

# **Managing Product Life Cycle for Effective Supply Chain Strategies - Case of Pharmaceutical Industry in Morocco**

**Sophia Youssar**

AMIPS Research Team  
Ecole Mohammadia d'Ingénieurs, Mohammed V University  
Rabat, Morocco  
[sophia.youssar@gmail.com](mailto:sophia.youssar@gmail.com)

**Abdelaziz Berrado**

AMIPS Research Team  
Ecole Mohammadia d'Ingénieurs, Mohammed V University  
Rabat, Morocco  
[berrado@emi.ac.ma](mailto:berrado@emi.ac.ma)

## **Abstract**

Product life cycle is not often used as a tool of decision making in supply chain management. In the early twenty-first century, product life cycle management emerged as a new paradigm for manufacturing companies. It enables companies to manage their products across their life cycles from the earliest idea for a product until the end of its life. It helps a company to be in control of its products across their life cycle. The consequences can be serious if a company loses control as it might affect both the customer and the company itself. In this paper, we present the impact of product life cycle on supply chain management. We use the case study of pharmaceutical products to underline this impact.

## **Keywords**

Supply chain management; product life cycle; pharmaceutical industry; supply chain strategies; therapeutic class

## **1. Introduction**

There is no single definition of supply chain management. According to Chopra and Meindl (2007), a supply chain incorporates all parties involved, directly or indirectly, in fulfilling a customer request. It includes the manufacturer, suppliers, transporters, warehouses, retailers and even customers themselves. Christopher (1992) defines the supply chain management as the management of upstream and downstream relationship with suppliers and customers in order to deliver superior customer value at less cost to the supply chain as a whole. American Production and Inventory Control Society (APICS, 1990) define the supply chain as the processes from the initial raw materials to final consumption of the finished products linking across supplier-user industries. A supply chain involves the constant flow of information, product and funds between different stages. It may imply that only one player is involved at each stage while in reality, a single manufacturer can receive product from many suppliers and at the same time supply many distributors. In this sense, most supply chains are actually networks (Chopra and Meindl, 2007).

There is a close connection between the design and management of supply chain flows and a success of a supply chain. Supply chain design, planning and operation decision play a significant role in the success or failure of a firm. The objective of the supply chain is to maximize the overall value generated and to improve the entire process rather than focusing on local optimization of particular business units (Chopra and Meindl, 2007; J. Heikkila, 2002).

For any company to be successful, its supply chain strategy and competitive strategy must fit together. We call it the Strategic Fit, meaning that both the competitive and supply chain strategies have aligned goals. To achieve strategic fit, a company needs to ensure that its supply chain capabilities support its ability to satisfy the targeted customer segments. Chopra and Meindl (2007) outline three basic steps to achieving this strategic fit: 1. Understanding the

Customer and Supply Chain Uncertainty: it helps the company define the desired cost and service requirements from the one hand, and the extent of unpredictability of demand and delay the supply chain must be prepared for on the other hand, 2. Understanding the Supply Chain Capabilities: the second step in achieving strategic fit between competitive and supply chain strategies is to understand the supply chain and map its responsiveness spectrum, 3. Achieving Strategic fit: the company need to restructure the supply chain to support the competitive strategy if a mismatch exists between what a supply chain does particularly well and the desired customer needs. To retain strategic fit, supply chain strategy must be adjusted over the life cycle of a product and as the competitive landscape changes. In fact, it is needed to adjust supply chain capacities in different life cycle phases. It gets complicated when we have multiple products.

The rest of this paper is organized as follows: we present the supply chain management in pharmaceutical industry and its interaction with product life cycle. In section 2, we give general analysis of the product life cycle. In section 3, we present the particularity of the supply chain management in the pharmaceutical industry and the actors in Morocco. We provide as well an illustrative example of the pharmaceutical products in order to reflect tendencies in product life cycle. Finally, we introduce a framework to tackle the supply chain management the pharmaceutical industry taking into consideration the changes in product life cycle.

## 2. Descriptive analysis of product lifecycle

The life cycle of products is a major concern in business all over the world. During the last decades, the product life-cycle has been used in business strategies such as research and development, marketing and supply chain management. Product life cycle is generally composed of four stages which can be judged by transition of sales. The product life-cycle views the life of certain products from the marketing perspective. The advancement of research and development is the driver of creating new products. Customer demand is very volatile and product life-cycle is shortening dramatically (Higuchi and Troutt, 2008).

Doyle (1976) demonstrated the four stage model for the product life-cycle: the introduction period, the growth stage, the maturity period and the decline phase.

Christopher (1992) advocates the five stage model: introduction, growth, maturity, saturation, and decline phases.

