 4		1.000000	0.342867	0.171433
3PL 5		0.194193	0.066582	0.033291
3PL 6		0.246673	0.084576	0.042288

Figure 20 Option 1. Ranking

The result is the ranking of the 3PL in accordance with all the criteria considered being 3PL 4 the best one, followed by 3PL 2, 3PL 3, 3PL 1, 3PL 6 and 3PL 5.

Sensitivity Analysis

What happen if the importance of the criteria changes? The answer is given by the sensitivity analysis.
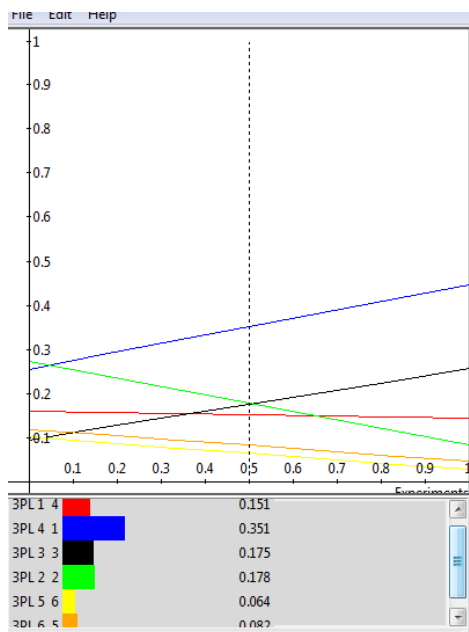
Figure 21 Option 1 sensibility analysis of competence(normalized values)

In this analysis we can see that almost for all the possible values given to the priority of Competence, 3PL 4 is always the best. But the ranking for the others 3PL changes a lot. If we want to see in a table with numbers, will be in that way:

Input Value	Matrix: Best	Chiapparoli	DHL	Eurodipharm	Neologistica	PHSE	STM group
0.000000	1,00E+02	1,60E+05	2,55E+05	9,45E+04	2,72E+05	1,01E+05	1,18E+05
0.166667	1,67E+05	1,57E+05	2,87E+05	1,21E+05	2,41E+05	8,82E+04	1,06E+05
0.333333	3,33E+05	1,54E+05	3,19E+05	1,48E+05	2,09E+05	7,59E+04	9,37E+04
0.500000	5,00E+05	1,51E+05	3,51E+05	1,75E+05	1,78E+05	6,36E+04	8,17E+04
0.666667	6,67E+05	1,48E+05	3,82E+05	2,02E+05	1,46E+05	5,13E+04	6,96E+04
0.833333	8,33E+05	1,46E+05	4,14E+05	2,29E+05	1,15E+05	3,89E+04	5,76E+04
1.000.000	1,00E+06	1,43E+05	4,46E+05	2,56E+05	8,32E+04	2,66E+04	4,56E+04

Table 33Option 1Table of sensitivity analysis for competence.(not normalized values)

If competence would be unimportant the ranking would be the following: 3PL 2 the best one, followed by 3PL 4, 3PL 1, 3PL 6, 3PL 5 and 3PL 3.

If competence would be the only factor taking in account, the main changes in the ranking would be, 3PL 3 being the second one, and 3PL 2 the four one.
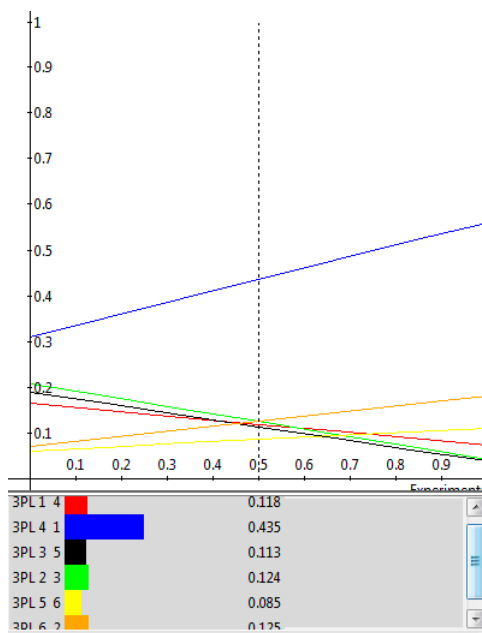
Figure 22Option 1 sensibility analysis of Brand

In this 3PL 4 is always the best 3PL for all the values given to the priority of brand. Changing the ranking for the others 3PLs. For example when the brand is not very important, for example 0.1 of importance, the ranking would be: 1. 3PL 4, 2. 3PL 2, 3. 3PL 3, 4. 3PL 1, 5. 3PL 6, 6. 3PL 5

But when brand is very important, 0.7 for example, the ranking is: 1. 3PL 4, 2. 3PL 6, 3. 3PL 1, 4. PSHE, 5. 3PL 2, 6. 3PL 3.
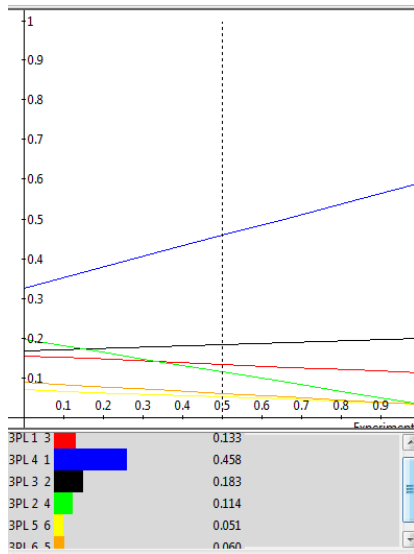
Figure 23 Option 1 sensibility analysis of market sales

3PL 4 is always the best 3PL, 3PL 5 and STM are also always the last ones and the ranking change for the others, being 3PL 2 the second best one when is not important the criterion and the fourth one when is very important. 3PL 3 is the third one when market sales is not important and second one when it is very important.
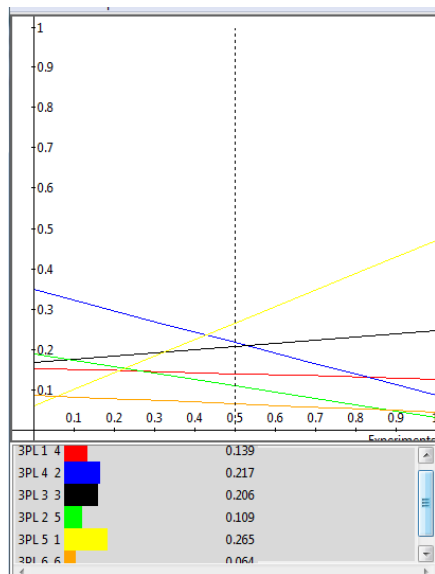
Figure 24Option 1 sensibility analysis of presence in the territory

If the most important criterion was the presence in the territory the raking would change a lot. With a preference of that criterion more than 0.45, the best 3PL is 3PL 5, because is the one with more warehouses in the national territory.

