Analyzing opportunities to improve Amgen’s distribution network within Europe

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In partial fulfilment of the requirements for the degree of
Master of Science
in Operations Management and Logistics

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Series Master Theses Operations Management and Logistics

Subject headings: Distribution, Network design, Simulation modeling, Operations Research
Abstract

This research project investigates opportunities of improvement in the current network distribution managed by Amgen in Europe. By means of a simulation generated using the IBM ILOG LogicNet Plus (2011), the current situation was deeply analyzed and described. Later on the tradeoffs of changing the network were tested through the analysis of several scenarios. In such scenarios the focus was on decreasing the overall transportation costs while maintaining or increasing the service level (based on delivery times). The scenarios were restricted by the situational requirements; by instance the regulations for distribution of pharmaceutical good and the location of the potential DCs (based on the footprint of the LSPs they are working with). This study provides insights regarding the actions that the company can perform to improve its distribution set up within Europe; as well as the limitations of it.
Executive summary

Within a competitive environment, it is a must to be efficient and provide a valuable service to the customer in order to stay in the business. It has been widely discussed the challenging situation that the pharmaceutical industry is experiencing. Changes in the healthcare reform, increase in patent expiries and increased service requirements are pushing the pharmaceutical companies to take some actions in regards to its operation and distribution strategies. In order to succeed, being able to offer added value to its customers, a pharmaceutical company will require to reduce costs, increase its agility and market speed while ensuring a high security standards aligned with the respective regulatory legal framework it is immersed (Buck Consultants International, 2013).

For the pharmaceutical companies, the optimization of costs has gained a powerful focus since the combination of patent expiries and the rise of generic brands is leading to a decrease on sales revenues and margins. Also on one hand, the governments and insurance companies are placing a strong pressure on prices of their products and prescription policies, due to the transition of the paying responsibilities from individuals to governmental agencies. While on the other hand, the establishment of regulatory authorities and market maturity have led to an increase in the costs and time to develop new drugs. This means lower productivity on R&Ds stage and a shorter effective patent live for the new molecules (Sousa, 2013; Buck Consultants International, 2013; Jusko, 2008).

For this reason the companies started paying extra attention to their supply chain activities and mainly to the distribution network; since an optimization on it could lead to a better service and to costs savings.
Amgen wanted to investigate the latent opportunities of improvement that its distribution network has, in order to create a robust strategy that assist the company to keep delivering added value to its clients in the upcoming years considering the foreseen challenges in the industry.

This report provides an insight on the opportunities that Amgen has to redesign its current distribution network setup. Different types of analyses were performed; going from customer profiles, and analysis of the distribution of the demand per country and customer type to the development of a set of scenarios to simulate the current situation regarding the distribution network of the company and analysis the tradeoffs in terms of costs and service level that it would have if some of its variables were tuned. The tools selected for this study were Microsoft Excel (2010) and the IBM ILOG LogicNet Plus (2011) because its combination provides a convenient and manageable manner to deal with the relevant relations present though the supply chain analysis.

The analyses lead to the following findings:

- Due to the local requirements of some countries were the distribution is done, Amgen requires having at least 8 DCs, additional to its owned DC in Breda (ABR), to cover its demand within Europe. Those have to be located in: PT, CH, PL, HU, RO, CZ, GR and LT, to cover at least their respective local market.
- It is not possible to meet the demand of Spain from the DC in Portugal without decreasing the current service level provided in Spain. Thus a local DC in Spain is required.
- A relaxation of the service level managed in Spain could have a positive impact in terms of cost, decreasing about 12% of the current costs due to the services of the LSP in place.
A segmentation of the supply chain in terms of customer type for the Spanish market, and a relaxation of the service level for the distributors and wholesalers could lead to a decrease of 2% of the current costs due to the services of the LSP in place.

In terms of service level, the DC located in France can be removed and the French customers can be supplied by either ABR or the DC in Switzerland without decreasing the current service level delivered in the country.

It is possible to improve the average time from DC to customer from countries like SI, SK, HR and BG by following a regionalization strategy.

In conclusion, from the options analyzed, Amgen have opportunities to improve its European distribution network in terms of service level (based on the average time in transit from DC to customer) by changing the distribution mode to SK, SI, HR and BG; passing from direct to indirect distribution. In this case it was shown that covering the demand of the first three countries from the DC located in HU while BG is delivered from RO could diminish the average time from DC to customers in those countries. Nevertheless a further analysis in terms of cost involved in such strategy must be assessed.

Due to the limitation in terms of time, there was not possible to have available the appropriate data to realize a tradeoff analysis for the regionalization approach or the strategy of optimize the assignation of different markets to the LSPs, aiming or reduce the number of different partners in the network. Hence, the proper analyses of those strategies are left for future research.
Acknowledgments

This Master Thesis report represents the end of my studies as a Master of Science in Operations Management and Logistics at Eindhoven University of Technology. I consider this instance as a giant achievement, which would not be possible without the support of some people and institutions. Thus I would like to take this opportunity express my gratitude towards them.

First of all, I want to thank Ivonne Abud Urbiola, for being an exceptional professor and for inspiring me to target the highest standards of quality in every aspect of my life.

Then, I would like to express my grateful feelings towards Olivier Bocquet, for providing me an interesting project within a fascinating organization. Next to it, I thank my company supervisors: Gert Jan Rombouts and Vera Malakhovskaya for supporting me with their expertise. I would also thank Gitte Brosens, Marga Estermans, Berit Biniass and Gerben van Dijk for being an awesome team to work with and for creating a certainly friendly and open atmosphere at the office. I am grateful I was given the opportunity to be part of this brilliant team.

I am particularly grateful for the assistance given by my first academic supervisor, Tom van Woensel. He provided really accurate and critical remarks which made me focus during this project. Also I wish to acknowledge the help provided by Emrah Demir. As my second supervisor, he shared his comments, ideas and feedback in regards to my project.

Also, I would like to thank CONACYT for the scholarship without which I would not be at this point.

Moreover, I am glad that during the past two years I was surrounded by wise, cheerful and energetic people who make this journey a really pleasant, adventurous and knowledgeable one. Mainly I would like to thank: Theo, Pablo, Ricardo, Diana, Carlos, Javier and Stephen for making this experience unique. And also a merited appreciation for: Brenda, Julieta, MaJo and Bruno for their support and invaluable friendship.

Finally, I would like to give the most special recognition to my family, since without their support, this achievement would not be possible: Gracias por el amor, apoyo e inspiración que me han brindado todos estos años. ¡Lo logramos!

Silvia Picazo Barragan

Eindhoven, 2014
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1. Introduction

In this chapter it is presented a brief description of the company in which the project was realized. This description includes an overview of the company; including: its focus, performance of the last years, the location of its facilities worldwide and an explanation of where the manufacturing activities are held and how the products are distributed (Visualization of Amgen’s supply chain).

Later on, Section 1.2 presents the methodology followed to develop this project. Finally, the structure of this report is developed in Section 1.3.
1.1 The company: AMGEN

Applied Molecular Genetics, better known as Amgen, is a biotechnological industry focused on the development and delivery of innovative medicines to treat grievous illnesses.

Amgen was established in 1980 in Thousand Oaks (California, US). Since then, it has continued growing and currently it is the world's largest independent biotechnology company, and has reached millions of patients around the world. By instance in their annual report of 2013, it is stated that Amgen’s revenues rose 8% to 18,676 million in that year (AMGEN, 2014).

Amgen's research and product development programs aim to help patients in five critical areas: nephrology, oncology, inflammation, bone diseases, and neurology.

The manufacturing and distribution facilities of Amgen are located in California, Colorado, Kentucky, Puerto Rico, Rhode Island, as well as Ireland and the Netherlands; but it has facilities spread all around the world (Senzee, 2008) as Figure 1.1 shows.

![Figure 1.1 Amgen’s facilities worldwide [Source: Amgen’s website]](image-url)
The company has been constantly growing. By instance, its annual report of 2013 reported an increase of 9% in product sales which was driven by a strong performance across its portfolio. Also the Earnings per share (EPS) and the free cash flow for the full year presented an increase compared to the obtained in 2012 (AMGEN, 2014).

It was indicated by Robert A. Bradway, chairman & chief executive officer, that the growth of Amgen in the past years is expected to continue in the long run; he said: "We now have ten innovative development programs with registration-enabling data expected by 2016, six biosimilars in development and expanded presence in more than 75 countries. We are excited about our prospects for long-term growth" (AMGEN, 2014).

1.1.1 Manufacturing & distribution Supply Network
The manufacture of the commercial products is mainly held in Puerto Rico, while the clinical products are manufactured in Thousand Oaks. Afterwards, the distribution of the product occurs in the following way: for the products within the United States, the Distribution Centers (DCs) of Kentucky and California handle the correspondent activities. Meanwhile, for the rest of the world, the distribution and some other logistic activities like labelling and packaging of the majority of commercial products is done via the DC located in the Netherlands; also known as Amgen Breda (ABR).

1.1.2 Amgen site Breda
The site in Breda started operations in 1997. Nowadays, it has grown and became a campus which hosts seven Amgen’s organizations: the Dutch Commercial Affiliate, Site Operations, Regions 1 and 2 of the Global Supply Chain Organization, Clinical Supply Chain, Finance Shared Service Center and Information Systems Europe. The logistic activities carried out there, are: distribution, assembly, packaging and labeling.

Currently ABR is covering the distribution activities to the western and eastern European countries, the Middle East, South-America, Australia and Africa.
This master thesis project is linked to an actual project handled ELC which is focused on the distribution activities. Hence, it is relevant to understand how these activities are held within the company. The focus of this research was placed in the last part of it, involving the distribution from the ELC (labelled as ABR) to the customers in Europe which belong to Region 1. A list of the countries that are part of this region is included in the Appendix I [Non confidential].

Figure 1.2 Visualization of Amgen’s supply chain-top level-

Figure 1.2 depicts, in a nutshell, how Amgen’s supply chain is established for the European market. It all starts with the bulk production in Amgen Colorado (ACO) and Amgen Thousand Oaks (ATO), then the product is moved to Amgen Puerto Rico (AML) where the fill and finish operations are performed. After that the products requested by the European market, Middle East, South-America, Australia and Africa; are sent to the ELC (ABR) where they are labelled, packed and distributed to the final customers. The distribution can be done in different ways, ABR can perform a direct distribution to the customers of send it via a partner. This subject is discussed with further detail in Chapter 3.
1.2 Research methodology

The methodology used for the development of this project is graphically shown in Figure 1.3.