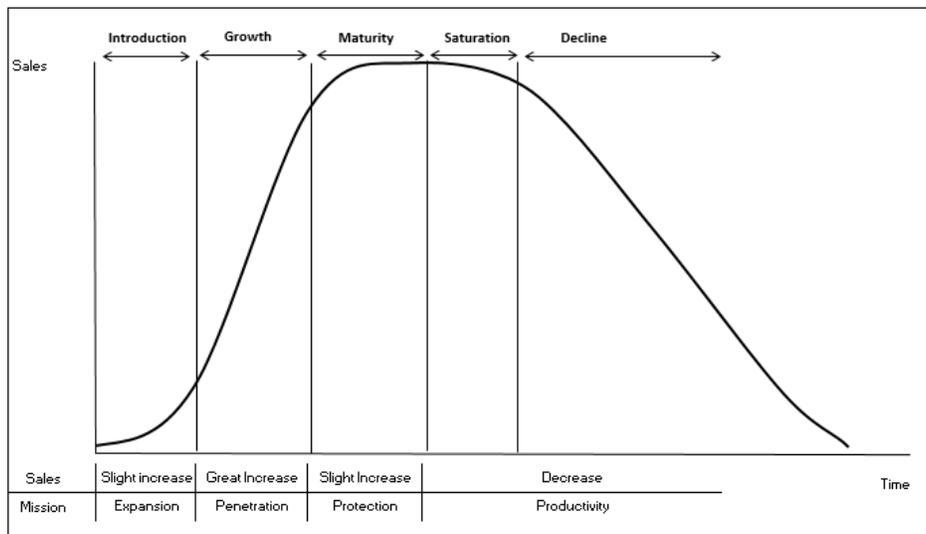


Figure 1. Life cycle pattern based on sales (inspired from Doyle, 1976 and Higuchi and Troutt, 2008)

When a new product is first launched in the market, sales are low and increase very slowly since the product is unknown and unrefined. In this stage, there is no proved demand and low awareness of the product in the market. It is called the “Introduction” phase (Fig.1). Companies spend an extremely important amount of money on the manufacturing facilities and promotion of the new product. In the growth stage, the demand begins to accelerate and the size of the total market expands rapidly because of the improvement and wide acknowledgment of products. It might also be called the “Take-off stage” (Levitt, 1965). In the maturity stage, the demand levels off and the

potential of further growth diminishes since the product has been widely diffused. In the saturation stage, the market allows no incremental growth and the demand starts to decline. Finally, in the decline stage, the amount of sales decreases rapidly (Higuchi and Troutt, 2008). The product must be managed in all these phases to make sure that everything works well, and that the product makes profit for the company (Stark, 2011). In the development stage, most new products don't have a classical life cycle curve. They have instead an infinitely descending curve.

Life cycles vary based on the objects of study. The duration of the phases varies from a market to another. Fisher (1997) introduces the concept of two types of products: functional and innovative products. The innovative/fashionable ones have a short lifecycle (from three months to one year), an uncertain demand and at the same time have high variety and high profit. The functional ones have longer lifecycle (more than two years), a small demand variance, a low variety and a low profit margin. Christopher and Towill (2005) developed the product classification system with five parameters: Duration of life cycle, time Window for delivery, Volume, Variety and Variability, with the acronym DWV<sup>3</sup>. Childerhouse et al (2002) apply the system to the supply chain management approach of their case company in the lighting industry. The product life cycle provides not only the basis for shaping the supply chain to suit particular marketplaces, but also incorporates the dynamic perspective needed in order to adapt to changing marketplace conditions (Wang, 2009). The dynamic product routing through its product life cycle is best supported by supply chain strategies ranging from "design and build" in the introduction phase, via "MRP" and "Kanban" in the growth and maturity phases, to "packaging centre" and "MRP" in the product's saturation and decline phases (Childerhouse et al., 2002).

From product life-cycle perspective, products can be grouped in three classes: the individual products, a series of products, and the whole category of products. We call a whole category of products an industry. The life cycle of an industry incorporates the life cycles of series and individual products (Higuchi and Troutt, 2008). In pharmaceutical industry, a series of products are called therapeutic classes and individual products are called pharmaceutical specialties.

In contemporary global market, organizations cooperate with other partners in a networked economy in order to be able to mass customize products to address different markets that could be approached with potentially different business partners. This requires support for the planning, management, and execution of the activities along the product lifecycle, whether they are collocated, distributed, across cultures, languages, continents, or time (Subrahmanian et al., 1997). Smarta (1991) suggests that the product profile of a pharmaceutical company should enable it to attain all or a few of these objectives; growth, survival, resource utilization, stability in sales, profit and return on investment, flexibility to adapt to changing customers' needs and profit. He points out that product policy and strategy affects a company's future significantly. The choice of products of a firm influences all the other elements in its marketing program and has significant implications for such functional areas as Finance, Production and Personnel. It gets more complicated when we have portfolio complexity with multiple products in different life cycle phases.

### **3. Supply chain management and product life cycle in Pharmaceutical industry**

#### **3.1 Supply Chain management in Pharmaceutical industry**

The pharmaceutical industry has an important role to play in society (Steele, 1962). It has produced breakthrough pharmaceutical drugs that have contributed to extending the average life span (Kuglin, 2016). Its importance come from its joint responsibility with the medical profession for the maintenance of health which, in itself, is a valuable asset, as well as being an important determinant of the productivity of human resources in the economy (Steele, 1964). According to Pattikawa (2007), there are two important goals that pharmaceutical industry is aimed to fulfill for society. First, it is in the benefit of society to improve competitiveness in the market for drugs in order to keep drug prices at a relatively competitive level. Second, it is in the best interest of society if the industry's technology advances at a reasonably fast rate.

