
**Universidad Nacional de Cuyo**

**Maestría en Logística**


# Modelado y Medición de Performance Logística en la Industria del Vino

## El caso de la Industria del Vino de Argentina


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# Resumen

En la actualidad considerando el ambiente dinámico, complejo donde las empresas de la industria de vino están inmersas, donde los clientes son cada vez más exigentes y donde algunas consecuencias de la crisis mundial han empezado a afectar las operaciones, es difícil para las empresas administrar de forma apropiada la interacción con otros actores de la cadena de abastecimiento, tomar las decisiones correctas que impliquen la menor cantidad de impactos negativos y permanecer competitivas en el mercado.

Las empresas de la industria del vino a lo largo de la cadena de abastecimiento se están dando cuenta de la importancia de administrar herramientas de negocios que les ayuden a facilitar el proceso de toma de decisiones, a integrar los procesos logísticos claves con otros eslabones de la cadena de abastecimiento, contar con modelos que representen la dinámica de la cadena, y medir el rendimiento logístico de los procesos claves. Estas herramientas ayudan a tener una mejor comprensión de la dinámica, las operaciones y a encontrar oportunidades de mejora.

Para poder comprender y optimizar la complejidad, las operaciones, la dinámica y los procesos de las cadenas de abastecimiento es necesario contar con modelos que brinden una apreciación completa de los factores que afectan la performance. La creación de modelos ayuda a identificar e innovar en estrategias para diseñar redes con alta performance. A su vez, para las empresas es necesario mejorar los procesos logísticos midiendo su performance y la de su cadena de suministros utilizando un sistema de medición de performance de clase mundial.

Hasta ahora poca investigación de forma integral se ha realizado sobre modelos en la cadena de abastecimiento del vino. Los sistemas de medición de performance e indicadores relacionados a la industria del vino no han recibido mucha atención por parte de los investigadores y profesionales.

Teniendo en cuenta estos aspectos en esta tesis se proponen dos herramientas de negocios que ayudarán a las empresas de la industria del vino a entender mejor las operaciones, la dinámica las relaciones de la cadena de abastecimiento, y a encontrar oportunidades de mejora. Primero, se propone un modelo que represente la cadena, los actores, las relaciones, los principales problemas, diferentes escenarios, las diferentes estrategias de producción, etc. Segundo, se presenta un marco de trabajo para medir la performance logística de los procesos claves a lo largo de la cadena. Además se presentan definiciones del marco teórico para soportar y entender conceptos como administración de la cadena de abastecimiento (Supply Chain Management), Modelado de cadenas de abastecimiento y Sistemas de Medición.

Un caso particular de la cadena de abastecimiento del vino se presenta como caso de estudio, para validar el modelo genérico propuesto y el marco de trabajo para medir la performance. En el caso de estudio se enumeran los problemas reales que afecten las operaciones de la bodega y se aplican

indicadores específicos para analizar un problema concreto. Este punto muestra como medir la performance a través de los indicadores logísticos y como encontrar oportunidades de mejora para aumentar la competitividad de las empresas de la industria del vino.

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# Modeling and Measuring Logistics Performance in the Wine Supply Chain

## The Case of the Argentine Wine Industry

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# Abstract

Nowadays, considering the dynamic and complex environment in which wine companies are immerse, where customers are more and more exigent and some consequences of the world crisis are influencing the operations, it is difficult for companies to manage appropriately the interaction with other actors, to make appropriate decisions which imply the lowest negative impacts, and to remain competitive in the market.

Wine companies along the supply chain (SC) are realizing the importance of managing business tools which facilitate decision making process, and which help them to integrate logistics processes with other members along the SC, to count with models that represent the dynamics, and to measure the logistics performance of key processes. These tools help companies to have a better understanding of the dynamics, the operations and to find opportunities of improvement.

In order to understand and optimize the operations, the dynamics and the processes along the chain, it is necessary to count with models which offer a full appreciation of the factors that influence the performance. Models help to identify and innovate in strategies to design better and high performance networks. Companies need to improve key processes performance and its SC's performance using a set of world-class key performance indicators.

So far, little research in holistic Wine Supply Chain (WSC) models has been developed. Performance measurement and metrics related to WSC have not received adequate attention from researchers and practitioners.