![Figure 1.3 Research methodology](image)

The process initiated with a problem that was perceived (Section 2.1). Afterwards, the problem definition was done (Section 2.3 and 2.4); at this point the objectives, framework and outputs of the research were established. Later, in the phase of data gathering, all the data related to the perceived problem was gathered. This process was mainly done via reports provided by the company, such as: demand experienced in the year 2013, contracts made with the several LPS and carriers, activity drivers, budgeted and actual expenses en 2013, regulatory knowledge (collected by the affiliates) and regulatory guidelines which frame the distribution of pharmaceutical goods. Then, the analysis of the collected data provided insights of the current situation, which was used as a foundation for the AS-IS scenario (Chapter 3). After that, different scenarios were developed by tuning the AS-IS simulation’s set up. These scenarios helped to identify opportunities to improve the network set up in terms of decreasing costs while improving or maintaining its service level (Chapter 4). Finally, the actions towards improvements were analyzed, as well as the tradeoffs involved in each case. The decision to implement one or more changes is left to the company managers. For this study this decision and further actions are out of scope, due mainly to time constraints which restrict the availability of relevant data.
1.3 The structure of the thesis

This brief introduction is followed by Chapter 2, where the problematic statement is described. There are also explained the ideas behind the development of their Pan European Distribution project. Within the same chapter, the link between this master thesis and the PAN European project is explained; as well as the expected outcomes of it. Further on, Chapter 3 focuses on the analysis of the current situation of the company in order to develop a mathematical model to simulate it. Later, the IBM ILOG LogicNet Plus (2011) was used to simulate and analyze the behavior of current set-up (AS-IS situation). Chapter 4 provides information regarding the opportunities that Amgen has for redesign and provides insights of how different modifications to the AS-IS situation could affect the expected behavior in terms of service level. Finally, Chapter 5 contains the conclusions and recommendations of this report as well as guides for further research. Additionally extra graphs, figures and tables that support the analyses performed throughout the study are attached at the end as appendixes. Some appendixes contain sensitive information for the company with confidential character; and therefore those have been removed from the public version of this Master Thesis.
The objective of this chapter is to clarify the link of this research project with the specific needs of the company, state the problematic situation on which the project is focused and detail the framework and approach followed for its development. Thus, it is composed as follows: the first section provides an overview of the problem perceived by the company. Later on, Section 2.2 describes the Pan European project initiative. Afterwards, Section 2.3 describes how this project is linked with the Pan European initiative; and its general framework.
2. Problem statement

2.1 Perceived problem
Amgen’s current distribution in Europe is built up upon a Distribution Center (further referred to as ABR), located in The Netherlands; and 12 outsourced locations across EU managed by Logistics Service Providers (LSPs). Roughly 20% of customer shipments are done directly from the central hub and the other 80% via LSPs.

The company wanted to explore the latent opportunities to redesign and optimize its current distribution footprint by selecting a number of regional DCs that could serve Amgen customers in one or more countries. With this action is expected a decrease in the number of total hubs intended to serve the European region. Figure 2.1 shows Amgen’s envisioned concept of its future European distribution landscape.

Another standpoint of the problem experienced with the current network has to do with the manageability of the parties involved in the distribution process; namely the number of different LSPs. Nowadays, Amgen is working with ten different LSPs to cover the European region, some of them have presence in several countries around Europe and some others are

*The location of hubs shown both images are arbitrary; only placed for explanatory purposes.
local parties (only have presence in a certain country). This set up stops Amgen from attaining a better negotiating position in respect of its contracts. Since the volumes managed are divided among all the different LSPs involved, leaving the company with smaller volumes to negotiate with each partner. Also this situation brings complexity in terms of manageability of the LSP, going from contract management, standardization of processes among all the parties involved and communication issues.

In summary, there is a need of assessing current distribution network’s capabilities and its opportunities for improvement by reducing the number of DCs following a regionalization strategy. Also, as a second objective, the reduction of parties involved in the distribution (LSPs) must be considered. Of course, any action has to be focused on reducing operational costs while sustaining or increasing the service level on deliveries and overall the legal and strategic frameworks of the business have to be considered.

2.2 Pan European project
The Pan European aims to work with the more developed LSPs within Europe in order to give a solution to the problematic situation already explained in the section above. There are two ways in which the company can be beneficiated. The first one is by reducing the number of local LSPs and instead partnering with the most mature pan-EU LSPs present in Europe. The second one is to bring consignment from a central location to regional DCs, improving the service level and optimizing the replenishment loads. It is important to keep in mind that Amgen does not own any DC except from the ELC, nor want to own more in the nearby future. Therefore all the possible hubs recommended for improvements, have to be already existing hubs managed by the LSPs considered for this project. Complementary information in regards to the planning of this initiative can be found in Appendix II [Confidential].
The expected advantages are: reduction in the lead times, freight cost reduction (domestic transport vs. parcel) and a release of storage space at ELC (ABR). As for the disadvantages, there can be an increase on the costs of inventory carrying at regional DCs.

In brief, the Pan European project looks for the opportunities offered by working with Pan European LSPs (pre-chosen service providers) instead of local partners, such as DC rationalization and a decrease in the number of partners involved in the network. And later, use those opportunities and to create a strategy from which the company can be benefited in terms of operational efficiencies, cost savings, risk mitigation, partnership, umbrella contracts and/or incentive based contracts.

2.3 Research project
This project aims to support the Pan European initiative providing an analysis with an academic approach by evaluating the Amgen’s current European distribution network set up and its improvement opportunities. The expected outcomes are several analyses which describe the current situation, a model able to simulate the current distribution behavior, a set of scenarios designed to test the tradeoffs of modifying the current setup and the recommendations and insights regarding the existent opportunities to improve the distribution network. The tools selected for this study are: Microsoft Excel (2010) and the IBM ILOG LogicNet Plus (2011), since its combination provides a convenient and manageable way to deal with the relevant relations existing though the supply chain analysis.

So, the aim of this research project is to extend the analysis of Amgen’s Pan European LSPs initiative, and lead to a more robust decision making process for Amgen’s management in this regard.
3. AS IS situation

In this chapter is described Amgen’s current distribution network. This was done in order to find out where room for improvement is; also it was used as a benchmark for a later comparison with the improvement proposals (tuned scenarios). Thus, this chapter is composed as follows: Section 3.1 focuses on introducing the products, including their special transportation requirements. Then, in Section 3.2, are explained the types of customers managed by Amgen and the differences among them. Section 3.3, shows how the demand is distributed around Europe in terms of customers. In Section 3.4 details the regulations which frame the distribution setup. Furthermore, Section 3.5 shows how Amgen is currently fulfilling its demand, which LSPs are used in each region and an analysis on the costs, service levels and CO₂ emissions generated by such set up.
3.1 Products
Amgen creates products targeted for five critical areas: nephrology, oncology, inflammation, bone diseases, and neurology. Appendix III [Non confidential] shows that in 2013 it was perceived an increase on the number of sales. And according to Robert A. Broadway, this growth is expected to continue in the long run (AMGEN, 2014). Next to that, the company is expecting to launch six biosimilars by 2017, and to expand into the Asian markets by 2020; this means that the numbers of products handled by ABR are expected to grow (AMGEN, 2014).

Another consideration to be done has to do with the specific handling and distribution requirements needed by the products. More than 90 % of the products managed by Amgen have cold chain requirements; which means that they require to be transported and storage within temperatures of 2-8°C. A detailed division of the products, its usage and its requirements can be accessed in Appendix III [Non confidential].

3.2 Customers’ analysis
Amgen manages mainly four types of customers: wholesalers, distributors, hospitals, and retail pharmacies. The differences among the customers are perceived in terms of the distribution structure that is used, namely: direct or indirect; the volumes transported, the service level demanded and the legal distribution requirements that need to be fulfilled in each case.

The first segmentation of clients has to do with the clients that are being served via LSPs and the ones that are served in a direct way from ABR. In the next section this segmentations is going to be deeply explained.

In terms of volume, the wholesalers normally demand higher volumes than the ones demanded by a retail pharmacy. Considering the average packs per order demanded by the different customer groups during 2013, it can be said that the wholesales request almost five times more products than a hospital, per order. Of course those quantities also differ per country. For more detailed information about these numbers refer to Appendix IV [Confidential].
Another important aspect to be considered is the use of Logistic Service Providers within the distribution network of Amgen. Normally the LSPs are managed under activity based contracts. This means that Amgen agreed to pay a fixed amount of money to a LSP every time it performs a certain task. For example, when considering the task of order delivery: Amgen will pay the same amount of money if a LSP delivers an order of fifty products to a wholesaler than if it delivers an order of three products to a pharmacy. Thus, under that scheme, delivering to pharmacies results in higher costs than delivering to distributors, due to the higher frequency and lower quantity managed by those clients. The situation gains complexity, considering that not all LSPs work under the same units and terms (further explanation on the management of LSPs can be found in Section 3.5).

Likewise in terms of local regulatory affairs, inherent to each country, there are restrictions that can affect Amgen network’s setup in Europe. Depending on the country, if a product is going to be distributed to local hospitals and/or retail pharmacies, the local quality regulations demand the manufacturer to perform certain GDP activities, ensuring the control of the products that are being distributed to the market within that country. It means that in some countries the delivery to hospitals and pharmacies leads to the need of a warehouse within the country. These regulations play an important role in the set-up of Amgen’s distribution network.

Furthermore, the type of customer also plays a role in terms of delivery lead times, by instance it is easier to negotiate longer lead times with wholesalers than it is with hospitals or retail pharmacies. But lately it has been experienced a common trend in the pharmaceutical environment, where the companies prefer to work with hospitals and pharmacies since they are closer to the customer and also the prices managed leave a better margin (Kanavos., Schurer & Vogler,2011).). An additional analysis in terms of the distribution of customer groups per country can be accessed in Appendix V [Confidential].
3.3 The structure of the distribution network

Amgen manages the distribution of its products to the final customers in as Figure 3.1 depicts. By analyzing the flows, it is perceivable that in all the possible distribution scenarios the product has to pass through either a pharmacy or a hospital to reach the patients. Also, it is perceived the existence of three types of flows in terms of control over the distribution in the network; direct, indirect and lack control in the distribution flows. For instances of this project, only the direct and indirect flows were considered; this because those are the flows can be measured and changed easily by Amgen. The attention in the selection of the variables related to the costs and delivery times was required, since those are related to economic savings and/or service level improvements, which was the ultimate goal of the project.