When the world of pharmaceuticals was apparently simpler, the performance of supply chains received little attention. The absolute necessity was to develop a supply chain capable of producing test materials to be used for clinical trials for regulatory scrutiny. A successful completion of clinical trials and subsequent regulatory approval would then open the door to gross margins that were orders of magnitude greater than the cost to manufacture the drug (Rees, 2011). The results of such a mindset and the associated lack of attention led to the following being

common for supply chains in the industry: procurement policies and practices not focused on supplier performance, short-term tactical sourcing and outsourcing decision making, inflated inventories to protect against *any* lost sales, maximization of batch sizes to minimize cost per unit, extensive off-line testing and document checking and resistance to changing the status quo (Rees, 2011). This was an issue of cost and supply chain performance, but at the same time, the entire industry, through focusing on the regulator, did not connect sufficiently with their end customer in the way in which other sectors do routinely.

Over the years, many healthcare organizations got engaged in the activities of storing essential medicines, distributing medical necessities, and scheduling patient services without coordinating and synchronizing those activities (H. Min, 2014). We may end up buying medical supplies and pharmacies far more than we need, keeping obsolete medical equipment and archaic technology, and underutilizing healthcare workers as these activities are treated as separate organizational functions. Thus, the lack of connectivity among these functions can create inefficiency by duplicating organizational efforts and resources. To capture the synergy of inter-functional and inter-organizational integration and harmonization across the healthcare operations, we need to realize the strategic importance of planning, controlling, and designing a healthcare supply chain as a whole (H. Min, 2014). Most companies have, in their product portfolios, many products at different life cycle stages. Managing product life cycles in a global economy is a daunting proposition. Product life cycle management provides a framework in which all of a company's products can be managed together across their life cycles (Stark, 2011).

### **3.2 Pharmaceutical supply chain in Morocco and product life cycle management**

Healthcare services in Morocco are provided by combination of public and private entities. By law, the Ministry of Health assumes full responsibility for the provision of public medical and health services. Direction of medicine and pharmacy (DMP) governs the regulatory compliance of marketing authorization.

The distribution network of a pharmaceutical product in Morocco is organized in three main chains (figure 2):

- Drug manufacturers ensure the supply of the products to the different distribution channels: wholesale distributors, pharmacies in clinics or any other assimilated entities (defined in article 21 of the law 10-94).
- Wholesale distributors are authorized to ensure distribution to retail pharmacies, pharmacies in clinics or any other assimilated entities.
- The retail pharmacist is the last link of the distribution chain. He is in charge of dispensing the medicinal products to the public.

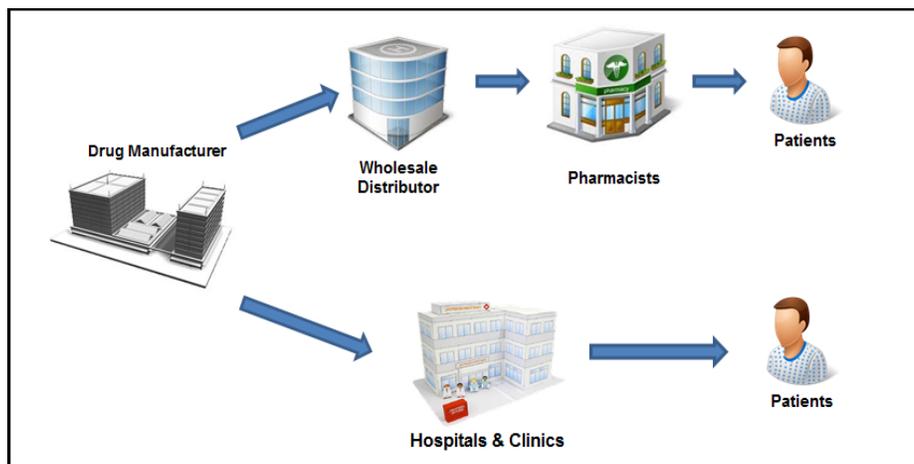


Figure 2. Distribution Network of Pharmaceutical Product in Morocco

These three main chains have the responsibility to ensure safety stock of the pharmaceutical products. Drugs manufacturers need to keep a safety stock which quantity is equivalent to the  $\frac{1}{4}$  of their previous annual sales of each pharmaceutical specialty.

This requirement might not be achievable in some cases for different reasons such as supply disruptions, unexpected demand, and product life cycle. If the product is on growth phase, keeping a safety stock equivalent to the  $\frac{1}{4}$  of the

previous annual sales will certainly lead to a stock out, while for a product on decline phase, keeping such level of safety stock might lead to write-off.

### 3.3 Statistics on actors

Most known multinational pharmaceutical companies are represented in Morocco in addition to local companies. In total, we count around 336. Each pharmaceutical company manage a portfolio of product mixed between therapeutic classes of an average of 130 products per company. These data have been calculated from IMS Health during the period 2011-2015. Brand-name drug products span a wide array of therapeutic classes (groups of drugs that are similar in their chemical structure, pharmacological effect, or clinical use); (CBO, 2006). The Anatomical Therapeutic Chemical (ATC) classification system and the Defined Daily Dose (DDD) are recommended by the World Health Organization (WHO) for drug utilization study. It serves as a tool for drug utilization research in order to improve quality of drug use.