But we don't have to take into account too much this criterion, because for some pharmaceutical companies it can be a disadvantage having their products divide in different warehouses.
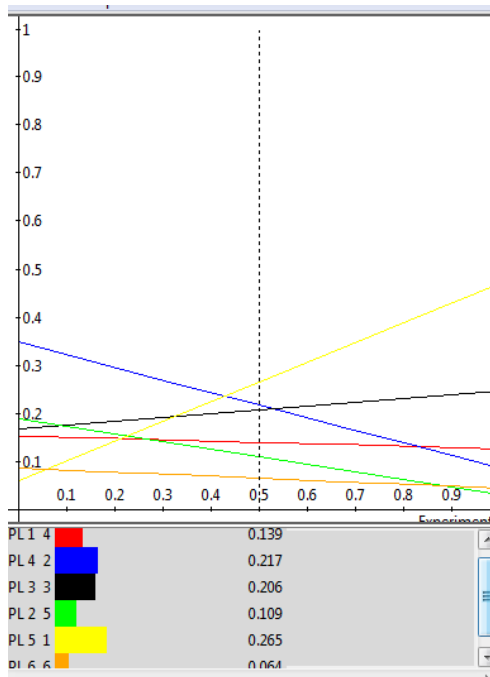
Figure 2526Option 1 sensibility analysis of quality customer/vendor

When the preference of the criterion quality customer/vendor is more than 0.4 the best 3PL is 3PL 2 and the second one 3PL 1, being 3PL 4 the third one.

We don't have to do the sensibility analysis for customer service and added values services, because in these criterions all the 3PL are the same.

After the analysis we can say that 3PL 4 is the best 3PL, because is the first one always in competence, brand and market sales. The ranking would change if presence on the territory would be less important, but this is not the case and also if quality customer/vendor would be the most important criterion.

Option 2

The main objective of that option is verified if they choose in accordance to what they have declared. In this part we are going to use the table2 to build the first level and the table 3 to build the second level.

The second step is to structure the hierarchy from the top (the objectives from a decision-maker's viewpoint) through the intermediate levels to the lowest level which usually contains the list of alternatives.
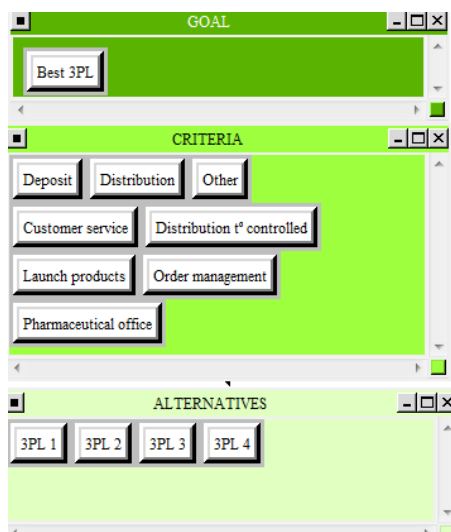
Figure 27 Option 2 Hierarchy Structure of Suppliers in a Pharmaceutical Supply Chain Option 2

The next thing to do to is create a set of pair-wise comparison matrices for each element of the lower levels, for this step need the answer from the questionnaire, table 2.

We have different answers for every pharmaceutical company; which are the following:

Service	Very important	Important	Less important	Not important
Deposit	X			
Pharmaceutical office	X			
Storage, distribution(room tº)	X			
Distribution(tº controlled)	X			

Service	Very important	Important	Less important	Not important
Order management (order entry, checking and validation)				X
Launch new products with automatic transmission				X
Customer service (call center)				X
Other value-added services (deposit account, home delivery, etc.)				

Table 34Option 2 Importance of every criterionfor the pharmaceutical company 1

Service	Very important	Important	Less important	Not important
Deposit	X			
Pharmaceutical office	X			
Storage, distribution(room t°)	X			
Distribution(t° controlled)	X			
Order management (order entry, checking and validation)		X		
Launch new products with automatic transmission		X		
Customer service (call center)		X		
Other value-added services (deposit account, home delivery, etc.)			X	

Table 35Option 2 Importance of every criterionfor the pharmaceutical company 2

Service	Very important	Important	Less important	Not important
Deposit	X			
Pharmaceutical office		X		
Storage, distribution(room t°)				X
Distribution (t° controlled)	X			
Order management (order entry, checking and validation)				X
Launch new products with automatic transmission				X

Customer service (call center)				X
Other value-added services (deposit account, home delivery, etc.)		X		

Table 36Importance of every criterionfor the pharmaceutical company 3

The criteria use to transform the answers of the questionnaire into numbers is the following:

If it is very important we assign a 4, important a 3, less important a 2 and not important a 1.

Very important	4
Important	3
Less important	2
Not important	1

Table 37Option 2 Criteria to transform qualitative answer into numbers

For example for deposit, the answers are very important for the 3 of the pharmaceutical companies, so we have (4+4+4)/3=4, an average of 4.

For pharmaceutical office the average would be (4+4+3)/3= 3.66

With the data that we have the table would be the following:

	Number
Deposit	4
Pharmaceutical office	3.66
Distribution(8-25ºC)	3
Distribution (2-8 ºC)	4
Order management (order entry, checking and validation)	1.66
Launch new products with automatic transmission	1.66
Customer service (call center)	1.66
Other value-added services (deposit account, home delivery, etc.)	2

Table 38Option 2 Transformation of the answer into numbers

We are going to subtract the numbers calculated before, and with the following rule we are going to obtain the final number that is going to be used in the pair-wise comparison table.

Result of the subtraction	Final number
0	1
0<x<1	3
1<x<2	5
2<x<2.5	7
2.5<x<3	9

Table 39Option 2 Criteria to create the pair-wise table comparison

	Deposit	Distribution(room t°)	Distribution (t° controlled)	Launch products	Order management	Other	Pharmaceutical office
Customer service	7	5	7	1	1	3	5
Deposit		3	1	7	7	5	3
Distribution(8-25°C)			3	3	3	3	3
Distribution (t° controlled)				7	7	5	3
Launch products					1	3	5
Order management						3	5
Other							5

Table 40Option 2 Pair-wise comparison of criteria

Inconsistency: 0.06830	
Customer ~	0.04561
Deposit	0.27921
Distribut~	0.10613
distribut~	0.27921
Launch pr~	0.03188
Order man~	0.03188
Other	0.04993
Pharmaceu~	0.17615
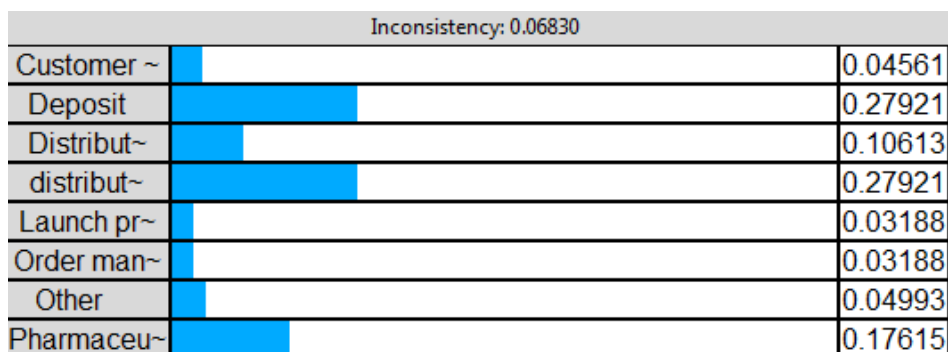
Figure 28Option 2 Importance of the criteria

The most important services are having deposit and the distribution (2-8 ºC) with temperature controlled. Having deposit means storage the pharmaceutical products. The distribution (2-8ºC) is an important service because many of the drugs endure longer conservation at these temperatures.