Considering these aspects, in this research two tools are proposed which will help wine companies to better understand the operations, its dynamics, its relations, and to find opportunities to improve performance. First, a model that represents the WSC, its actors, its relations, its problems, different scenarios, production strategies, etc. is presented. Second, a framework to measure logistics performance of key processes present along the chain is proposed. In addition, some definitions of the theoretical framework are presented to support and understand Supply Chain Management, Supply Chain Modeling and Performance Measurement.

A particular instance of the WSC is presented as a case of study in order to validate the generic model and the measurement framework proposed. In this case of study real problems that affect the winery's operations are enumerated and specific indicators are applied in order to analyze a specific problem. It shows how to measure the performance through the proposed logistics indicators and how to find opportunities for improvement to enhance the competitiveness of wineries.

# Résumé

Actuellement, en considérant le dynamisme et la complexité où les entreprises de l'industrie du vin sont plongées, où les clients sont à chaque fois plus exigeants et où quelques conséquences de la crise mondiale ont commencé à affecter les opérations, c'est difficile pour les entreprises d'administrer correctement les interactions avec les autres acteurs de la chaîne d'approvisionnement, de prendre des décisions appropriées qui réduisent les impacts négatifs et de rester compétitif dans les marchés.

Les entreprises de l'industrie du vin au long de la chaîne d'approvisionnement ont commencé à rendre compte de l'importance de gérer les outils d'affaire qui aident dans les processus de prendre des décisions, et intégrer les processus logistiques essentiels avec autres enchaînes de la chaîne d'approvisionnement. Un autre chose important est avoir des modèles qui représentent la dynamique de la chaîne d'approvisionnement, et mesurer la performance logistique des processus essentiels. Ces outils aident à comprendre la dynamique et les opérations, et à trouver des opportunités pour améliorer la performance.

Pour comprendre et optimiser la complexité, les opérations, la dynamique et les processus de la chaîne d'approvisionnement il faut avoir des modèles qui offrent une appréciation complète des facteurs qui affectent la performance. La création des modèles aide à identifier et innover les stratégies pour dessiner des réseaux avec une meilleure performance. Quant aux entreprises il faut améliorer les processus logistiques en mesurant leur performance et la performance de sa chaîne d'approvisionnement par le moyen d'un système de mesure de class mondiale.

Peu de recherche intégrale a été effectuée sur des modèles de la chaîne d'approvisionnement du vin. Les systèmes de mesure de la performance et des indicateurs de l'industrie du vin n'ont pas reçu l'attention des chercheurs.

Dans cette thèse, deux outils d'affaire aideront ces entreprises à comprendre les opérations, la dynamique des relations de la chaîne d'approvisionnement et à trouver des opportunités d'amélioration. Le premier outil est un modèle qui représente la chaîne d'approvisionnement, les acteurs, les relations, les principaux problèmes, les différentes scènes, et les stratégies de la production, parmi d'autres. Le deuxième outil développé est un cadre de travail pour mesurer la performance logistique des processus essentiels au long de la chaîne d'approvisionnement. Des définitions des concepts ont été développés pour soutenir et pour comprendre la gestion de la chaîne d'approvisionnement comme le SCM (Supply Chain Management), la modélisation des chaînes d'approvisionnement, et les systèmes pour mesurer la performance.

Comme cas d'étude un cas particulier de la chaîne d'approvisionnement du vin pour une cave est présenté dans cette thèse, pour valider le modèle et le cadre de travail proposés. Dans ce cas d'étude une liste avec tous les

problèmes qui affect les opérations de la cave et un ensemble des indicateurs pour analyser  la performance des processus sont présentés.

# Agradecimientos

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A Dios por esta oportunidad.

# Table of Contents

# Figures

# Tables

# Chapter 1: Introduction

In this chapter a description of the general context is presented along with an introduction to the wine supply industry and the particular case of the Argentine Wine Industry. Section 1.1 presents a description of a general context of the research. In section 1.2 a description of the general context of the wine industry in the world and the particular case of the Argentine wine industry is presented. In section 1.3 the problem statement is presented and the objectives of the research in section 1.4. Finally in section 1.5 the thesis organization is presented.