In the Anatomical Therapeutic Chemical classification system, the active substances are divided into different groups according to the organ or system on which they act and their therapeutic, pharmacological and chemical properties. Drugs are classified in groups at five different levels. The drugs are divided into fourteen main groups (1<sup>st</sup> level), with pharmacological/therapeutic subgroups (2<sup>nd</sup> level). The 3<sup>rd</sup> and 4<sup>th</sup> levels are chemical/pharmacological/therapeutic subgroups and the 5<sup>th</sup> level is the chemical substance.

The Defined Daily Dose is the assumed average maintenance dose per day for a drug used for its main indication in adults.

Table 1. Number of products managed in Morocco per Therapeutic Class (\*)

<b>Therapeutic Class (Major subclasses)</b>	<b>Number of products</b>
Alimentary tract and metabolism	452
Blood and blood forming organs	240
Cardiovascular system	290
Dermatologicals	236
Genito urinary system and sex hormones	168
Systemic hormonal preparations, excl. sex hormones and insulins	40
Anti-infectives for systemic use	348
Antineoplastic and immunomodulating agents	47
Musculo-skeletal system	141
Nervous system	267
Antiparasitic products, insecticides and repellents	21
Respiratory system	230
Sensory organs	170
Various	94
<i>Total</i>	2 744

Source: data extracted from IMS Health for the period 2011-2015.

### 3.4 Challenges and problem definition

Unlike a typical market, the demand side of the drug markets consists of three separated divisions, namely consumers (patient), decision makers (doctors), and payers (health insurance); (Pattikawa, 2007). Pharmaceutical markets are extremely complex in many aspects. From the Ministry of Health perspective, several stock-outs are faced all along the year on essential medicines while a huge inventory is already available at the division of supply. Some of this inventory is stored until its expiry date with no consumption from patients. The Ministry of Health realized in the recent years that a total transformation is needed on its pharmaceutical supply chain management in order to serve the Moroccan patient and limit product losses. In this sense, the division of supply set up a reform project in order to redesign the entire supply chain processes. Considerable research efforts have been made to evaluate the performances (Chorfi et al., 2016), support strategic outsourcing decisions (El Mokrini et al., 2015),

optimize inventory (Mouaky et al., 2016), analyse risk (Elamrani et al., 2016) and drugs consumption (Serbout et al., 2016), design transportation network (Haial et al.; 2016) and select transportation suppliers (Laghrabli et al. 2016). In this paper, we give an illustrative example of product life cycle in pharmaceutical industry and we introduce a suggested framework in order to adapt supply chain strategies to the product life cycle.

### **3.5 Illustrative example of the importance of product life cycle in pharmaceutical supply chain in Morocco**

Through an example of a pharmaceutical product portfolio in Morocco, we analyze the challenges the product life cycle creates. The data used in this paper are issued from IMS health database which collect healthcare information spanning direct sales from retail pharmacists to patients / customers; per product, therapeutic class and even per drug manufacturer.

#### **3.5.1 Analysis of changes within C10A1 therapeutic sub-class:**

In our example, we analyze the C10A1 class of traded pharmaceutical products in the Moroccan market. The first letter C refers to the third group of the Anatomical Therapeutic Chemical which is the cardiovascular system. C10 refers to lipid modifying agents where the Defined Daily Doses are based on the treatment of hypercholesterolemia. C10A is for cholesterol and triglyceride regulating preparations. It includes all products regulating cholesterol and triglycerides only. Finally, the C10A1 stands for Statins (HMG-CoA reductase inhibitors).

We take the quarterly sales figures of five years from January 2011 until December 2015. The data provide 28 products from a mix of the eight following statins: Atorvastatin, Ciprofibrate, Fluvastatin, Ezétimibe, Pravastatin, Rosuvastatin, Fénofibrate and Simvastatin.