Pharmaceutical office and distribution (8-25ºC) are the next important services followed by other value-added services (deposit account, home delivery, etc.), customer service, order management (order entry, checking and validation), and launch new products with automatic transmission

The inconsistency of the comparison is less than 0.1 so is acceptable.

To create the other pair-comparison matrices, i.e. the pair-wise comparisons between the alternatives (the 3PLs), we are going to use the questions in which every pharmaceutical company had to say which 3PL they use for every services:

	3PL
Deposit	3PL 1
Pharmaceutical office	3PL 1
Distribution(8-25ºC)	-
Distribution (2-8 ºC)	3PL 3/3PL 5
Order management (order entry, checking and validation)	IN HOME
Launch new products with automatic transmission	-
Customer service (call center)	IN HOME
Other value-added services (deposit account, home delivery, etc.)	HOME DELIVERY CON ALLIANCE

Table 41Option 2 Services offer by 3PL pharmaceutical company 1

	3PL 1 : 3PL 1	3PL 2 : 3PL 2
Deposit	X	X
Pharmaceutical office	X	X
Distribution(8-25ºC)	X	X
Distribution (2-8 ºC)	X	X
Order management	X	X

(order entry, checking and validation)		
Launch new products with automatic transmission	X	X
Customer service (call center)	X	X
Other value-added services (deposit account, home delivery, etc.)	X	

Table 42Option 2 Services offer by 3PL pharmaceutical company 2

	3PL
Deposit	3PL 1
Pharmaceutical office	3PL 1
Distribution(8-25°C)	3PL 1
Distribution (2-8 °C)	3PL 1
Order management (order entry, checking and validation)	IN HOME
Launch new products with automatic transmission	IN HOME
Customer service (call center)	IN HOME
Other value-added services (deposit account, home delivery, etc.)	

Table 43Option 2 Services offer by 3PL pharmaceutical company 3

	3PL
Deposit	3PL 4
Pharmaceutical office	3PL 4
Distribution(8-25°C)	3PL 4
Distribution (2-8 °C)	3PL 4
Order management (order entry, checking and validation)	INTERNAL
Launch new products with automatic transmission	INTERNAL

Customer service (call center)	INTERNAL
Other value-added services (deposit account, home delivery, etc.)	_

Figure 29Option 2 Services offer by 3PL pharmaceutical company 4

	3PL
Deposit	3PL 4
Pharmaceutical office	3PL 4
Distribution(8-25ºC)	3PL 4
Distribution (2-8 ºC)	3PL 4
Order management (order entry, checking and validation)	INTERNAL
Launch new products with automatic transmission	INTERNAL
Customer service (call center)	INTERNAL
Other value-added services (deposit account, home delivery, etc.)	-

Figure 30Option 2 Services offer by 3PL pharmaceutical company 5

Internal and in home means that they do that service by themselves.

To assign numbers we are going to implement the following rule:

If a 3PL has been selected at least one time for a service means they are good in respect to this service, so they would receive the highest mark in this aspect. In order to compare with another 3PL in this service, if the other 3PL was also been chosen at least for one company, they would be at the same level, which translated into numbers is a 1, but if it has not been chosen by any company, they would receive a 9. The following table explain it a clearly way:

	3PL selected more than once	3PL selected once	3PL no selected
3PL selected more than once	1	5	9
3PL selected once		1	5
3PL no selected			1

Table 44Option 2 Criteria to compare the alternatives

It is needed the answer from the questionnaire in which the companies said what is the ·3PL they used, the answers are the following:

Deposit

	3PL 2	.3PL 3	3PL 4
3PL 1	5	9	1
3PL 2		5	5
3PL 3			9

Table 45Option 2 Comparison between alternatives in criterion Deposit

Figure 31 Option 2 Inconsistency of Deposit

3PL 1 and 3PL 4 are selected for the service deposit more than once, so we assume that they are the best in that service.

3PL 2 has been selected once, so is better than3PL 3, but not as good as 3PL 4 and 3PL 1.

3PL 3 has been selected by any of the five companies, so we suppose is not as good as the others.

The inconsistency here is less than 0.1 so is acceptable.

Pharmaceutical office

	3PL 2	.3PL 3	3PL 4
3PL 1	5	9	1
3PL 2		5	5
3PL 3			9

Table 46Option 2 Comparison between alternatives in criterion pharmaceutical office

Figure 32 Option 2 Inconsistency of the criterion pharmaceutical office

3PL 1 and 3PL 4 are the best ones for the pharmaceutical office service

The inconsistency is less than 0.1 so is acceptable.

Distribution (8-25ºC)

	3PL 2	.3PL 3	3PL 4
3PL 1	5	9	1
3PL 2		5	5
3PL 3			9

The ranking in respect of this criterion is the same as the ranking in respect of pharmaceutical office service, so the inconsistency is also the same, and it is acceptable.

Distribution (2-8ºC)

	3PL 2	.3PL 3	3PL 4
3PL 1	5	5	1
3PL 2		1	5
3PL 3			9

Table 48Option 2 Comparison between alternatives in criterion Distribution(2-8ºC)

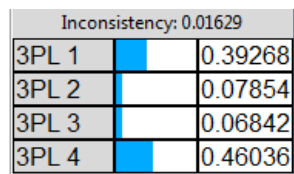| Inconsistency: 0.01629	
3PL 1	0.39268
3PL 2	0.07854
3PL 3	0.06842
3PL 4	0.46036

Figure 33 Option 2 Inconsistency of the criterion Distribution (2-8ºC)

The best 3PL for the distribution (2-8ºC) is 3PL 4 followed by 3PL 1, 3PL 2 and 3PL 3. The inconsistency is acceptable.