## 1.1 General Context

Nowadays, in a global, competitive and turbulent environment companies of all industries are realizing the importance of counting with new business management tools such as *Supply Chain Management* (SCM), supply chains *modeling* and *performance measurement systems*. SCM is the integration of key business processes from original suppliers to final customer that provides products, services, and information that add value for customers and other stakeholders [Lambert & Cooper, 2000]. There is a growing need to integrate both cross-departmental and cross-company processes. Therefore, improving supply chains (SC) effectiveness and efficiency becomes a critical factor to remain competitive and to develop competitive advantages. The key to effective SC management is closing the gap between day-to-day changes in the SC, and companies' ability to recognize and respond to them. Specifically, companies must be able to identify these changes as they occur, to quickly understand their potential impact and to act immediately to deal with them [Stefanovic *et al.*, 2009].

The implementation of SCM needs the integration of processes from sourcing, to customer. In order to optimize SCs it is necessary to understand its dynamics, its complexity, its operations, and processes. Only through knowledge of the SC's complexity, a full appreciation and understanding of the factors that affect its performance are gained. The creation of logistic models helps to identify and innovate on strategies for designing high performance SC networks.

In order for companies to reach a world-class standard and to adapt to such a dynamic environment, it is necessary to improve their logistics processes by measuring its SC's performance. A world-class performance measurement system must be defined inside companies in order to evaluate processes' performance and to find opportunities of improvement to increase customer satisfaction levels.

In the particular case of the Wine Supply Chain (WSC), SCM is very important for wine companies because they compete in an international marketplace, where consumers have raised expectations for price-quality relation and where the competition is strong. As global pressure continues, SCM can help wine companies remain competitive and profitable. In recent years wine companies realized the potentials of SCM and the benefits of knowing its performance; there is more and more integration, which is very important not only to make wine efficiently, but to create true competitive advantages all along the SC.

## 1.2 The Wine Industry

World wine consumption has been affected by the economic crisis and has decreased in 2008. World wine production remains at a relatively low level. Nevertheless, the largest world exporting countries keep their ranking. The state of world viniculture in 2008 has recorded the first effects of the world economic crisis. World wine consumption has recorded a drop of 2 Miohl (million of hectoliters) in 2008 compared to 2007. This overall decrease in production is mainly due to a further decrease in consumption in traditional large producer and consumer European countries: France, Italy and Spain, in addition to Germany [OVI, 2009]. Figure 1.1 shows the global production of the first five larger producers. Figure 1.2 shows the second group of five larger producing countries. (Data can be seen in Appendix B)

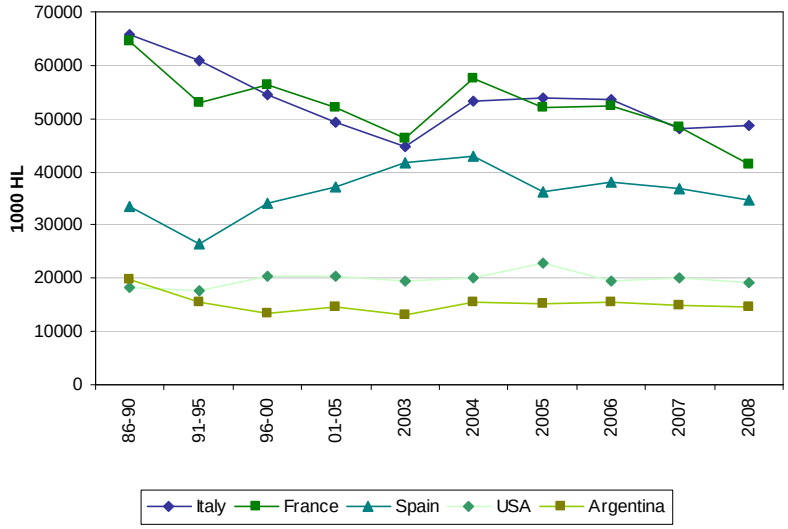


**Figure 1.1:** World wine production- (the first five producers of the world)
Sources: OIV- Organisation Internationale de la Vigne et du Vin
and INV – Instituto Nacional Vitivinicultura