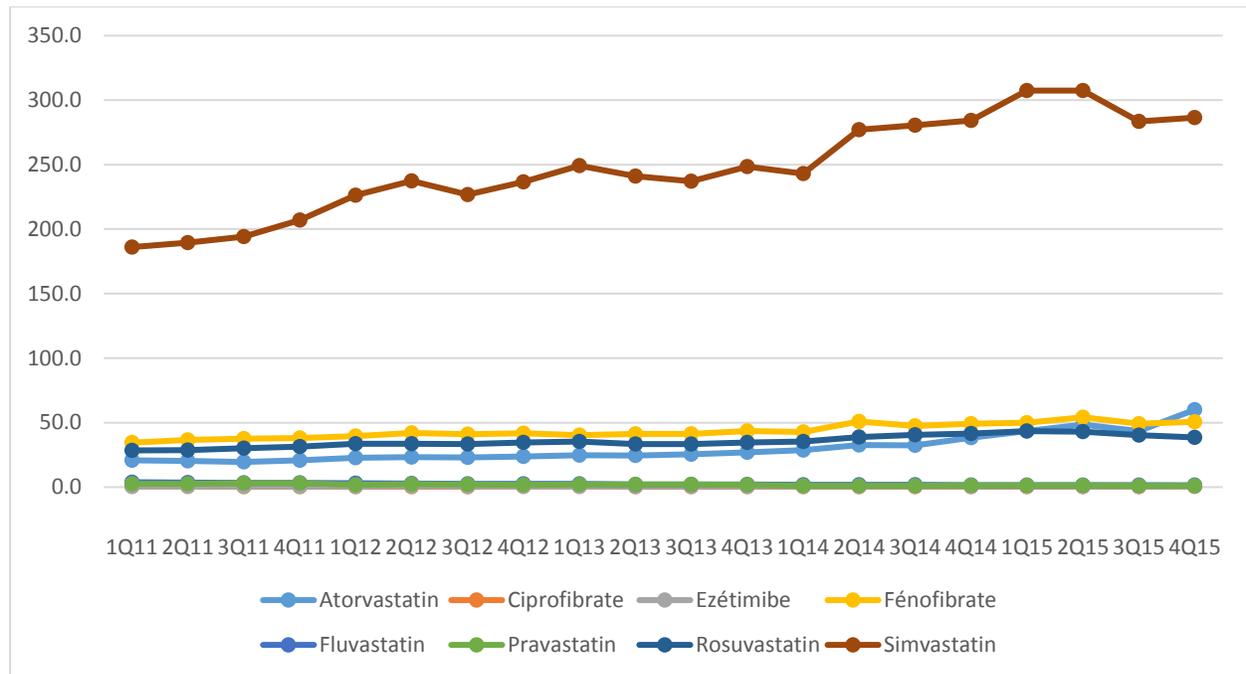


Figure 3. Quarterly sales figures of C10A1 class from January 2011 until December 2015 (in k units)

When plotting these quarterly sales of the 20 periods we follow for these 8 statins shown in figure 3, we notice that the Simvastatin is leading the market with almost 8 products in its portfolio. It is followed by the Fenofibrate who is sharing the market with the Fluvastatin and the Rosuvastatin. The remaining statins are observing low sales and are not competing with the Top 4.

In 2014, the pharmaceutical industry was impacted by a general price cut of all pharmaceutical products. This price cut was effective in May 2014. Therefore, the general demand on the market was too low in the first quarter of the year while in the second quarter we note a significant jump of sales. This change in consumption's behavior is shown in figure 3.

We have chosen to analyze best the product portfolio of the Simvastatin. Figure 4 is showing the quarterly sales for the 20 selected periods of the 8 products. Nocol® is leading the market while Staticol®, Civastine® and Redlip® are competing for the market share. The remaining products are sharing the rest of the market. We note that some products have been insensitive to the 2014 price cut and that the introduction of new generic products in the market like Simvacol® and Simvastatine Win® significantly impacted the growth of the others.

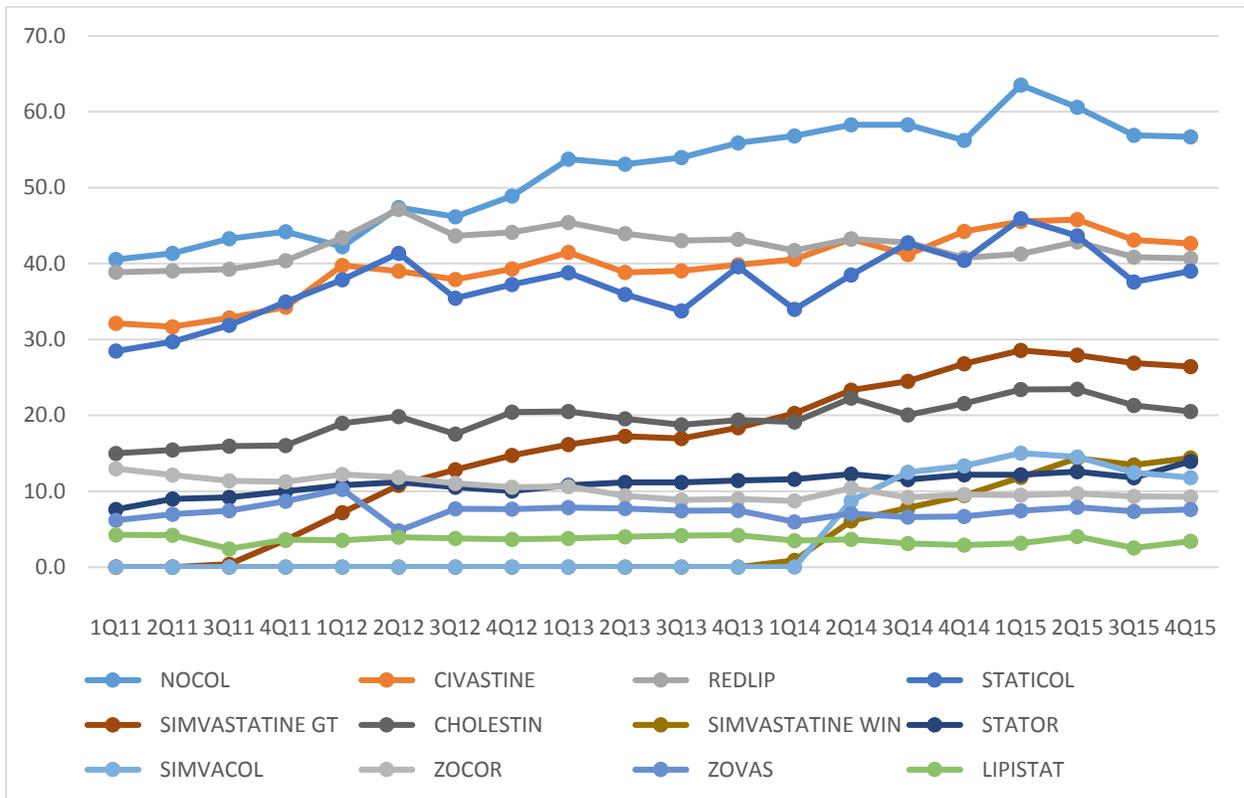


Figure 4. Quarterly sales figures of Simvastatin from January 2011 until December 2015 (in k units)