Launch new products with automatic transmission

	3PL 2	.3PL 3	3PL 4
3PL 1	1	5	5
3PL 2		5	5
3PL 3			1

Table 49Option 2 Comparison between alternatives in criterion Launch new products with automatic transmission

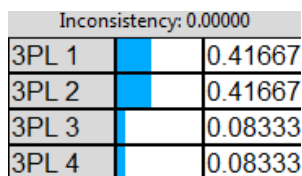| Inconsistency: 0.00000	
3PL 1	0.41667
3PL 2	0.41667
3PL 3	0.08333
3PL 4	0.08333

Figure 34 Option 2 Inconsistency of the criterion Launch new products with automatic transmission

3PL 2 and 3PL 1 are the best ones in launch products with automatic transmissions, because for example 3PL 4 launch the products in a manual way.

But that criterion is not very important because some pharmaceutical companies don't want automatic transmissions because they don't trust in them.

The inconsistency is acceptable.

Order management

	3PL 2	.3PL 3	3PL 4
3PL 1	1	5	5
3PL 2		5	5
3PL 3			1

Table 50Option 2 Comparison between alternatives in criterion Order management

The ranking in respect to that criterion is the same as in launching new products with automatic transmission so the inconsistency is also the same, and it is acceptable.

Customer service

	3PL 2	3PL 3	3PL 4
3PL 1	1	5	5
3PL 2		5	5
3PL 3			1

Table 51Option 2 Comparison between alternatives in criterioncustomer service

For customer services the ranking is the same as for order management and launching new products with automatic transmission.

Other services

	3PL 2	.3PL 3	3PL 4
3PL 1	5	5	5
3PL 2		1	1
3PL 3			1

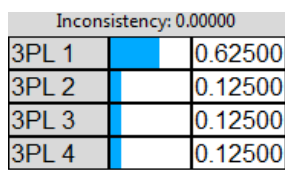Table 52Option 2 Comparison between alternatives in criterion other services

Figure 35 Option 2 Inconsistency of the criterion other services

3PL 1 is the only 3PL that has been selected once for other services.

Analysis of the results

Figure 36Option 2. Results

3PL 1 is the best 3PL taking in account what the pharmaceutical companies have declared, followed by 3PL 4, 3PL 2 and 3PL 3.
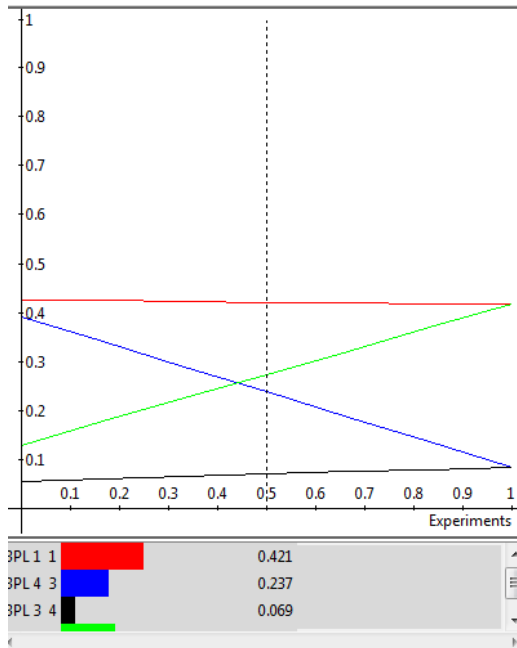

Figure 37 Option 2 sensitivity analysis for customer service

Doing the sensitivity analysis for customer service we can see that 3PL 1 is always the first one, changing the second and the third, when customer service is not very important 3PL 4 is the second one and 3PL 2 the third one and when customer service is a factor very important 3PL2 is the second one and 3PL 4 the third one. That graphic is the same for order management and launching new products with automatic transmission.
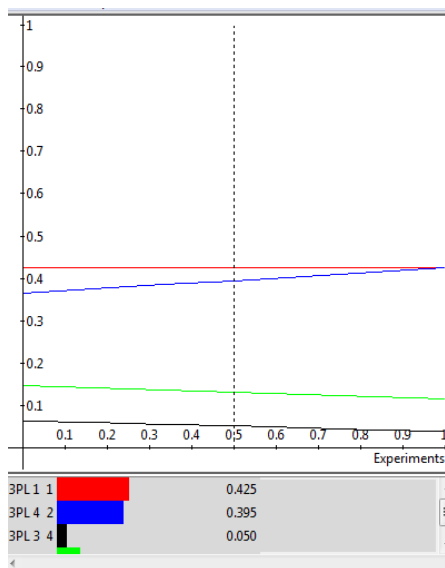
Figure 38 Option 2 sensitivity analysis for deposit

Changing the priority for the criterion deposit the ranking doesn't change and also we can see that if deposit was the only criteria taking in account, 3PL 1 and 3PL 4 would be both the best ones, because they were selected twice for this service.
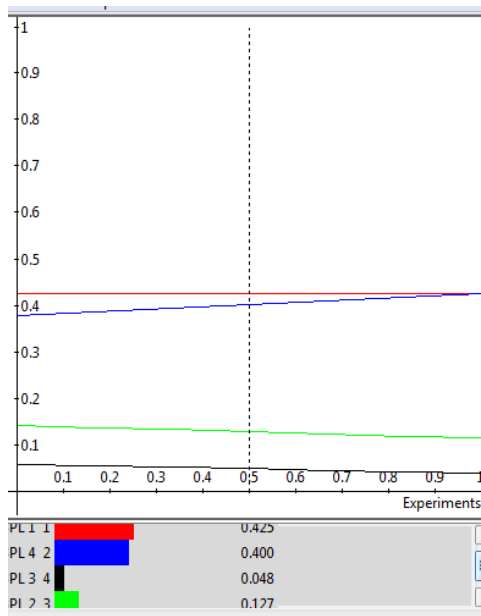
Figure 39 Option 2 sensitivity analysis for distribution (8-25ºC)

For the distribution(8-25ºC) we can say the same as for depositcriterion. The ranking is the same for all the different priorities for distribution(8-25ºC). That graphic is the same for pharmaceutical office.
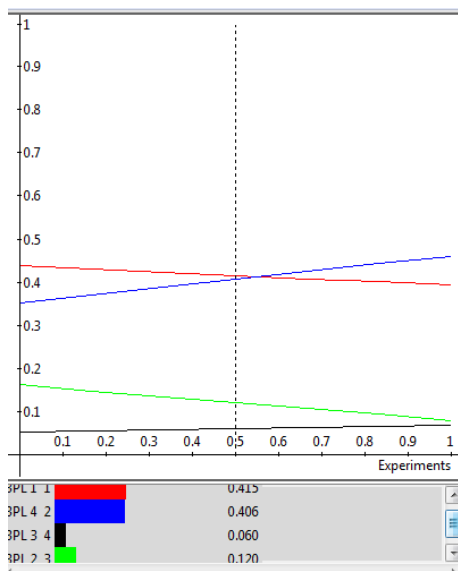
Figure 40 Option 2 sensitivity analysis for distribution(2-8ºC)

The ranking change when we change the priority for the distribution (2-8ºC) criterion, being 3PL 4 the first one when the priority for this criterion is more than 0.6.