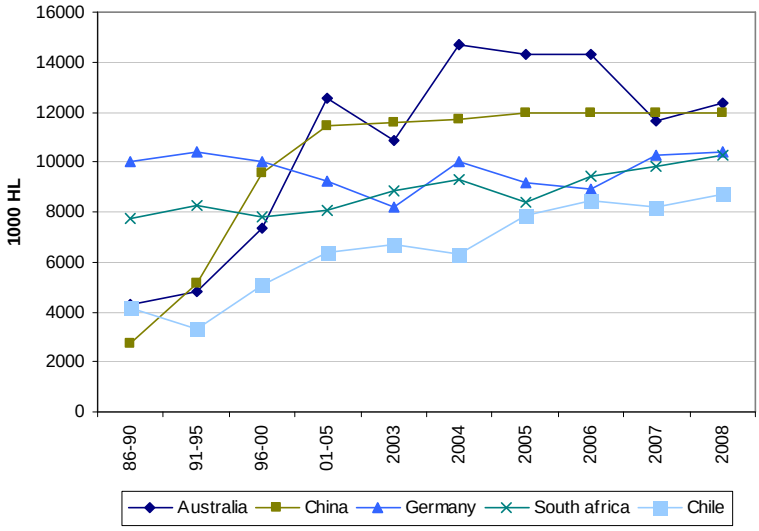


**Figure 1.2:** World wine production- (second larger producers in the world)
Sources: OIV- Organisation Internationale de la Vigne et du Vin
and INV – Instituto Nacional Vitivinicultura

Despite the global economic crisis and the reduction on production of traditional winemaking countries, the exportations in the world wine market as a whole, continues to grow in terms of volume. Almost all the larger players, except France and Australia, have kept their ranking in 2008: Italy remains the world leader in volume of wine exported. The group of six new exporter countries including Argentina and the United States has also continued to grow as shown in Figure 1.3. From the exporter countries, there was a tendency to increase their exportation until 2008. Argentina is the 7th country in the ranking as shown in Figure 1.3.

Since in this thesis a particular winery of the Argentine Wine Industry is used as a case study, in next section a description of the general context and environment of the industry is exposed.

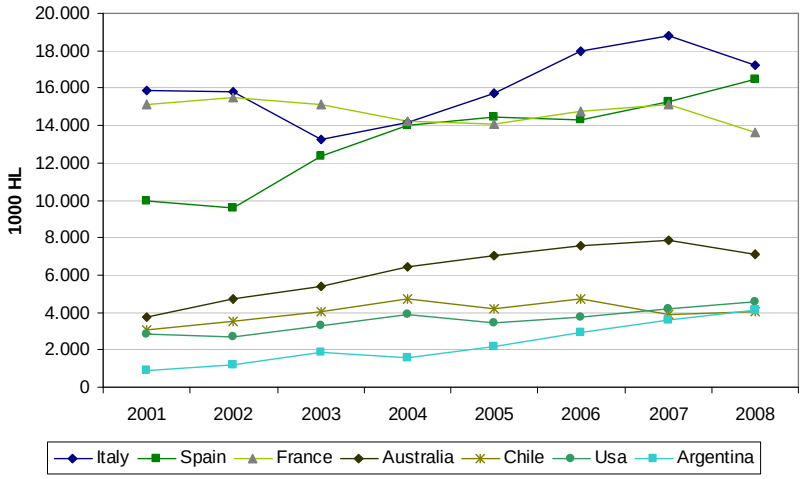


**Figure 1.3**: World wine exportation-
Sources: OIV- Organisation Internationale de la Vigne et du Vin

### 1.2.1 Argentine Wine Industry

Argentina has a surface planted with vineyards of 225.846 ha as shown Figure 1.4 distributed in 4 regions: north-west, center-west, south, other. The majority of vineyards are in the center-west region. One thing to notice in this figure is that the number of vineyards has not increased while their surface has increased.