Focusing on the continuous blue lines, it can be identified the flows which are totally controlled by Amgen. That means that Amgen is in charge of negotiating the contracts with the carriers used for those distributions. On the other hand, the red continuous line shows distributions flows in which Amgen has no control. For those instances, Amgen delivers the products to its customer (blue flow) and the later distribution of that product to the patient cannot be controlled, nor improved by Amgen (red flow). Moreover, there are the flows represented with an intermittent blue line, those ones are the distribution flows controlled by contracted Logistic Service Providers. Those flows are indirectly controlled by Amgen, but with limitations. By instance, they allow Amgen to select in between an active or a passive solution, or the service level required: pre 10 am, next business day, 1-3 days; but they don’t allow them to directly negotiate with the contracted carriers for that service. Also if an optimization process is handled for an indirect flow, the savings will be first perceived by an external party (wholesaler, distributor or LSP) and then depending on the agreement that Amgen has with each party, a part of the benefits will be perceived by Amgen.
Formerly, it was relevant to map clearly how Amgen is distributing to its products among its European customers (distributor, wholesaler, pharmacy and hospital). Referring to the location of its DC used for direct deliveries and the DC’s used for indirect deliveries.

Amgen serves Europe making use of 13 DCs, including ABR, managed by 10 different LSPs. Figure 3.2 shows the locations of the DCs. The main distribution center, also referred to as European Logistics Center (ELC), is represented in green. From there all the products are delivered to the rest of DCs (represented in blue) managed by the LPs, for its further transportation towards the final customer.
The demand of the products varies from country to country, but overall it can be stated that the demand for the whole Europe is on average around one million packs per month\(^2\). That estimate provides a frame to imagine the size of the volumes that are managed by the company on a regular basis. Nevertheless the demand is not evenly spread among all the European countries. As detailed in Appendix V [Confidential]: Figure 0.4 Distribution of Amgen’s demand in 2013 among Europe.

Recapitulating, the analysis shows that there are mainly five countries responsible of more than a half of the total demand. Then, considering that the countries are being served in a local scheme: having either an LSP delivering only in one country or having direct shipments departing from the ELC to a specific location, it leads to several low volume orders that need to be delivered to different locations. This situation leads to an increase of LTL shipments, translated into higher costs of transportation.

One of the common used practices in order to deal with the LTL shipments cost is to consolidate the different loads. The fact that the freight cost are directly related to the size of the shipment and the length of the haul, places a premium upon freight consolidation (Bowersox, D. J., Closs, D. J., & Cooper, 2010); also the awareness of LSPs towards the costs reductions derived from economies of scale, makes them keep on searching for ways of improvement (Zhou, Hui & Liang, 2011) enables the field for consolidation.

Consolidation is the process of combining different items, produced and used at different locations and times, into single vehicle loads (Figure 3.3). The logic behind the idea of

\(^2\) Taking the annual demand in terms of products for 2013 and dividing it per 12 months; considering that the demand is stable though the whole year – no seasonality-. (*Amgen Distribution data in EU and Turkey, 2014*)
consolidation is to take advantage of the lower transportation charges by handling larger load sizes instead of higher amount of smaller shipments (Hall, 1987). The topic of freight consolidation has been studied for a while. During the 70’s, it was seen as a way to achieve a reduction on transportation costs for shipments that represent less than a truck load (LTL), linked with the concept of economies of scale (Russell & Cooper, 1992).

Briefly, the main idea of using a consolidation strategy is to reduce costs, and sometimes even reduce the transit times. Those benefits are related to the demand’s volume and concentration.

However, if volume is not sufficient, or the customer is not willing to wait for an economic shipment quantity to ensue, then consolidation can be more expensive, longer and more variable than direct shipment (Russell & Cooper, 1992).

One crucial decision that needs to be taken in relation to consolidation is the release policy that is going to be followed. The decision is relevant because dispatching a vehicle with empty space (less than truck load – LTL) means, in practice, a waste of transport capacity. Thus, there are rules to decide when to dispatch a vehicle, release policy, and the most common policies are: quantity policy, time policy and the mixture time and quantity policy (Zhou, Hui & Liang, 2011). The first one, quantity policy, dispatches a vehicle when a certain quantity of product is reached by the accumulated freight quantity. The time policy releases the vehicle when a shipment deadline arrives. And lately, the time and quantity policy is a mixture of the previous behaviors; meaning that the vehicle is being released whenever a shipment deadline arrives or predetermined accumulated freight quantity is reached.
Another perspective that needs to be considered is the balance between the benefits and tradeoffs of consolidation. These ones can be summarized as Hall (1987) did in his paper “Consolidation strategy: Inventory, vehicles and terminals.” In the paper, it was mentioned that the main benefit of consolidation was the reduction of transportation costs on route segments. This reduction was obtained due to the increase on quantities of items per load as an action to reduce the number of shipments done. And the reason for which the carriers want to diminish the amount of shipments is that every time a vehicle is sent from one place to another, it incurs in fixed cost caused by driver wages, fuel and vehicle maintenance. Those fixed cost are nearly the same whether the truck is full or empty, thus it is less costly to send fuller vehicles less number of times, than a lot of almost empty vehicles; in terms of direct fixed costs.

By the other side, the mentioned reduction in costs should be weighed against the consolidation penalties inherent of the approach. Hence, inventory consolidation is usually connected to an increase in the number of items that must be stored before being transported (waiting to reach the minimum order quantity); which means an increase on inventory holding costs compared to an approach where the items are shipped individually. Likewise, it is not possible to achieve vehicle consolidation without driving adding extra stops in the normal routes transited by the vehicles; which means longer vehicle routes and travel times. Finally, in the case of having a terminal consolidation, it is needed to build or rent a terminal, sort shipments and move indirectly (out of their route); which is translated in extra costs of handling products, longer vehicle routes and longer travel times.

Concisely, it has been explained that the consolidation concept applied, allow carriers to take advantages of the principle of transportation economies of scale and employ larger and more efficient vehicles between terminals. On the other side, the disadvantages of using a consolidation approach are: the increase of distance to travel from the departure to the arrival point (whenever extra stops are added to the route), and the added costs for handling and storage the loads to be consolidated. There are decisive choices, in terms of efficiency, that
need to be taken when handling a consolidation approach, such as the release policy that is going to be followed and the consolidation points that are going to be used for a particular shipment.

In this case, the consolidation can be achieved by using regional DCs. The objective of these DCs is to gather the orders required for a region of countries in one single location, strategically chosen, to reduce the last mile distances to the final customers within that area. With this approach the orders can be delivered faster, improving the service level. Also, the company can make use of the economies of scale for the replenishment shipments done from the ELC to each regional DC.

Continuing with the analysis of the demand, it came out that three countries (France, Italy and Spain) were responsible for more than half of the total demand perceived in 2013 (Appendix VI [Confidential]). Considering this fact, the prior calculation which states that on average 885.785 packs per month are distributed within Europe, is not clearly showing how that demand is divided among the European countries. Then, an analysis of the distribution of the demand was done and the countries were classified in accordance to the percentage of the demand that each of them account for, four groups were created considering the cumulative percentage of demand that the countries within each group represent. Then, the group A (composed of two countries) represent almost 50% of the demand; while the combination of group A and B (composed of 8 countries) represent 80% of the demand. Thus, stating that 80% of the total demand of 2013 was due to 8 out of 32 countries involved in the study provides an idea of the disparity in terms of demand distribution among the European countries involved in region 1.

An insight gained by this analysis was that the countries of group A required on average fifty times more packs than the average number of packs required by group D within the year 2013. Those have to be considered when choosing the most appropriate distribution set up network to cope with the demand of each country or region.
3.3.1 Overview of the network distribution in Europe

The locations of the current DCs used by Amgen, as well as the countries to which the shipments are done in a direct or indirect way are shown in Figure 3.4.

This shows the location of the ELC (green pin), which is in charge of the direct distribution (customers located in the area colored in dark blue) and the replenishments done to the other DCs (red pins). Likewise, it is perceived the area of the indirect distributions; in other words, the one which distribution is covered by the DCs of the Logistic Service Providers (area colored in light blue).

Furthermore, in order to know how the demand is distributed in terms of customer type, a deeper analysis was performed (Figure 0.3 Customer profile per country: Appendix V [Confidential]), this time considering also the number of orders and number of packs (single units) demanded per type of customer. Such study clarified the nature of the demand. By instance, Italy turned out to have a hospital driven demand with 96% of the packs allocated to that customer type and the rest to wholesalers and pharmacies. On the other hand, Lithuania turned out to have a wholesaler driven demand, having 100% of the demanded packs allocated to that customer type, while the rest is due to distributors.
3.4 Rules of the game (The constraints of the network)

As it has been mentioned in the previous sections, the biopharmaceutical industry is highly regulated by different bodies; some of them include laws dictated by the governments of each country. These local regulations frame the way the distribution network can be detailed; by instance, knowing within which country the allocation of a permanent stock is required. For the development of this project, the local regulations as well as the distribution capabilities offered by the LSPs and contracted carriers limited the way the network was set up. Therefore in this section all the constraints for the network are listed and explained.

3.4.1 Current regulations

For the pharmaceutical companies it is extremely relevant to follow up and cover properly all the legal requirements that their products require within the different countries were they operate. The pharmaceutical environment is highly restricted and monitored to ensure that the quality and the integrity of the medicinal products are maintained during the entire supply chain from the manufacturer to the patient (EUROPEAN Comission, 2013), since the life of a human being can be directly affected otherwise. Without this control there would be plenty of ground for fake products to get in the market, there would not be an organism regulating the availability of offered products where necessary, nor inspecting that the drugs are produced and distributed under strict quality controls and the adequate conditions.

Nowadays, the main organisms that regulating Amgen’s operations are: the Food and Drug Administration (FDA) in the US and the European Medicine Agency (EMEA) in Europe. These because Amgen is an American company, therefore it has to fulfill the requirements stated by the US. But it also operates in Europe, being requested to follow also the European regulations. Besides these organisms, there are extra prescriptions and regulations stated by the European Union and some Member States of de EU including also their own local regulatory laws related to the distribution of the medicines within their countries. Taking as an example the topic of the licenses: it is required to have a license which allows a company to manufacture (manufacturing
license) and another one (wholesaler license) which allows the distribution of medicinal products. All these regulations control the way and quality with which the medicines are produced and distributed in order to safeguard the public health.

However, it is important to differentiate these licenses and the limits of their authority. According to the European Commission (2013), a manufacturing authorization can include a distribution authorization. Meaning that if a company owns a manufacture license, without need of an extra import license, it is entitled to distribute its products to all licensed wholesalers within the European Economic Area (EEA). The reason is that the countries within that area share an open market agreement. But, on the other side, it is not possible to perform manufacturing activities by holding only a wholesaler license.