64

Figure 41 Option 2 sensitivity analysis for other services.

The ranking doesn't change when we change the priority of the criterion other services. When that factor is the only one taking in account, 3PL 3, 3PL 2 and 3PL 4 have the same preference.
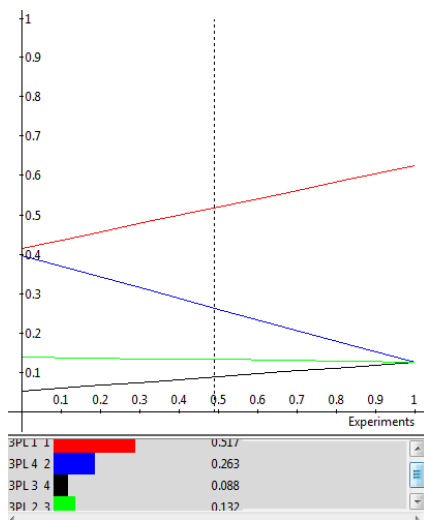
10.   CONCLUSIONS

Option 1

The ranking in that option established that 3PL 4 is the best one, followed by 3PL 2, 3PL 3, 3PL 1, 3PL 6 and 3PL 5.

The sensitivity analysis tell us that even changing the priority of 5 of the 7 criterion, brand, market sales, competence, customer service, added value services, 3PL 4 is always the best one, and for the others 2 criteria, presence on the territory and quality customer/vendor the priority has to be very high, more than 0.6, to change the ranking. This is something good, because with that we can say with more security that 3PL 4 is the best 3PL.

Comparation with the real data

If we compare with the real choice made by the pharmaceutical companies we see that it differs a little. But it has an explanation, for example 3PL 3 and 3PL 4 are ones of the best leaders in transport in the international market, but we have analysed the most hired 3PL in the Italian territory, and in Italy they are not the leaders because some Italian pharmaceutical companies declared that they prefer national 3PL instead of big multinationals 3PL because they don't have dependence on the "parent" (multinational direction) so they can make decisions in a quick way.

Some of the companies have said that they choose 3PL 1 just because the timing of the decisions is very fast. So that is the reason why 3PL 1 is the most popular between the Italian pharmaceutical companies interviewed.

Limitation of the results

To build the second level, we needed objective data that we found in the official page of the 3PL, but maybe there is a better way to measure the criteria. For example, to measure the brand criterion we have used the number of the occurrence of the name in Internet in the last two years, using Google Trends, which is related to brand but maybe is not the most accurate way.

The criteria were given to few pharmaceutical companies and they had to rank them, but it could be that for other companies another criterion is more important and it wasn't in the list, for example prize, speed....

Option 2

In that option the method AHP has been used in an unusual way. We have used the answers of the pharmaceutical companies to build the comparison between criteria and between alternatives.

Comparison with real data

3PL 1 is the best 3PL in general for all of the services, according with the answer of the 5 pharmaceutical companies, followed by 3PL 4 with not much difference. 3PL 2 is the third one and 3PL 3 the last one.

If we compare the results with the reality we can see they are really close, because 3PL 1 is the 3PL most chosen by the pharmaceutical companies followed by 3PL 4.

Limitations

The limitations are that we have only asked to 5 pharmaceutical companies but there are 180 Italian companies.

We have assumed that the best 3PL is the one that is the best in all of the services, but some of the 3PL are specialized in only one service being the best in that service, and are hired only to do that. So the problem is that we try to find the best 3PL in general, but we don't take in account that one pharmaceutical company can hire different 3PL for different services.

General limitations.

Another limitation is the limited choices to answer to the questions of the questionnaire: maybe for the pharmaceutical companies others choice would be more important, and we haven't asked about them.

We interviewed the most important pharmaceutical companies, but there aren't enough to have a definitive answer.

It is also a subjective method so the results can change a lot if the persons who answered the questionnaire were different, if the inputs were different.

There is not an exact rule to make the conversion from verbal to numeric scale, so we had to create it.

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11. LIST OF ABBREVIATION

3PL: third part logistic.

AHP: analytic hierarchy process

DEA: data envelopment analysis

MCDM: Multiple-criteria decision-making

CD: Central distributor

PC: Peripheral distributor

KPI: key performance indicator

SAW: simple additive weighting

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Poner referencia de los que dijeron que tenía desventajas.

12.   APPENDIX

12.1 SUPERDECISIONS

"SuperDecisionsis a decision making software based on the Analytic Hierarchy Process (AHP) and the Analytic Network Process (ANP). The program was written by the ANP Team, working for the Creative Decisions Foundation. You can download it here http://www.superdecisions.com/

The process for solving Multicriteria problemis the following:
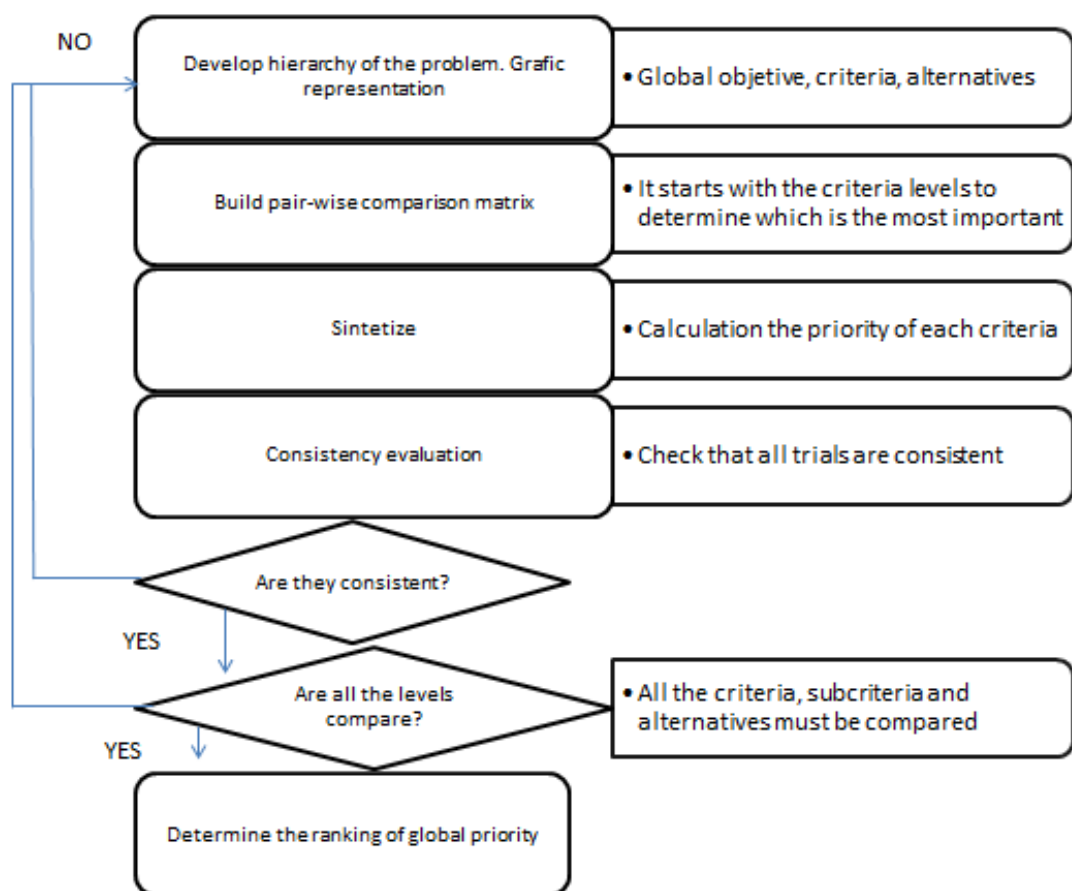