### 3.5.2 Analysis of changes between the major therapeutic classes:

In our example, we analyze the changes between the major therapeutic classes. Figure 5 is showing the quarterly sales for the 20 selected periods of the 16 therapeutic classes. We note the seasonality of N and R therapeutic classes. They are related to the products of the Nervous System and the Respiratory. In fact, patients recourse to this type of products between autumn and fall: season change for respiratory and blues (depression period) mainly for neurological pathologies. We note also the common sensitivity to 2014 price cut.

Taking into consideration the above examples of product behavior with the same therapeutic class and between the different therapeutic classes, we clearly come with the fact that the one size fits all strategy cannot be applied. Supply chain strategies need to be customized to each product taking into consideration many aspects such as price sensitivity (which is fixed by the Ministry of Health depending on the countries within the benchmark), type of product (princep/generic), product shelf-life, and patent and indications extension. In the following section, we introduce an approach in order to integrate the product life cycle management in supply chain decisions.

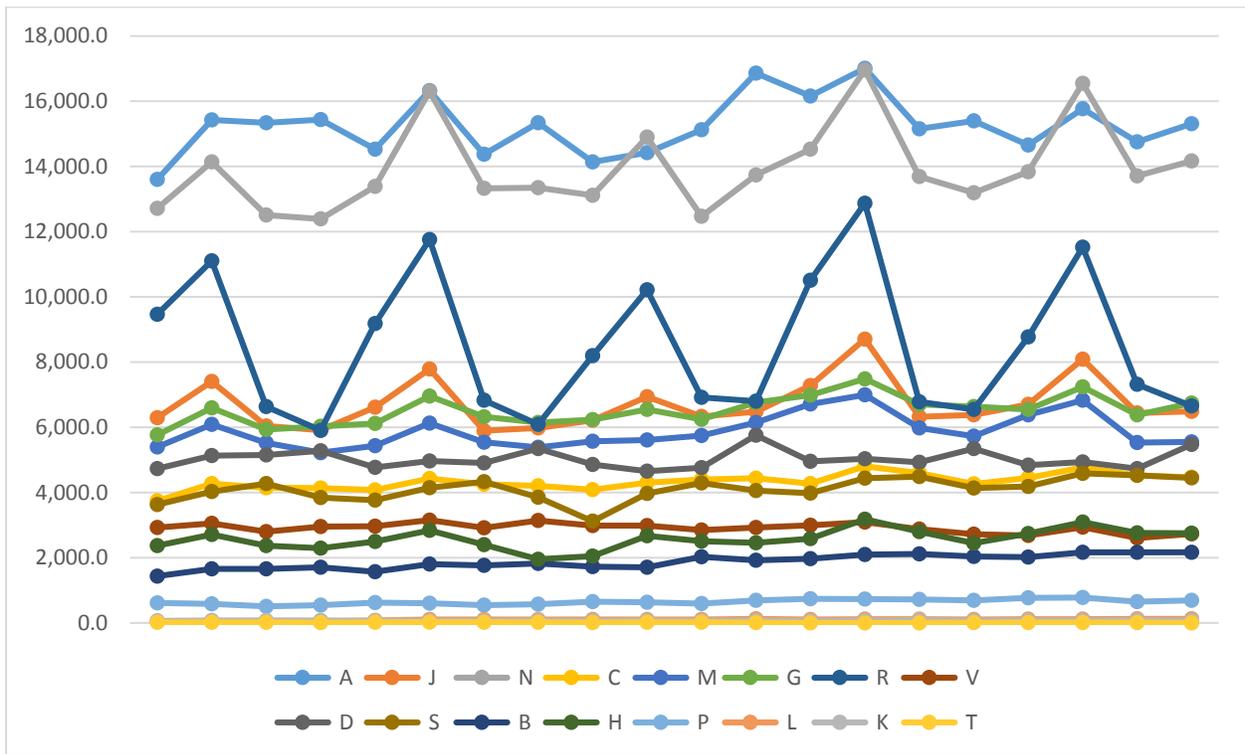


Figure 5. Quarterly sales figures of major therapeutic classes from October 2011 until September 2016 (in k units)

#### 4. Suggested approach to tackle this study

We suggest the following framework illustrated by figure 6. First, we begin by data collection and preparation. It is needed to gather all relevant information regarding the pharmaceutical products in Morocco such as the type of product (princep /generic), its launch date, existing worldwide competitors and annual sales volumes. Second, we proceed to a different classification of the products. We will not use the pre-classified Anatomical Therapeutic Chemical method, instead we will use some clustering methods. Clustering is a broad class of methods for discovering unknown subgroups in data. It is an exploratory data analysis. There is no universally accepted mechanism for performing cross-validation or validating results on an independent data set. Clustering looks to find homogeneous subgroups among the observations. The clustering can be applied in marketing for market segmentation purpose. There are two best-known clustering approaches: K-means clustering which partitions the observations into a pre-specified number of clusters and hierarchical clustering which provides a tree-like visual representation of the observations, called dendrogram. Through this clustering, we find collective change point detection what enables product life cycle prediction. Finally, based on the outcome of the clustering, we will define the supply chain strategies that most fit each life cycle.