In summary, there are two types of licenses relevant for this case; one is the wholesaler license which entitles the holder to distribute products to licensed wholesalers within the EEA. The other one, is the manufacturing license, which on top of the having the authorization provided by the wholesaler’s license, it also entitles the holder to perform manufacturing activities. Amgen’s ELC holds a manufacturing license; thus it is also authorized to distribute product to licensed wholesalers within the EEA.

Other regulatory guidelines that need to be followed are the Good Manufacturing Practices (GMP) and the Good Distribution Practices (GDP) (Figure 3.5). The GMP guidelines are focused on the way a product manufactured. They also set the quality standards that must be reached, safeguarding the high standard on quality that each pharmaceutical product requires for its future distribution.
Meanwhile, in accordance to the EMEA, the GDP guidelines were created to ensure that the levels of quality determined by GMP procedures were retained throughout the distribution network. Leading to a situation where the authorized medicines are distributed without any alteration of their properties.

The GDP guidelines should be implemented though a quality system operated by the distributor or wholesaler of medicinal products to ensure that:

- The medicinal products that they distribute are authorized in accordance with European Union (EU) legislation.
- The storage conditions are observed at all times, including during transportation.
- The contamination from or of other products is avoided.
- An adequate turnover of stored medicinal products takes place.
- The products are stored in appropriately safe and secure areas.

In addition, the quality system should ensure that the right products are delivered to the right addresses within a satisfactory time period. A tracing system should enable any faulty products to be found and there should be an effective recall procedure (European Medicines Agency, 2013).
### 3.4.2 Local regulations

Besides the US and European regulatory bodies and the GDP and GMP guidelines, in some instances, there are extra requirements settled by the local authorities. In some countries in order to perform a direct distribution to hospitals or pharmacies it is required to realize a local batch release (by a local QP-Qualified Person-) for the products distributed within the country. This stock must comply with certain specifications related to variety of products and quantities established by the local regulations in place. These extra requirements intend to satisfy in time the demand of that country at all time (avoiding shortages).

Furthermore, it has to be taken into account the license under which the products are being shipped from one place to another, from a taxation point of view. Since mismanagement in this terms can lead to an increase of costs due to the distribution network setup.

![Figure 3.6 Countries which require permanent local stock](image)

Figure 3.6 highlights the countries in which a local presence is required. Those countries were identified by the different affiliate’s regulatory affairs department of Amgen. A table with a further description of the reasoning followed to consider each of them can be accessed in Appendix VII [Confidential].

### 3.5 LSPs

The Logistic Service Providers represent an important party that should be further described, since its services and footprint can also frame Amgen’s distribution network set up. Since Amgen does not own more DCs than its ELC (in the Netherlands) and it is not part of its future...
strategy to own any, then the location of the DCs used for its distribution network depends on the location where its selected partners (LSPs) are settled. Thus, the company can only choose the best location for a DC from the pool of options offered by its partners. But the location is not the only variable which has to be considered when choosing among the different Logistic service providers. The activities that each LSP is enable to do (due to the licenses they hold), the storage area that they offer, the degree of product traceability that they manage, if they have an Active Cold Chain solution (for products which need to be handled with a temperature range from 2 to 8°C), among other capabilities, must be assessed before making a final decision regarding which LSP to use, in each location and the customers it is intended to serve (local or regional DC). In this section it is going to be described the definition of a LSP as well as the variety of services that can be provided by them. Afterwards, the LSPs situation of Amgen is analyzed.

3.5.1 LSPs definition

A Logistic Service Provider (LSP) is an entity which performs the logistics functions on behalf of their clients (Panayides & So, 2005). In accordance to Forlound (2012) the LSPs offer services like transportation and warehousing, but also additional ones like order administration and track-and-trace can be also performed. The LSPs are differentiated according to their ability to find ways to accelerate the flow of materials and information along the supply chain, giving added values to their clients (Panayides & So, 2005).

To keep a track of the services offered by a LSP, it is important to measure its performance. And for doing so, the following actions need to be performed (Forslund, 2012):

- Select the performance variables to be evaluated
- Define the metrics that are going to be followed
- Set the targets that are expected
- Measure the ongoing performance in accordance to the metrics selected
- Analyze the results obtained and comparing them to the targets.
There is an extensive range of logistics performance variables that can be used. Some of them are: on-time delivery, costs, CO2 emissions, on-time shipments, flexibility and capacity utilization. The most commonly used are on-time deliveries and costs, but there is a growing trend to use also the number of CO2 emissions as an important discriminant variable (Fabbe-Costes, Jahre, & Roussat, 2009).

3.5.2 Overview of LSPs used by Amgen

Amgen’s distribution network is currently using ten different Logistic Service Providers among its European distribution network. Each LSP is accountable for performing different range of activities in accordance to the contract that it holds with Amgen.

The assortment of services provided by the LSPs are classified in term of their nature, placing the activities such as goods receipt or storing nearby the logistics operations category while the activities like invoice sending and cash collection, are placed closer to the customer facing spectrum. Figure 3.7 shows how Amgen divides the complete spectrum of activities which can be done by an LSP on its behalf.
Most of the LSPs contracted by Amgen perform the activities shown from goods receipt to delivery to customer. But some of them perform extra activities, increasing their spectrum from customer order taking to cash collection. A more detailed description of which LSP is providing which actions can be seen in Appendix VII [Confidential].

3.5.3 Cost per activity offered by the current LSP

Another important fact that has to be taken into consideration is the way each LSP charges Amgen for its services. There is a lack of standardization in terms of the way the company is charged for each service. The rates can be stated in terms of pallets, weight, number of orders; and also vary in terms of sourcing and delivery locations. This situation brings Amgen in a complex position when trying to compare the bids among the different LSPs that it is managing and the latent offers done by potential partners.

By instance, taking as an example the activity: “delivering to customers”, some LSPs manage different rates depending on the country of departure and country of reception, others can be more detailed and charge differently depending on the cities to which the order needs to be delivered. Another differentiation commonly done has to do with the volumes managed; some LSPs charge per box that is being handled, while others do it per pallet used or even per kilo transported.

All these distinctions must be taken into consideration when comparing the service provided by each LSP, because not always the high rates equals a high performance. Hence, it is important to have one standard measurement in order to have an easier overview of the current rates managed and compare it against the performance delivered by the respective LSP. Also, this allows an easier comparison among the current LSPs offers and latent opportunities provided by external parties. These comparative actions could help the company to seek for improvements in terms of LSPs management, which can be translated into cost reductions.
and/or service level improvements. They also deliver a better perspective, useful for future LSP’s contract negotiations.

3.5.4 Performance of current LSPs

Amgen measures the performance of its LSPs using the On Time and Full delivery metric (OTIF). According with the company records, it was perceived that in the last two years the LSPs have been delivering an overall good service (Appendix VII [Confidential])

In 2012 the OTIF was roughly 94%, having a really good performance in the month of April and going down in the following moths. On the other hand, the performance obtained in 2013 showed a great improvement from its prior year. In 2013 the OTIF was roughly 97%, having is peak of improvement on May of the respective year.

For Amgen it is vital to receive a high service level, since its means that its products are being received by its customers on the promised times and in the required quantities. Also, the OTIF includes the performance of other activities, such as order taking, invoicing and cash collection; so, the higher the OTIF scores, the best the activities handled by the LSPs on behalf of Amgen are performed.

3.6 Model of the Current distribution network setup

The company provided a report with the number of sales performed in the year 2013. This report included the location of the deliveries, number of products sent, and point of supply and delivery mode (via LSP or direct shipment). Together with the sales report it was provided a file containing the latest estimated of transportation budget spent in 2013 divided per delivery mode, LSP and carrier used. These two files provide the basis for the creation of the AS-IS
model. It was possible to create graphical models which illustrate the distribution flows easily by means of the IBM ILOG LogicNet Plus (2011). The tool also kept a constant track of the costs divided per party used, and areas of delivery and supply. The mathematical model, in which this simulation is based on, is available in Appendix VIII [Non Confidential].

After analyzing the data gathered, it was perceived that the costs charged by the LSPs vary mainly in accordance to three factors: the location (origin and destination of the delivery), the type of service used (delivery before a specific hour, or under a specific temperature range) and the type of customer which is receiving the shipment, that can be pharmacy, hospital, wholesaler or distributor.

The first differentiation, location of origin and delivery point, has to do with the distances that the shipment has to undergo. By instance, most of the LSPs charge different tariffs for the shipments delivered within the country in which their DC is located than they do when shipping to surrounding countries. Other LSPs perform a more detailed differentiation and charge differently depending on the city to which the delivery is made. For example, the LSP currently operating for Amgen in Spain charges higher for the shipments delivered to Toledo than to Madrid.

The second differentiation has to do with the type of service that the LSP is delivering. Each LSP has a variety of services to offer; those services can be distinguished in different terms. One distinction can be done in terms of delivery times offered, which is directly related with the service level delivered by the Amgen. For example a LSP can offer: deliveries pre 10 am, EOB (end of business day), 24 hrs. delivery or deliveries within a specific time range (i.e. 2-3 days). In this case the costs will vary depending on the type of service selected. Another distinction can be done in terms of the special conditions that are carried within each type of service offered.
For example the deliveries done under an active cold solution (ACC) are more expensive than the ones carried under an ambient solution.

Later, the third differentiation done is related to the type of customer which is receiving the shipment. Thus, for example the LSP operating in the UK for AMGEN, charges higher for the deliveries done to pharmacies than to the ones done to hospitals.

Hence, all the distinctions already described were considered when modelling the current situation of Amgen’s distribution network; mainly for the calculations of its cost.

![Figure 3.8 Distribution of AMGEN’s demand 2013](image)

Figure 3.8 shows how the demand is distributed among the European countries, within the scope of this research. The green dots represent a customer that was active during the year
2013, while the LSPs are represented in red. This overview provides a visual understanding of how the distribution network is settled in comparison to the clients’ distribution.

![Map showing direct shipments](image)

**Figure 3.9 Direct shipments done in 2013**

Figure 3.9 displays the direct distribution flows presented in 2013. In this image, the orange arrows are used to show graphically the origin and destination of a flow; thus all of these arrows have as starting point the ELC, located in the Netherlands.

As it can be perceived, there is a vast density of direct served clients located in the Benelux region, Germany, Austria, and Czech Republic. This result is in accordance to the customers profile that each of those countries have (Section 3.2). Assuming that it would make no sense to have a high amount of wholesalers and distributors operating in a small area; then must likely those countries’ demand is hospital or pharmacy driven. On the other hand, the flows going to Hungary, Poland, Lithuania and the Nordics, have less green points; describing how the demand of those countries is driven by the presence of warehouses or distributors, as explained in Section 3.2.
The relationship between the high density of customers and the type of customer that is leading the demand can be understood as follows: warehouses and distributors are players which later on will further distribute the products of the company. This implies that instead of distributing to several different pharmacies in a zone, the products can be delivered to a warehouse or distributor which will later spread them, among pharmacies and hospitals. Accordingly, this type of flows will be perceived as a small number of locations spread all over the studied area; i.e. Hungary. Opposite to this, stands the distribution of clients perceived in France which has high amounts of different clients standing next to each other.