Figure 42Modeling a multidecision problem, superdecision

Software Components:

A) Cluster, nodes and links

B) Evaluation of cluster nodes

C) Results

Example

As an example of application of SuperDecisions is going to be used to make decisions in the project management field, to select the most suitable contractor repeating the results of *Al-Harbi, L. (2001).*thecriteria that willbe used in example for prequalification are experience, financial stability, quality performance, manpower resources, equipment resources, and current workload.

	Contractor A	Contractor B	Contractor C	Contractor D	Contractor E
Experience	5 years experience	7 years experience	8 years experience	10 years experience	15 years experience
	Two similar projects	One similar project	No similar project	Two similar projects	No similar project
		Special procurement experience	1 international project		
Financial stability	$7 M assets	$10 M assets	$14 M assets	$11 M assets	$6 M assets
	High growth rate No liability	$5.5 M liabilities Part of a group of companies	$6 M liabilities	$4 M liabilities Good relation with banks	$1.5 M liabilities
Quality performance	Good organization	Average organization	Good organization	Good organization	Bad organization
	C.M. personnel Good reputation Many certificates	C.M. personnel Two delayed projects Safety program	C.M. team Government award Good reputation	Good reputation Many certificates Cost raised in some projects	Unethical techniques One project terminated Average quality
	Safety program		QA/QC program		
Manpower resources	150 labourers	100 labourers	120 labourers	90 labourers	40 labourers
	10 special skilled labourers	200 by subcontract	Good skilled labors	130 by subcontract	260 by subcontract
		Availability in peaks	25 special skilled labourers		
Equipment resources	4 mixer machines	6 mixer machines	1 batching plant	4 mixer machines	2 mixer machines
	1 excavator	1 excavator	2 concrete transferring trucks	1 excavator	10 others
	15 others	1 bulldozer 20 others 15,000 sf steel formwork	2 mixer machines 1 excavator 1 bulldozer 16 others 17,000 sf steel formwork	9 others	2000 sf steel formwork 6000 sf wooden formwork
Current works load	1 big project ending	2 projects ending (1 big + 1 medium)	1 medium project started	2 big projects ending	2 small projects started
	2 projects in mid (1 medium +1 small)		2 projects ending (1 big + 1 medium)	1 medium project in mid	3 projects ending (2 small + 1 medium)

Table 53 Example *Al-Harbi, L.(2001).*

The contractor E does not meet the minimum criteria in organization, it is bad and its techniques are unethical, so it could be eliminated from the list at the first time. Nevertheless it is up to the decision-maker to decide of eliminating the contractor or not. For this reason we are not going to delete it because it is going to be used for demonstrative purposes, helping us to know the consistency of the pair-wise comparison which is a part of the AHP- procedure.

All models generated under the methodology of AHP / ANP must have at least three levels; first, an overall purpose or goal, which is located at the top; second, two or more criteria which are attributes that should satisfy the alternatives for decision making in respect to the goal; and, finally, several alternatives as possible solutions (contractors in this example) to the problem, located on the bottom.

Figure 43 Hierarchy of the project example.*Al-Harbi, L.(2001).*

Once it is known the hierarchy of the project, it is time to do the graphic representation in SuperDecisions, including the clusters and nodes.

Create a cluster; Select Design>Cluster>New ; Select cluster name and description; Save

Figure 44 Creating of clusters

Create a node; Right-click on cluster background>Create node in cluster; Enter node name
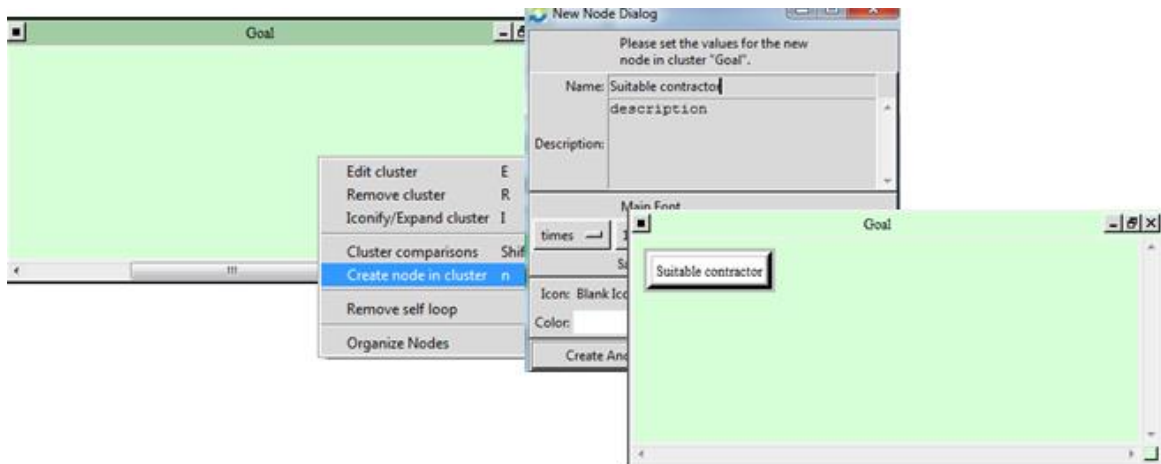
Figure 45 Create nodes in a cluster