A new approach has been developed recently in the extension of the product life cycle through the extension of the patent terms of drug approvals. The marketing authorization of the first generic product version is an important moment in a drug product lifecycle. Regulatory rethinking might be needed for a sustainable stimulation of extensions of indications in the post-generic period of a drug product lifecycle (Langedijk et al., 2016).

Yamakana and Kani (2016) conducted a survey in order to map lifecycle management activities for blockbuster drugs in Japan based on drug approvals and patent term extensions. From the perspective of drug approval and patent term extension, they have used a quantitative analytical framework that took into account characteristics of Japanese drug life cycle management (including multiple patent term extensions that can be obtained based on any drug approval). They obtained new findings regarding drug life cycle management in Japan. In particular, their survey revealed that patent terms of drug approvals were extended mainly during the growth stage.

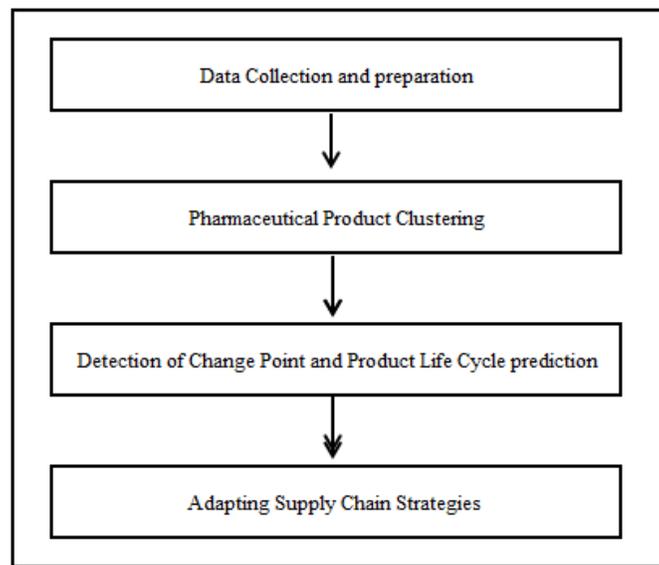


Figure 6. Suggested Framework to adapt supply chain strategies to pharmaceutical product lifecycle

They also divided drug life cycle management activities in the growth stage into three clusters and analyzed the characteristics of each to reveal that the drug approval-oriented life cycle management and the patent term extension-oriented life cycle management have been implemented since the late 1990s.

## 5. Conclusion and Future works

It is important to adapt the approaches of supply chain management using the product life cycle in order to best fit healthcare mission and actors's objectives. Supply chain strategies need to be customized to each product taking into consideration many aspects such as price sensitivity, type of product (princep/generic), product shelf-life, and patent and indications extension in a market in a context that most parameters are regulated by the Health authorities and might impact other countries. Future works can be done on challenging the Anatomical Therapeutic Chemical classification and suggest another clustering method that can best describe inter-class change and collective change.

## References

- Aitken, J., Childerhouse, P., and Towill, D., The impact of product life cycle on supply chain strategy, *International Journal of Production Economics*, 85: 127–40, 2003.
- Aitken, J., Childerhouse, P., Christopher, M., and Towill, D., Designing and managing multiple pipelines, *Journal of Business Logistics*, 26(2): 73-95, 2005.
- American Production and Inventory Control Society Dictionary, 9<sup>th</sup> edition, 1990.
- Childerhouse, P., Aitken, J., and Towill, R., Analysis and design of focused demand chains, *Journal of Operations Management*, 20: 675-689, 2002.
- Chopra, S., and Meindl, P., *Supply Chain Management, Strategy, Planning and Operation*, 3rd edition, Pearson Prentice Hall, 2007.
- Chorfi, Z., Benabbou, L., Berrado, A., A two stage DEA approach for evaluating the performance of public pharmaceutical products supply chains, *3rd International Conference on Logistics Operation Management*, 2016.
- Christopher, M., *Logistics & Supply Chain Management*, Pitman, 1992.
- Congressional Budget Office (CBO), *Research and Development in the Pharmaceutical Industry*, Congress of the United States, October 2006.