Nevertheless, it can happen that in a country the amount of customers served is not too high, compared to the area covered by the country. In which case it will not be easily perceived which customer type is driving the demand. An example of it is Romania. By looking at the map it can be thought that the demand of Romania is driven by wholesalers or distributors, without a doubt. But then, looking at the customer’s demand analysis done in Section 3.2, it comes out that 52% of its demand is due to hospitals and 48% to wholesalers. Thus, both analyses should be used as a complement of each other before drawing any conclusion.

Later on, the flows of products distributed via the LSPs are depicted in Figure 3.10. In that image the black arrows represent the flows going from the ELC to the different warehouse locations of the LSPs, replenishments. Then, from that point each LSP is in charge of the distribution of those products to its intended customer. Hence, it is appreciated that countries like France and UK are mainly driven by the distribution to hospitals and clients, due to the high density of green spots appreciated in Figure 3.10, while the demand served by Lithuania, Hungary and Romania seems to be mainly driven by warehouses and distributors.
Based on the given information and the assumption that each order registered represents one shipment done, it was possible to calculate the number of shipments delivered from each DC to customers and from the main distribution center to both: LSPs and customers. This assumption was also used in some reports from the company and is based on the fact that each time an order is received it has to be shipped almost immediately, depending on the cutoff times, in order to meet the service level promised. Of course, in some cases (when the volumes of demand allow it) some consolidation of orders can be done, but it is constrain due to the need of track and trace each order. In general assuming that each order represents a shipment can be a good approximation for calculating the number of shipments done by each company and thus having a more certain approximation of the charges per product delivery (Appendix VII [Confidential]).
Later on, this information was used in the simulation of the AS-IS situation; and the reports that were generated after the running such simulation stated that the costs incurred by this network was closer to the numbers stated in Amgen’s Distribution Cost Actuals 2013FY report.

An additional insight gained by this simulation was the average weighted distance that each DC has in relation to the customers that it is serving (Figure 3.11). This information served as an input to calculate the average service level delivered in the current situation. The calculation was performed via the IBM ILOG LogicNet Plus (2011). This software is able to calculate the time in hours that it takes a product to travel from the ELC to each DC, and later from each DC to the final customer. These calculations are done first by obtaining the direct linear distance between two points (either ELC to DC or DC to customer) based on the given geocode of each instance. Then the
direct distance is multiplied by a factor to consider the existing deviations of the roads from a direct line. This factor can change among the different countries, but for this project it was assumed to be the same all over Europe and the factor used was 1.35 (average among the countries studied). Later, the obtained distance is divided by the average speed of the transportation mean used. It was assumed that the vehicles used traveled with a speed of 70 km/hr. As a result, the Figure 3.12 was obtained. It shows which percentage of the total demand can be met within the different time frames, departing from a DC of the network. For instance, it shows that almost 15% of the total demand can be reached within one hour, while more than 25% of the total demand can be reached within four hours.

With the last figure, some approximations in regards to the service level could be obtained. For example, if the service level specifies that the deliveries should be met within 12 hours, then the expected service level for the overall situation would be on average around 78%. While if the specified service level to be met was of one hour, then the service level would had fallen to less than 15%. In this case on average the service level expected to be meet is of 24 hours, giving an average service level around 94% for the overall situation.

Besides the service level and costs, it was also calculated an approximation of the CO2 emissions that the current network is accountable for, as an added characteristic for its later comparison.

As a brief background, it is mentioned in the Guidelines for Measuring and Managing CO2 Emission from Freight Transport Operations (Cefic, 2011) that the share of transportation activities represent about 20% of the overall EU Green House Gases Emissions, and it is expected to increase to 30% by 2020 if no action against it is performed. Also, considering that almost one third of these transport emissions are accountable to freight transport, and that the CO2 emissions account for 93-95% of GHG emissions from transport operations (Cefic, 2011).
Thus by reducing the CO₂ emissions on the freight transport, reductions on GHG emissions would be achieved and that action will lead to a decrease in the total EU GHG emissions share due to transport activities.

The production of CO₂ emissions is linked to the type and quantity of the energetic source used during the transportation activities. Also according to Demir Bektas & Laporte (2011), the quantity of fuel used can be optimized by controlling a variety of vehicle, environmental and traffic-related parameters, such as vehicle speed, load and acceleration. Driving under optimal speeds is not an easy task to fulfill; there are restrictions framing this context, i.e. speed limits within urbanized areas, traffic jam and other external issues like the condition of the roads to be transited, and even the weather conditions play a role in this regards (Dekker, Bloemhof, & Mallidis, 2012).

There are different approaches to measure the carbon emissions, depending on the available data for such calculation. The European Chemical Industry Council (Cefic) in collaboration with the European Chemical Transport Association (ECTA) developed two approaches to measure the CO₂ emissions of a process: the activity based approach and the energy based approach. The first one is recommended for the companies which have no direct access to energy or fuel consumption data, such as companies which outsource the freight transport operations. This approach is based on the mode of transportation, volumes shipped, distance travelled and a CO₂ emission factor in terms of volume per distance. The second one, the energy based approach, is more recommended for transport companies which have access to the records of energy/ fuel consumed in their transport activities. This is done following a formula in which the total fuel/ energy consumption is multiplied by an emission conversion factor depending on the type of energy/ fuel used (Cefic, 2011).

For this case, the activity based approach was performed. The CO₂ emissions were calculated in terms of distances, volumes and a CO₂ emission factor. The calculation was done using the IBM tool, and the data required for it was:
• Fuel Efficiency: The average fuel consumption for the each carrier, typically expressed in miles per gallon or kilometers per liter.

• Carbon Conversion Factor: The carbon dioxide emissions on average in kilogram per unit of fuel.

• % Carbon Responsibility Factor: The percentage of total carbon emissions from the carrier, which are attributable to the supply chain. If the responsibility factor is 50% and the vehicle emits 10 metric tons, 5 metric tons will be reported on the Carbon Footprint Report.

The fuel efficiency was calculated in accordance to the speed. According to the MEET (Methodology for calculating transportation emissions and energy consumption) the for diesel vehicles weighing less than 3.5 tones and managing speeds from 10-110km, the fuel consumption is estimated using a speed dependent regression function of expressed in Equation 1 (Hickman et.al, 1999). For this exercise, it was considered the use of the described type of trucks and following the assumption of an average speed of 70 km/hr the fuel consumption factor was calculated as follows:

\[
CO_2 = 0.0617(v)^2 - 7.8227(v) + 429.51
\]

Equation 1 Regression function to calculate the fuel efficiency

\[
CO_2 = 0.0617(70)^2 - 7.8227(70) + 429.51
\]

\[
CO_2 = 184.251 \text{ gr/km}
\]

The carbon conversion factor required by the software was obtained following the IPCC Guidelines (Eggleston & Walsh, 2002) considering that the transportation is done with diesel vehicles within Europe. It states that the CO\(_2\) emission factor is: \(3140 \text{ g CO}_2 \text{ kg fuel}\)

And in respect to the percentage of carbon responsibility factor, it was assumed a 100% from the replenishment shipments since these done are with only for Amgen products, without
sharing the transport with products from any other company. For the LSPs shipments, since there is no data available in regards to the truck utilization that the LSPs manage to distribute Amgen’s product, it was assumed that Amgen products was responsible for 10% of the emissions generated assuming also that each order done represents a trip from the DC to a customer.

The output obtained is shown in Figure 3.13. This figure shows that the total Carbon emissions within the network, considering only the transportation, are 1292.43 mtCO2. This quantity reflects a quick approximation to the actual number of CO2 emissions generated by the network, it has to be considered also it is not fully reflect actual emissions since factors like speed, weight of load, road inclines and other factors were left out of the equation (Maden, Eglese & Black, 2009). Also the assumptions done with the management of orders by the LSPs influenced a lot this number; for that reason and since Amgen has no control over that flows in terms of efficiency, it was given a major attention to the CO2 emissions generated only by the replenishments and direct distribution; which in this case was roughly 259,04 mtCO2.

This exercise is relevant since based on that Amgen could compare the current network with the proposed scenarios just by allocating an internal price per ton of CO2 generated by each option. This practice is being followed by several companies in the US for planning purposes, to evaluate their options. Companies like Exxon Mobil, Disney, Microsoft and Google, are some of the companies that have started using this practice. The reasons for doing so vary from preparing themselves for the expected future environmental legislation to getting an approximation of the value of future projects to guide investment decisions (The economist, 2013).
Figure 3.13 Carbon emissions for transportation AS-IS scenario

It has to be considered that the exercise was realized following the assumption of a constant speed of 70km/ hours managed though the whole network. This assumption affects directly the results displayed, thus Appendix X [Non confidential] shows a closer view to the effects of that assumption in regards with the CO2 emissions calculated and the average service level expected in the different scenarios analyzed in this and the following chapter.
4. Opportunities for redesign
In the previous section, was presented a model that represents the current situation of Amgen’s distribution network. This model is able to simulate the behavior of the current set up of AMGEN with an acceptable margin of error (less than 5 %), compared to the actuals expenditure file of Amgen for the year 2013. Thus, it can be used as a reference point for further analysis. In order to gain deeper insights in the way the setup is working and propose actions for its improvement, there were analyzed several scenarios. In the next section these scenarios, as well as its background, are explained.
4.1 Reducing the number of DCs

4.1.1 Overall reduction of DCs

In regards with the number of distribution centers which are part of the network, the current relation of number of DC and number of partners is positive; meaning that less number of distribution centers will mean a reduced number of partners. This reduction in partners can lead to a reduction of operational and managerial costs. On the other hand having less distribution centers will complicate the delivery times; perhaps making them longer and therefore reducing the service level delivered to the customers. Nevertheless, it also has to be considered that one of the main reasons for having several DCs has to do with the local regulatory affairs of certain countries. Therefore following these line of thoughts, the next question aroused: what would happen if Amgen handles its distribution only with ABR and the DCs that are requested by local regulations?.

For solving these doubts, a scenario was built in order to gain insights of the tradeoffs in terms of service level that would be experienced in the different countries by performing the European distribution based only using the DCs required by regulatory local affairs in addition to ABR.