Make Connections; Make sure "connections icon is depressed; Left-click on "from" or parent node; Right-click successively on "to" or children nodes; Link then automatically appears between clusters.
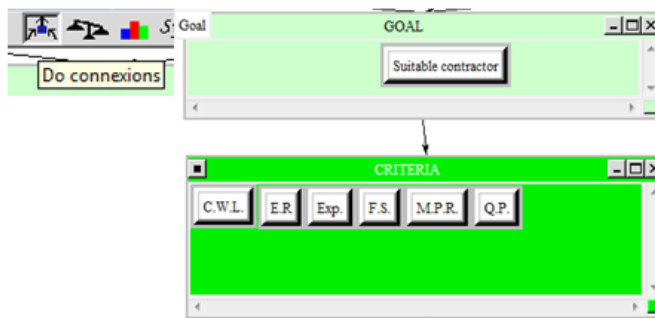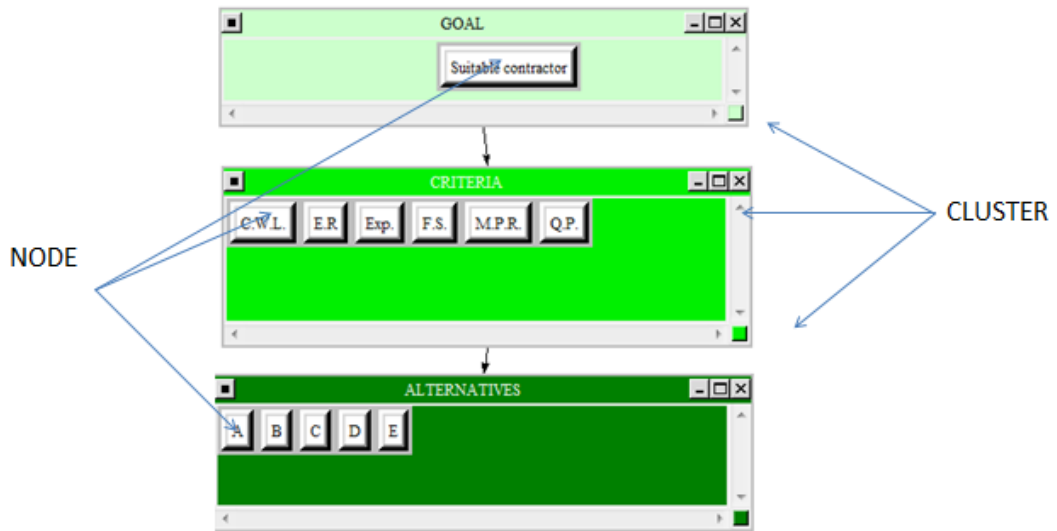

Figure 46 Make connections

Figure 47 Example: Cluster and node representation

Comparison judgment; Assess/Compare> pair-wise comparison

The graphic representation withSuperDecisions of that is the following:

Figure 48 Pair-wise comparison for the six criteria

The meaning of the table is the following; comparing C.W.L. with E.R., the 4 blue means that C.W.L. is 4 times more important than E.R.

Elements in red are actually reciprocals. For example, 4.0 stand for ¼.

Diagonal elements are always 1 and do not need to be displayed as well as the crossed out elements because there are always inverses of the judgment in the reciprocal cell.

$$\begin{array}{c|ccccc} K & A_1 & A_2 & \cdots & A_n \\ \hline A_1 & 1 & a_{12} & \cdots & a_{1n} \\ A_2 & 1/a_{12} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ A_n & 1/a_{1n} & 1/a_{2n} & \cdots & 1 \end{array}$$

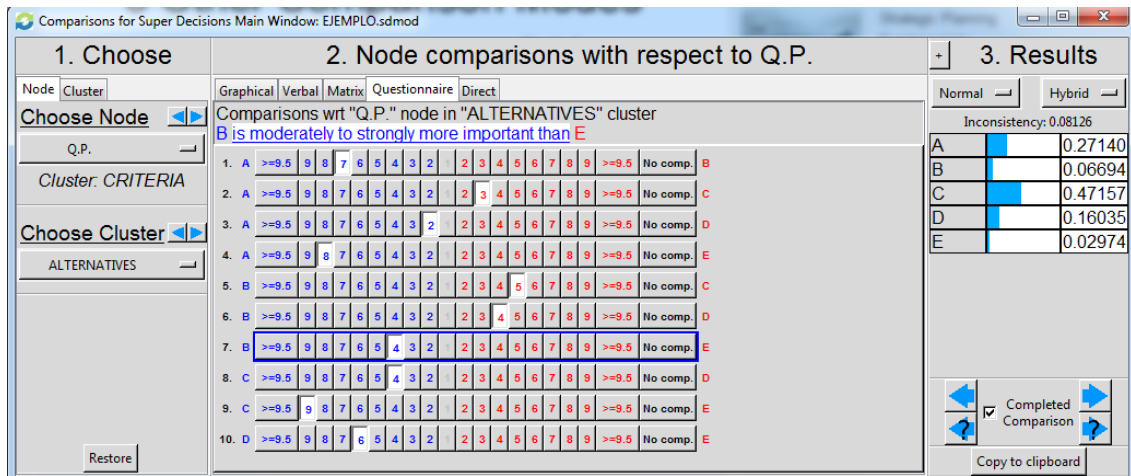Figure 49Matrix A pairwise comparison *Karimi, A.R. et. al 2011*

Other comparison modes;

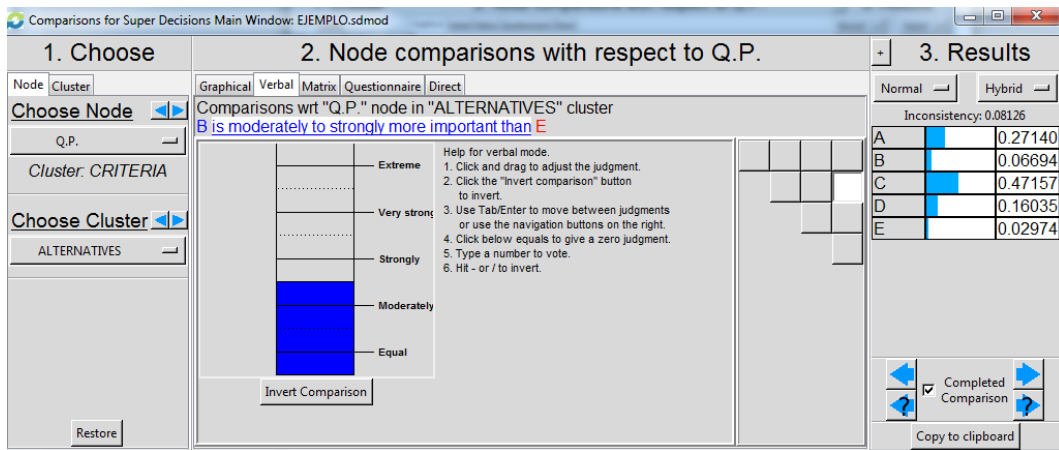Figure 50Questionaire comparisonwith respect Q.P. example