- Elamrani, A., Benabbou, L., Berrado, A., A model for classification of outsourcing related organizational risks in a pharmaceutical supply chain, *11th International Conference on Intelligent Systems: Theories and Applications*, 2016.
- El Mokrini, A., Dafaoui, E.M., El Mhamedi, A., Berrado, A., A decision framework for outsourcing logistics in the pharmaceutical supply chain, *International Conference on Industrial Engineering and Systems Management*, 2015.
- Fisher, M. L., What is the right supply chain for you product?, *Harvard Business Review*, 83-93, March-April 1997.
- Haial, A., Berrado, A., Benabbou, L., A framework for designing a transportation strategy: The case of a pharmaceuticals supply chain, *3rd International Conference on Logistics Operation Management*, 2016.
- Heikkila, J., From supply to demand chain management: efficiency and customer satisfaction, *Journal of Operations Management*, 20, 747-767, 2002.
- Higuchi, T., and Troutt, M., *Life cycle management in supply chains: identifying innovations through the case of the VCR*, pp 30-53, 2008.
- Laghrabli, S., Benabbou, L., Berrado, A., Multi-criteria decision aid model for transportation supplier selection: Case of a pharmaceutical supply chain, *3rd International Conference on Logistics Operation Management*, 2016.
- Langedijk, J., Whitehead, C.J., Slijkerman, D. S., Leufkens, H.G.M, Schutjens, M.D.B., and Mantel-Teeuwisse, A. K., Extensions of indication throughout the drug product lifecycle: a quantitative analysis, *Drug Discovery Today*, Volume 21, Number 2, February 2016.
- Levitt, T., Exploit the product life cycle, *Harvard Business Review*, November 1965.
- Kuglin, F. A., *A Pharmaceutical supply chain: Drug Quality and Security Act*, CRC Press, Taylor & Francis Group, 2016.
- Min, H., Healthcare Supply Chain Management: Basic Concepts and Principles, *Business Expert Press*, LLC, 2014.
- Min, H., Zhou, G., Supply Chain Modeling: past, present and future, *Computers & Industrial Engineering*, 43, Pergamon, 231±249, 2002.
- Ministry of Health, Texte de Loi 10-94: <http://www.sante.gov.ma/Reglementation/ProfSante/Documents/PROLIB96.pdf>, September 10, 2016.
- Mouaky, M., Berrado, A., Benabbou, L., A Kanban based system for multi-echelon inventory management: The case of pharmaceutical supply chain, *3rd International Conference on Logistics Operation Management*, 2016.
- Pattikawa, L. H., Innovation in the Pharmaceutical Industry: Evidence from Drug Introductions in the U.S., Erasmus Research Institute of Management (ERIM), 2007.
- Secrétariat Général du Gouvernement, Texte de Loi 17-04 portant code du médicament et de la pharmacie, [http://www.sgg.gov.ma/Portals/0/lois/code\\_medic\\_fr.pdf](http://www.sgg.gov.ma/Portals/0/lois/code_medic_fr.pdf), September 10, 2016.
- Serbout, M.A., Berrado, A., Benabbou, L., Toward consumption characterization in a pharmaceutical products supply chain, *3rd International Conference on Logistics Operation Management*, 2016.
- Stark, J., *Product Lifecycle Management: 21st Century Paradigm for Product Realization*, Second Edition, Springer, 2011.
- Steele, H., Monopoly and competition in the ethical drugs market, *J. Law Econ*, 5: 131-163, 1962
- Steele, H., Patent restrictions and price competition in the ethical drugs industry, *J. Indust. Econ.* , 12:198-223, 1964.
- Subrahmanian, E., Reich, Y., Konda, S.L., Dutoit, A., Cunningham, D., Patrick, R., Thomas, M., Westerberg, AW., The n-dim approach to building design support systems, in Proceedings of ASME Design Theory and Methodology DTM097, ASME, 1997
- Rees, H., *Supply Chain Management in the Drug Industry: Delivering Patient Value for Pharmaceuticals and Biologics*, Wiley, 2011.
- Wang, D., Analysis of Supply Chain Management Based on Product Types and Life Cycle, *International Conference on Management and Service Science*, 2009.
- WHO Collaborating Centre for Drug Statistics Methodology, *Guidelines for ATC classification and DDD assignment 2013*, Oslo, 2012.
- Yamanaka, T., and Kano, S., Mapping lifecycle management activities for blockbuster drugs in Japan based on drug approvals and patent term extensions, *Drug Discovery Today*, Volume 21, Number 2, February 2016. H. Min, Healthcare Supply Chain Management: Basic Concepts and Principles, *Business Expert Press*, LLC, 2014.

## **Supplemental Reading**

### **References**

Karniel, A., Reich, Y., *Managing the Dynamics of New Product Development Processes: A New Product Lifecycle Management Paradigm*, Springer, 2011.

### **Biography**

**Sophia Youssar** is an engineer from the National Institute of Statistics and Applied Economy (INSEA, 2007), Rabat, Morocco. Currently, a PhD student since 2015 at AMIPS research team, Ecole Mohammadia d'Ingénieurs (EMI), University Mohammed V, Rabat, Morocco. She has 10 years' experience in demand and supply management and is actually holding the position of Supply Chain Manager in a pharmaceutical company in Morocco.

**Abdelaziz Berrado** is an Associate Professor of Industrial Engineering in the Ecole Mohammadia d'Ingénieurs at the Mohammed V University, Rabat, Morocco. He earned MS/BS in Industrial Engineering from Ecole Mohammadia d'Ingénieurs, an MS in Industrial and Systems Engineering from San Jose State University, and a PhD in Decision Systems and Industrial Engineering from Arizona State University. Dr. BERRADO's research interests are in the areas of Supply Chain Management, Data Mining, Quality, Reliability, Innovation and Safety. His research work is about developing frameworks, methods and tools for systems' diagnostics, optimization and control with the aim of operational excellence. He published several papers in international scientific journals and conferences' proceedings. In addition to academic work, he is a consultant in the areas of Supply Chain Management, Data Mining and Quality Engineering for different Industries. He was also a senior engineer at Intel. He is member of INFORMS and IEEE.