The scenario, named RA_DC, used the same data that the AS-IS situation (from the year 2013), also it considered the same parameters of vehicle speed and CO2 emissions factor per liter of fuel, that were used in the simulation for the current situation. The major changes done were in terms of the DCs used. The RA_DC scenario did not consider as existing option the DCs which were not requested by RA. For example: the DC in France, Spain and UK were not considered.

Another difference between these two scenarios is that in the RA_DC was made an assumption related to the shipping costs from the DC to international markets (market outside the country where the DC is located). Since the actual data of those shipping costs was not available, it was consider that all the deliveries from a certain DC to an international market was 25% more expensive than the highest local quote for local inland deliveries. Thus, if the highest inland rate
of the LSP in Portugal was €1 per pack delivered within Portugal, it was considered that a pack delivered to Spain or France from that warehouse had a rate of €1.25.

Consequently, a new optimization run was performed and the results were compared with the costs and service level obtained in the AS-IS situation (Figure 4.1). For these comparisons, it was important to keep in mind the assumptions (mainly in terms of costs) that were considered for the RA_DC scenario, in order to avoid misleading conclusions.

As a result of this simulation the distribution of products changed from the AS-IS situation. The main changes that can be seen (Figure 4.1) are the increase of countries covered by a single DC (regional DCs). One example is the DC located in Portugal, which in the RA_DC scenario is also serving the customers located in Spain apart from the ones in Portugal. The DC of Switzerland delivers to Swiss and Italy, while the customers from Croatia, Slovakia, Slovenia and Austria experienced a change to an indirect distribution via the DC located in Hungary. Finally, the
distribution of products in UK and France changed to a direct distribution within the RA_DC scenario.

Since the products were delivered from different DCs locations in the RA_DC scenario, the delivery times from DC to customer and so the service level were altered. These changes can be appreciated mainly in the average time in transit from DC to customer of the DCs which cover extra customer locations in this new simulation: PT, HU, CH and NL. The most representative changes were appreciated in the DCs in Portugal and Hungary.

![Cumulative % of Demand](image1)

**Figure 4.2 Comparison of the average time to customers experienced from the DC in Portugal.**

![Cumulative % of Demand](image2)

**Figure 4.3 Comparison of the average time to customers experienced from the DC in Hungary.**

Figure 4.2 and Figure 4.3 show the changes experienced in the DCs located in Portugal and Hungary, respectively. It is displayed that in the AS-IS situation for Portugal, near sixty percent of the demand could be meet within a time frame of one hour; while in the RA_DC scenario less than 20% of the demand could be meet within the same time frame. For the DC in Hungary, it was perceived that in the AS-IS scenario the complete demand could be meet within one hour,
while in the RA_DC scenario it would take approximately ten hours to meet the complete demand of the customers. These changes could also be observed graphically by comparing images Figure 3.10 and Figure 4.1. In the case of the DC in Hungary, in the AS-IS scenario it was only delivering to customers located in the surroundings of the Hungarian DC, thus it is logical that these customers could be met within one hour. While in the graphical distribution of the RA_DC scenario (Figure 4.1), the DC of Hungary is delivering to a high amount of customers located not only within Hungary, but also in the surrounding countries; which makes sense with the average increase on time to customers that could be reached from that point.

Thus, by doing working under the RA_DC scenario settings, the time to customer of the countries that experience a change on their distribution structure, were affected. For this reason a closer attention should go to the countries were the service level was threatened to reduce. Since the service level is reduced when more products are not delivered within the promised time frame, it is vital to know the maximum time in transit that a product can have to maintain an on time delivery status. For the Italian market it is managed an EOB day delivery. The considering the cutoff time to be at 16:00, 2 hours for having the orders ready in a truck to be shipped and considering the deadline for the EOB service to be at 18:00; then it roughly means that the products have can roughly spend up to 24 hrs. time in transit to be considered on time.

A comparison between the times in transit from DC to customer that the Italian customers experienced is displayed in Figure 4.4. It is perceived that the AS-IS scenario scores higher service level that the RA_DC, which is expected since in the as-is scenario the customers are delivered from a local DC while in the alternative situation they are delivered from a DC in Switzerland. In regards to the service level, both scenarios are able to handle the 100% of the demand within 24 hrs. Thus it will be possible, from a service level perspective, to deliver the Italian market from Switzerland instead of using the Italian DC (decreasing one DC location).
Nevertheless, it still needs to be evaluated the feasibility of that option in terms of ability of the LSP in Switzerland to handle the demand in Italy. And also it is required an evaluation of the proposed rates that would be managed in that situation. By doing a quick analysis with the on hand data, it is perceived that the local rates managed by the current LSP in Switzerland are higher than the ones managed by the LSP in Italy. So even considering that the LSP in Switzerland will charge for the international shipments to Italy the same rates that it is charging for the Swiss market, it will imply an increase of more than 100% of the current costs incurred by the Italian LSP. Then considering that the costs are expected to increase and the service level is not showing an improvement, it is even getting tighter to the limits; this option would not be recommended to be pursued.

Another market which changes observed in the RA_DC solution caught the attention was Spain; the Spanish market is really sensitive since its delivery service is highly restricted. Amgen requires that the distribution to the customers located in Spain (inland) is handled with a pre-10 service, which will mean around 16 hrs. maximum of time in transit. By delivering the Spanish customers from Portugal, as suggested in the RA_DC scenario, this requirement is not met.
Then, it is not a recommended solution to be followed; unless the service level in Spain change; hence a further study about the tradeoffs and the possibilities to relax the service level managed in Spain for all or some of the customer groups (segmentation of the supply chain) is recommended. In section 4.2 a brief exploration in this regards is presented.

In regards to the costs incurred in the RA_DC scenario (Figure 0.12: Appendix IX [Confidential]), it was appreciated that the cost increased 21% in comparison to the AS-IS scenario. This number should not be taken as a straight forward increase in costs since some of the costs used in the calculation are not the actual cost managed by the parties involved, but a mere assumption (international shipment’s rates were considered to be 25% higher of the most expensive local inland rate). In order get additional insights about that increase it was done a supplementary exploration.

It was observed that the costs that showed the biggest increase were the ones associated to the direct deliveries, labelled as “plant to customer” (ABR is considered as a supplier plant for the different DCs and customers). Considering that, in the RA_DC scenario, the countries that changed from indirect to direct deliveries (plant to customer) were France and UK and that both handle a big amount of orders mainly to hospitals and pharmacies, it was decided to explore further the relation that those changes had with the increase of direct deliveries’ costs.

In order to test this relation, two new scenarios were created taking as reference the RA_DC scenario. In one setup all the customers located in France were set as inactive and in the other all the customers from UK were set as inactive. The result of these scenarios was that the one with the inactive UK customers provided a decrease of 12% in relation to the RA_DC setup. This means that direct deliveries to customers in UK represent a 12% of the costs from plant to customer observed in the RA_DC solution. On the other hand, the setup that considered the French customers inactive had a decrease of 58% in the pant to customer’s costs. This means
that the French deliveries account for 58% of the costs displayed in the plant to customer category of the RA_DC solution.

Thus, the insights gained from these tests was that even though it is possible from a RA perspective to eliminate the DC in UK and FR from the distribution network set up and deliver to both markets in a direct fashion, the costs of such actions must be evaluated beforehand since both markets have a big number of deliveries to hospitals and pharmacies; specially the French market. Also it has to be considered that the UK is currently offering special services: homecare that may also be affected if the DC in that place is removed and a direct delivery structure is settled.

In consequence, it is recommended to maintain the DC in UK and further asses the opportunities of improvements that can be reached with that DC. By instance the distribution to Ireland from the DC in UK instead than by ABR (direct distribution), as it is currently done.

![Figure 4.5 Service level comparison for the UK & IE markets](image-url)
This change was evaluated from a service level perspective and it was observed (Figure 4.5) that by distributing Ireland from UK the service level will improve, since the time in transit from DC to customer will decrease.

A similar study was performed for the DC in Romania. In accordance to the RA_DC solution, the LSP in Romania was covering only the distribution within the local market while the customers in Bulgaria were still covered directly; even though it is perceivable that a huge service level improvement could be done if the Bulgarian customers were served via the DC in Romania (Figure 4.6). This decision was done by the program because the optimization parameters were set to minimize the costs and the LSP in Romania happens to have really high costs in comparison to the direct distribution done from ABR to Bulgaria. This situation is due to the contract in place with the LSP in Romania, in which the rates are settled in terms of percentages of sales instead of a fixed rate per activity. Accordingly, it is recommended to try to negotiate a fixed rate per activity scheme with the same partner and compare that with other LSPs within Romania, considering also their ability to distribute to international markets (mainly Bulgaria).

![Figure 4.6 Service level comparison for the RO & BG markets](image-url)
Summarizing, in terms of cost it can only be stated that the increase on costs appreciated in the RA_DC scenario in comparison to the AS-IS is due mainly to an increase of small shipments performed from ABR to UK and FR, and to the assumptions regarding the costs of international shipments handled by each carrier and LSP. In order to have a more precise estimate in terms of costs it would be necessary to have the actual costs that each LSP and carrier will charge for the international deliveries and also to check the feasibility of that distribution; since it can happen that the LSP could not deliver products in some locations.

Additionally, in regards to the overall service level observed in both scenarios, it can be stated that the service level obtained by the AS-IS simulation is better than the one obtained with the RA_DC one. Figure 4.7 shows that with the network setup of the AS-IS situation more than 50% of the demand covered indirectly could be met from its respective DC within 4 hours (only transit times), while in the RA_DC scenario only near 40% of the demand could be met in the same time frame. It is noticeable that along the complete graph, the RA_DC solution stays always below the cumulative demand covered by the AS-IS network. This means that the AS-IS performs better than the RA_DC setup, in terms of overall service level.
Finally, in terms of CO₂ emissions it was seen an increase of 5% in comparison to the AS-IS scenario, but also the same increase was perceived in terms of distance. Then due to the assumption of managing a constant speed on the vehicles (since no further information can be accessed), the increase of CO₂ emissions is directly linked with the total distance covered. Hence a reduction in the total distance will also lead a reduction on the CO₂ emissions in this simulation. Nevertheless, it has to be pointed out that in reality this results can vary due to different factors, by instance the speed at which the vehicles are driven. Within the literature, authors like Eglese and Black (2010) state that the speed at which the vehicles are driven is a more determinant factor than the distance when estimating CO₂ emissions (Demir, Bektas & Laporte, 2013). And also a more precise estimate of CO₂ could be done with the actual data of the energy sources spent, but that data should be requested to the LSP and carriers.