Figure 51 Verbal comparison with respect Q.P. between contractors B and E. example
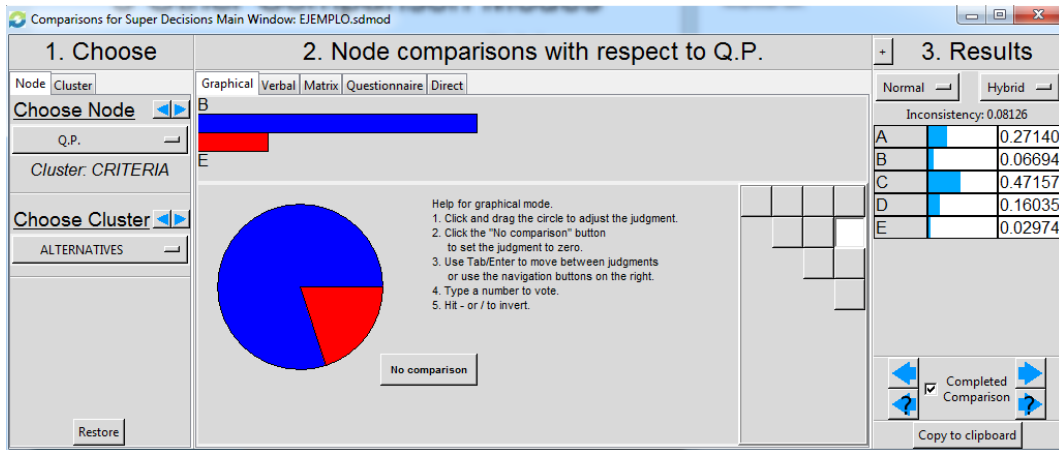
Figure 52 Graphical comparison with respect Q.P..between contractors B and E example

Consistency: an interesting side effect of asking people to make a series of pairwise ratio-based comparisons is the way that they "forget" prior assessments as they go. If their understanding of the system is coherent, the whole set of pairwise comparisons should stack up in a self-consistent way. In a preference assessment, if a person places A much greater than B, then A slightly greater than C and then B slightly greater than C, they have created a set of circumstances that do not make sense as a whole. They have revealed inconsistency in their thinking on the matter. *David L. Hallowell (2016).*

In every comparison you can check the inconsistency of the judgment, aninconsistency less than 0.1 is acceptable. (*Al-Harbi, L. (2001).*

You can also introduce direct data to make the comparisons but is not usually a good way to determine personal priorities.

Results; Selects Computations> Synthesize

The raw values come from the Limit Supermatrix. The normalized values are obtained from them by normalization. The Ideals are obtained by dividing all raw values by the largest of them.

Name	Graphic	Ideals	Normals	Raw
A		0.750733	0.222505	0.111252
B		0.661776	0.196139	0.098070
C		0.812916	0.240935	0.120467
D		1.000000	0.296383	0.148192
E		0.148584	0.044038	0.022019

Figure 53 Priority matrix for contractor prequalification

The contractor are now ranked, being the most suitable contractor D followed by C, A, B and E

Graphic	Alternatives	Total	Normal	Ideal	Ranking
	A	0.1113	0.2225	0.7507	3
	B	0.0981	0.1961	0.6618	4
	C	0.1205	0.2409	0.8129	2
	D	0.1482	0.2964	1.0000	1
	E	0.0220	0.0440	0.1486	5

Figure 54 Alternatives Ranked example

Sensitivity analysis; Computations>sensitivity>edit>independent variable.

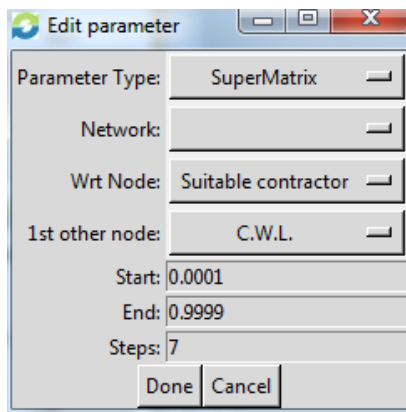Introduce the following, to study the sensibility of C.W.L to select the suitable contractor:

Figure 55 Parameters to introduce in the sensibility analysis of C.W.L example
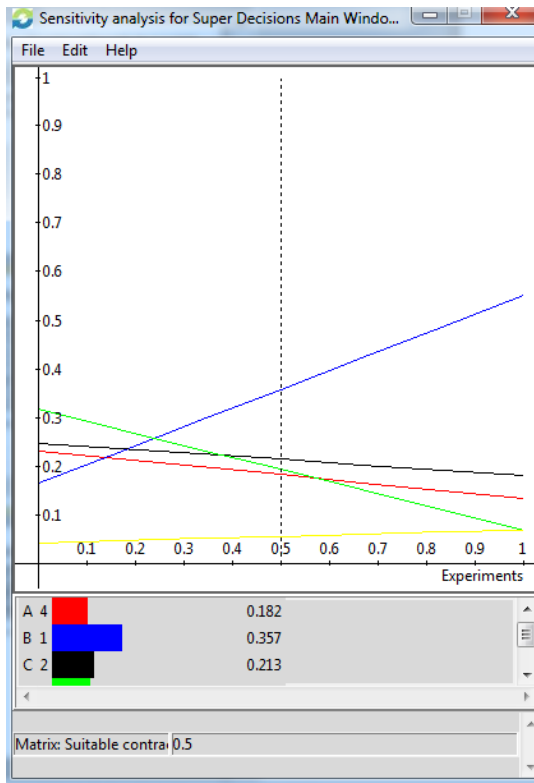
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Figure 56 Sensibility analysis of C.W.L in the selection of the best contractor. Example

The sensibility analysis is initially set at 0.5 on the X- Axis for the priority of the *C.W.L*. The respective priorities of the contractor are indicated by the Y-Axis values where their lines intersect the vertical line: A: 0.182; B: 0.357; C:0.213; D:0.192; E:0.055.

To see the values used to plot the current graph, select File>Save in Sensitivity and save to a .txt file. Start Excel, select File>Open and enter the name you gave the .txt file. The Data Import Wizard will appear. Keep clicking Next to import the data. Below are the values for the Price graph with 6 steps.

Input Value	Matrix: Suita A	B	C	D	E
0.000000	1,00E+02	2,30E+05	1,64E+05	2,46E+05	3,17E+05	4,19E+04
0.166667	1,67E+05	2,14E+05	2,29E+05	2,35E+05	2,75E+05	4,62E+04
0.333333	3,33E+05	1,98E+05	2,93E+05	2,24E+05	2,34E+05	5,06E+04
0.500000	5,00E+05	1,82E+05	3,57E+05	2,13E+05	1,92E+05	5,49E+04
0.666667	6,67E+05	1,66E+05	4,22E+05	2,02E+05	1,51E+05	5,93E+04
0.833333	8,33E+05	1,50E+05	4,86E+05	1,91E+05	1,09E+05	6,36E+04
1.000.000	1,00E+06	1,33E+05	5,50E+05	1,80E+05	6,80E+04	6,79E+04

Figure 57Graphic of sensibility analysis of C.W.L in the selection of the best contractor. Example

http://www.slideshare.net/erokou/tutorial-5-ahpandanp

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