4.1.2 Tradeoff of consolidating the products going to France with a surrounding DC.

Later on, more specific simulations studies were carried out; one of them related to the DC currently located in France. The question that aroused was: Is it possible to perform the distribution to France from one of the DCs located in the surrounding areas; namely: Netherlands, Swiss or Spain? And if so, which are the tradeoffs that have to be considered with each option.

In order to solve this question three new scenarios were created and compared between them and with the baseline (AS-IS) model. The analyses of the scenarios were managed with a focus on the service level achieved in each option, the costs are also seen, but cannot be strictly compared since some costs are based on assumptions due to the lack of actual information. The creation of these scenarios is aligned with the objective of decreasing the number of DCs in the current network. There is not a regulatory requirement for permanent stock to be held in France. Thus, the scenarios are considered feasible from a regulatory point of view.

Main Assumptions:

- The vehicles used to transport the products travel at a speed of 70 km/hr.
- One order is considered as one shipment
- Only the inland orders within France were considered
- All the orders have to be met within 22 hours to consider acceptable, in terms of service level.
- The demand can only be meet from one source. Thus it is not possible to deliver to France from a combination of the DCs in Spain, Swiss and the Netherlands because it would imply more managerial work related to product planning (differentiation of the products per DC).
- The DCs are able to deliver to France (Have enough fleet capacity and proper licenses).
- The costs allocated to the international connections; meaning from an external DC to France are charged on a basis of 25% on top of the most expensive (EOB) inland service provided within the country where the DC is located.

**Scenario 1a. Covering the demand of France from Spain**

As a first approach it was decided to fulfill all the demand of France from the DC located in Madrid, and observe the changes of service level that would be seen in that situation. The Figure 4.8 shows how the products are transported from the ECL to the DC in Spain, from where they are further distributed to the demanded locations in France. Due to this adjustment, it was expected to have an increase in the distances and therefore in the delivery times for the products going to France. Nevertheless, the main concern was to quantify the impact that those increases would have in the service level managed in France. The customers in France are delivered within an EOB service level, which means that an order realized today before the cutoff time, must be delivered tomorrow within office schedule. Assuming that the cutoff time is realized at 16:00 hours, that it takes about 2 hours to arrange the orders for being shipped, and that the EOB means that the products must be delivered before 17:00. Thus, all the orders delivered within 22 hours would be considered on time, and the deliveries made within that time frame would not harm the service level delivered in France.
It was compared the service level delivered of the proposed scenario, in which the DC located in Spain provide distribution services to the customers within France, versus the current situation where the customers in France are served from a DC in France. As Figure 4.9 shows, the delivery times are highly increased; i.e. within 10 hours less than 10% of the demand in France can be covered from the DC in Spain, while with the DC in France more than 80% could have been delivered within the same time frame of 10 hrs. As mentioned before, the service level of France would only be affected by those deliveries with transit time higher than 22 hours. The difference in service level was as follows: the DC in Spain could cover 85.75% of the demand on France on time; while the DC in France was able to meet 100% of that demand within 22 hours. Thus, considering the service level as a characteristic to discriminate between these two options, it can be stated that the better decision is to stay with the current DC in France for the distribution within that country.

**Scenario 1b. Covering the demand of France from Switzerland**

The same procedure was used to evaluate the option of distributing the demand of France from Switzerland. Figure 4.10 shows how the distribution of the French market is realized via the DC in Switzerland. And according to Figure 4.11, even though within some timeframes the AS-IS setup performed better than the proposed scenario; for example within 6 hours the DC in
France could meet near 50% of the demand while the DC in Switzerland could only meet less than 10% of it. Nevertheless in both cases 100% of the demand could be met within 22 hours. This result means that covering the demand of France from a DC in Switzerland is possible and the service level would not be affected. Therefore, a further analysis of tradeoffs related to the costs of each option should be realized, since on one hand this option can lead to a reduction of a DC but also it may end up with higher total costs due to all the required “international deliveries” from Switzerland to France.

![Figure 4.11 Comparison of delivery times from DC to customer AS-IS vs CH DC](image)

**Scenario 1c. Covering the demand of France from Netherlands**

The third and last scenario tested concerned with the distribution of products within France, is the one considering a direct distribution from the ELC to the French consumers. Figure 4.12 shows graphically how the distribution would look like in such scenario.

![Figure 4.12 Distribution of France from the ELC](image)

The comparison of the service level obtained with this scenario versus the one obtained in the AS-IS situation, is presented in Figure 4.13. In that graph it can be observed that the AS-IS situation perform
better than the direct distribution, in almost all the different time frames i.e within 12 hours the ELC could cover 60% of the demand while the DC in France could cover about 80% of it. But both options are able to deliver 100% of the demand within a time frame of 22 hours. Which means that the distribution of products to French customers can be realized from the ELC without affecting the current service level. Also it is recommended a more detailed analysis of this scenario in terms of costs to fully evaluate the tradeoffs of this option.

![Figure 4.13 Comparison of delivery times from DC to customer AS-IS vs CH DC](image)

### 4.2 Relaxing the service level in Spain

The service level delivered currently in Spain is a pre-10 am service. This service means that an order received today before the cutoff time must be delivered tomorrow before 10 am. Assuming that the cutoff time is at 16:00 and providing two hours for preparing the order and has it ready for being shipped; the transit time from the DC to the customer must be below 16 hours; to achieve an on time status. Nowadays the LSP that is in charge of the distribution of products in Spain offers Amgen a variety of services with different rates, and it happens to be that the pre 10 service is the most expensive one. Nevertheless, it is supposed to be a local standard and it is requested by the local hospitals and pharmacies. The wholesalers and distributors are getting the same service even though they do not request it. By relaxing the delivered service level, Amgen would have the option to contract a cheaper service (pre 13:00, or EOB), hence a general analysis of the implied savings was performed.
Based on the current contract of the LSP in charge of the distribution in Spain, and the distribution of the demand experienced in 2013, there were calculated the costs of managing a service pre 10:00 and a service pre 13:00. Later those quantities were compared and as a result it was obtained that by choosing a service pre 13 for all the customers in Spain; savings representing the 12% of the total LSPs cost for Spain could have been achieved during the whole year of 2013. Also it was calculated the impact that would have such relaxation in service level only for some customers; namely, wholesalers and distributors. The results were that 2% of the total LSPs cost for Spain could have been achieved during the whole year of 2013 by following this strategy. A detailed calculation is presented in Appendix IX [Confidential].
5. Remarks and conclusions

Within this chapter, the major remarks and conclusions obtained through the whole project are gathered and presented. The objective of this is to sum up all the ideas and guide future actions and research initiatives.
In accordance to the objectives of the study, one of the focuses was on reducing the number of DCs or the number of parties involved in the network setup. It was seen that the number of DCs is restricted to the regulations of the countries were the distribution is taking place; thus there is a minimum of eight DCs that have to be in placed just to cover the RA needs. This situation leads a small room of improvements in terms of diminishing the number of DCs. For this situation the alternative is looking for partners which can offer a similar or better service than the one in place in more than one country, thus diminishing the number of LSPs. With this approach the company would have to deal with less partners and it would help to standardize the metrics for performance and rates managed by the LSPs. Also it would set Amgen in a better position (higher volumes to a single LSP in different locations) to negotiate the contracts. Last but not least, it will ease the implementation of interfaces to increase the communication and transparency between the parties. In this line of study, it will be required as next step to compare the current LSPs among them and investigate if the one providing the better service is able to over more locations and if so, then a further analysis on the tradeoffs for that change must be performed.

In terms of the comparison between the LSPs, it was stated the lack of standardization in that process. This project provided a basis for doing such comparison; it provided an approximation of the average cost per pack for each country. This information in combination with the OTIF report can provide a useful perspective to compare the performance delivered by each LSP in relation with the rates that it charges. Also, it can be used as a basis for evaluating future latent opportunities presented as offers/ bids from external parties.

Another point to highlight is the high service level offered by the company, since it is another factor which restricts the number of needed DCs in the network. The best example of this is the DC in Spain, which is not required by RA but due to the high service level delivered to all the customer types in that country, it is mandatory to have a DC within Spain. It was shown with
the RA_DC scenario that a distribution of the Spanish market from the DC in Portugal is not a viable option. Amgen requires that the distributions to its customers located in Spain (inland) are covered within a maximum of 16 hours. With the regionalized solution in place in Portugal, this requirement is not met. This situation can change by relaxing the service level offered in Spain.

An approximation of the benefits that can be obtained with a segmentation of the customers’ service level in Spain was calculated. According to the demand data of 2013 and the current costs manage by LSP in charge of the distribution within Spain, savings representing 2 % of the total costs charged by the LSP could have been achieved by performing such segmentation on the service level delivered to customers; Specifically, remaining with the current level service for the retailers, while negotiating more flexible deliveries (EOB) with wholesalers and distributors, in this case pre 13 instead of pre 10 deliveries. Also it was showed that the savings would increase to 12% of the total costs charged by the LSP in 2013, if the relaxation was done for all the customer types. For this reason, a further research on the service levels established in Spain for the different customer types should be done. And later decide based on costs-benefits of maintaining or changing them, the next actions in this concern.

Additionally, it was shown that in the simulations the current setup provides a better service level than the proposed set up with only the required DC by RA (RA_DC scenario). This was due to the small and continuous shipments done to UK and France form the ELC. Nevertheless, the RA_DC provides a better overview of the regionalization opportunities that could be done using a DC in the locations where it is required by RA. It remains for future analysis the costs assessment of such regionalization options, since the data required (ability and costs for international transportation by the current and external parties located in the needed areas) was not available within the time frame of this project.
Three scenarios were developed to test the variation in service level obtained by handling the distribution to the French market from a DC located outside France. The locations tested were: the ELC, the DC in Spain and the DC in Switzerland. The simulations showed that if the DC located in Spain was used for fulfilling the demand of the French market, its current service level would decrease since the DC in Spain could only cover 85.75% of the French demand on time; while the DC in France was able to meet 100% of that demand within 22 hours.

On the other hand, it was showed that the DC in Switzerland as well as the ELC could be an option to cover the French deliveries, since the distribution from those lotions to the customers could be completely done within a time frame of 22 hours. This means that the current service level would not be decreased by choosing one of those options. Nevertheless, a further analysis in terms of costs involved in the distribution operations is recommended for these two scenarios; in order to have a better understanding of the tradeoffs that each of them involves.

Related to the CO₂ emissions, it was observed that the assumptions considered within the scope of this project, contribute to directly linking the CO₂ emissions with the total distance traveled. This means that an increase or decrease of distance travelled will produce an alteration of the same magnitude and direction in the number of CO₂ emissions produced by the network. This relation in reality is not lineal, since other factors have to be taken into consideration; such as speed, weather conditions, and inclination of the road, among others. For the scope if this project and due to the inaccessibility to detailed data about the transportation activities, the approximations done provided a quick idea of the state of affairs of the current network in terms of CO₂ emission. This measurement assists as a general attempt to measure the carbon emissions generated by the transport activities held by company.

Alterations in the type of vehicles, fuels and speed used, are not under the direct control of Amgen, since it does not perform the transportation activities by itself. Nevertheless, a closer
collaboration with its partners in these topics may bring further benefits for both companies. Changes such as usage of alternative fuels or eco efficient driving can impact the costs of transportation and bring a decrease of the carbon emissions generated by these activities. A further research in this concern should be done to analyze the tradeoffs of these actions; capturing the effects on costs, service level and environment.

Thus, the recommended actions for the company to follow are:

1. Perform a detailed costs analysis of the implementation of regional DCs as follows;
   a. DC Hungary supplying Hungary, Austria, Slovenia, Croatia and Slovakia
   b. DC UK supplying UK and Ireland.
   c. DC in Romania supplying Romania and Bulgaria

Since from a service level perspective, it is possible to maintain and in some instances even improve the service level currently delivered in the listed locations.

2. Perform a partial assessment of the market and cost related tradeoffs of:
   a. Distributing France from either Netherlands or Switzerland
   b. Distributing Italy from Switzerland [main focus on the security of items and the Italian market structure-]

3. Review with the sales department the feasibility of negotiating more relaxed lead times (pre 13:00 instead of pre 10:00) for the customers in Spain.

4. Start working closer with the carriers and LSPs towards ways to decrease the consumption of fuel which is mainly linked to the production of CO2 emissions. This reduction in fuel can be later translated in reduction of transportation costs, and even in better service level (if the reduction is done by optimizing the routes used).
References


IBM. (2011). *ILOG LogicNet Plus (Version XE 7.2)[Software PC]*.IBM.


Appendices

Appendix I [Non confidential]

Countries considered in the study, part of “Region 1”

<table>
<thead>
<tr>
<th>Country Name</th>
<th>Abbreviation used</th>
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Appendix II [Confidential]

Figure 0.1 Pan European project’s overview [Source: AMGEN- Pan EU LSP benchmark review]
Appendix III [Non confidential]
Figure 0.2 lists the distributions requirements per products as well as further information of its main function and the type of treatments in which they are used (AMGEN, 2014). There is shown that Sensipar (also named Mimpara in some countries) is the only product which does not requires to be transported though a cold chain solution.

<table>
<thead>
<tr>
<th>Product</th>
<th>Main function</th>
<th>Treatment for which it is mainly used</th>
<th>Distribution requirements</th>
</tr>
</thead>
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<tr>
<td>Epogen</td>
<td>Increase the number of Red Blood Cells (RBCs) in the body.</td>
<td>Patients with anemia due to Chronic Kidney disease.</td>
<td>Cold chain 2-8°C</td>
</tr>
<tr>
<td>Aranesp</td>
<td>Increase the number of Red Blood Cells (RBCs) in the body.</td>
<td>Patients with anemia due to Chronic Kidney disease.</td>
<td>Cold chain 2-8°C</td>
</tr>
<tr>
<td>Neupogen</td>
<td>Increase the number of White Blood Cells (WBCs) in the body.</td>
<td>Patients going through strong chemotherapy.</td>
<td>Cold chain 2-8°C</td>
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<tr>
<td>Neulasta</td>
<td>Increase the number of White Blood Cells (WBCs) in the body.</td>
<td>Patients going through strong chemotherapy.</td>
<td>Cold chain 2-8°C</td>
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<td>Enbrel</td>
<td>Block the protein called Tumor Necrosis Factor (TNF).</td>
<td>Patients with Chronic inflammatory diseases like: severe rheumatoid arthritis.</td>
<td>Cold chain 2-8°C</td>
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<td>Nplate</td>
<td>Increase the number of blood platelet in the body.</td>
<td>Patients with chronic immune thrombocytopenia (ITP).</td>
<td>Cold chain 2-8°C</td>
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<tr>
<td>Sensipar/Mimpara</td>
<td>It causes the parathyroid glands to release less parathyroid hormone (PTH), calcium and phosphorus.</td>
<td>For patients with secondary hyperparathyroidism (HPT) on dialysis</td>
<td>Ambient chain</td>
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<tr>
<td>Vectibix</td>
<td>Is a man-made version of an immune system protein, it binds to the Epidermal Growth Factor receptor (EGFR).</td>
<td>For patients with colorectal cancer</td>
<td>Cold chain 2-8°C</td>
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<td>Prolia</td>
<td>Helps to stop the development of bone-removing cells in the body (osteoclast).</td>
<td>It treats osteoporosis in women after menopause.</td>
<td>Cold chain 2-8°C</td>
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<tr>
<td>XGEVA</td>
<td>Helps to stop the development of bone-removing cells in the body (osteoclast).</td>
<td>Prevention of skeletal-related events in patients with bone metastaseses from solid tumors</td>
<td>Cold chain 2-8°C</td>
</tr>
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</table>
Table 0.1 Product sales detailed by product and geographic region

Table 0.1 shows the sales behavior observed in 2013 in comparison to the prior year. It can be observed an increase in the number of product sold for every product except for Aranesp which experienced a decrease of 6% in its total number of sales.
Appendix IV [Confidential]

Table 0.2 Distribution of demand per country and per customer type, according to the orders of 2013
Appendix V [Confidential]

Figure 0.3 Customer profile per country
Appendix VI [Confidential]

Figure 0.4 Distribution of Amgen´s demand in 2013 among Europe

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Source: Amgen Distribution data in EU and Turkey [part of the information for PAN European LSPs RFI]
Appendix VII [Confidential]

Figure 0.5 RA Requirements for Local Warehouses

Figure 0.6 Activities performed by each LSP

Figure 0.7 LSPs’ performance 2012

Figure 0.8 LSPs’ performance 2013

Figure 0.9 Overview of the replenishment costs for each DC
Appendix VIII [Non Confidential]

Mathematical model

The total transportation costs considered were composed as follows:

**Parameters**

- $Y_1$: Set of DCs available
- $Y_2$: Set of customer locations (points of demand)
- $R$: Set of DCs requested by local RA
- $P_i$: Cost of sending one product from ABR to DC $i$
- $D_j$: Demand generated from customers located in $j$
- $C_{ij}$: Costs of sending one product from DC $i$ to a customer located in $j$

**Decision variables**

- $X_{ij}$: Number of products sent from DC $i$ to a customer located in $j$
- $A_i$: Number of products sent from ABR to DC $i$
- $S_i$: 1 if DC is used, 0 if it is not.

**Objective function**

Minimize

$$Z = \sum_{i \in Y_1} A_i P_i S_i + \sum_{i \in Y_1} \sum_{j \in Y_2} X_{ij} C_{ij}$$

Subject to

1. $A_i - \sum_{j \in Y_2} X_{ij} = 0 \quad \forall i, i \in Y_1; \forall j, j \in Y_2$ (1)
2. $P_i = 0$ (2)
3. $S_i = 1$ (3)
4. $s_i = 1 \quad \forall i, i \in R$ (4)
5. $\sum_{i \in Y_1} \sum_{j \in Y_2} X_{ij} - \sum_{j \in Y_2} D_j = 0 \quad \forall i, i \in Y_1; \forall j, j \in Y_2$ (5)
Constraint (1) ensures that all the products sent to DC \( i \) are further distributed to the end customers’ locations \( j \); continuity of flows. For the direct shipments, ABR was considered as both supplier plant and DC, labelled as \( S_{ABR} \), consequently constraint (2) states that the costs involved in transporting from ABR to DC\(_i\) are inexistent and constraint (3) states that ABR is a DC always open, because there is always the possibility to send directly from there to the customers. Then, constraint (4) ensures that the DC requested by RA are being used in the network. Constraint (5) specifies that all the products shipped are only intended to meet the demand experienced, no extra shipments are done. For the binary variable it was used constraint (6) and for the no negativity it was used constraint (7).

\[
S_i \in \{1, 0\} \quad \forall i, i \in Y_1 \quad (6)
\]

\[
A_{ij}, X_{ij} \quad \forall i, i \in Y_1; \forall j, j \in Y_2 \quad (7)
\]
Appendix IX [Confidential]

Simulation outputs

AS-IS situation

Figure 0.10 Transportation Summary report of the AS-IS simulation

Figure 0.11 Time in transit of the network with only the requested DC

Redesigned situation

Figure 0.12 Transportation costs incurred in the RA_DC SCENARIO

Figure 0.13 CO2 emissions of the RA_DC scenario

Extra scenarios

Figure 0.14 Savings due to relaxation in the service level for Spain

Figure 0.15 Savings from relaxing the service level to WH and distributors in Spain
Appendix X [Non confidential]

Sensitivity Analysis (speed)

Since for the model it was considered an average speed and it was stated that the speed was linked with the carbon emissions generated when driving a vehicle, then a deeper analysis were performed to see how much the assumption of having a constant speed of 70 km/h could influence the results given in metric tons of CO2 per year. It was observed that the assumption of 70 km/h actually provides a lower estimate that the one obtained by assuming 50 km/hour; but higher that assuming 60 km/hour. The optimal fuel efficiency could be reached between 63 and 64 km/hr, thus the best results in terms of less mt tons could be obtain driving under those speeds.

Since the normal speed in the cities is between 50 to 30 km/h, having some cities changed to a limit overall the urbanized area of 30 km/h, then the emissions would be higher for the last mile deliveries. The expected variability of the actual emissions of the network versus the calculated by this exercise would be roughly 60 metric tons of CO2 per year.

![Figure 0.16 Comparison of mt Co2 emitted by different average speeds](image-url)
Scenarios Sensitivity

The assumption of 70 km/hour also has an impact on the expected time in transit, meaning that in some scenarios the service level can decrease to unacceptable levels when considering a 50 km/h speed.

Then an assessment regarding the impact of the average speed considered in the different scenarios was done. The following graphs show the expected service level achieved in the different setups.

Figure 0.17 Analysis of the speed assumption in ASIS

Figure 0.18 Analysis of the speed assumption in RA_DC
Figure 0.19 Analysis of the speed assumption in FR_ASIS

Figure 0.20 Analysis of the speed assumption in FR_NL

Figure 0.21 Analysis of the speed assumption in FR_CH
Figure 0.22 Analysis of the speed assumption in IT_ASIS

Figure 0.23 Analysis of the speed assumption in IT_CH