**Table 1.1:** Data of Argentina
Source: INV – Instituto Nacional de Vitivinicultura

| | |
|---|---|
| Cultivated surface | 225.846 ha |
| Wineries | 1322 |
| Vineyards | 26194 |
| Grape harvest | 2822 mill kg |
| Wine elaboration | 1468 mill lit |

Some detailed data of Argentina is shown in Table 1.1. Inside the country there are some provinces which, due to weather and altitude, make vineyards to grow in excellent conditions. Mendoza is a viticulture province; it has 879 wineries which represent 66% of all the wineries registered in Argentina. It produces more than 80% of the country's wine production. It has 3 big viticulture regions, where the altitude goes from 600 to 1400 meters over the sea level. There are a lot of foreign capitals which buys wineries. A big percentage of these wineries export their production to foreign countries.

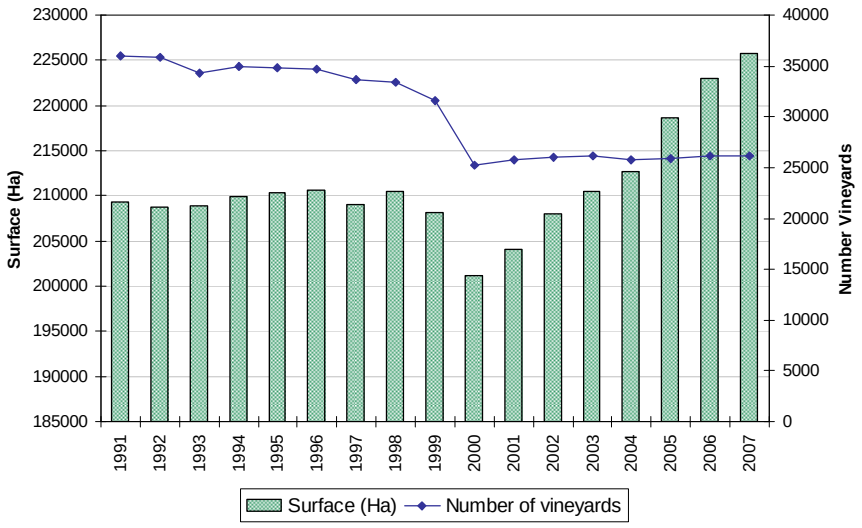


**Figure 1.4**: Surface planted and number of vineyards.
Source: INV – Instituto Nacional de Vitivinicultura

Argentina occupies an important place in the wine world context, and it begins to become a high and competitive wine exporter to the old world wine countries as Spain, France and Italy [INV, 2009]. It has participated on wines negotiations between MERCOSUR, European Union, and with

countries of the Wine World Commerce Group. Figure 1.5 shows the exportation data of last years in Argentina.

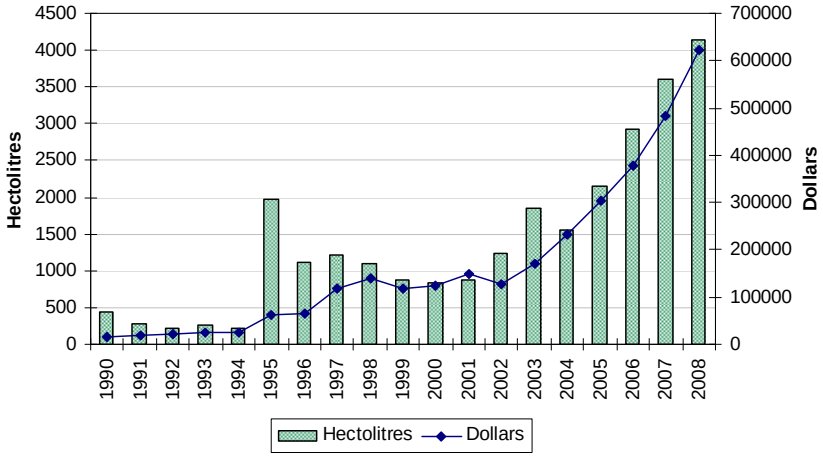


**Figure 1.5**: Argentine Exportations from 1990-2008.
Source: INV – Instituto Nacional de Vitivinicultura

A progressive increment of exportation can be observed in last years. In order to introduce to international markets and to adequate to new importers' exigencies, Argentina has invested in viticulture technology innovation, it started a conversion process of vineyards to reach high enological quality of grapes; it has implanted different red varieties such as Malbec, Bonarda, Cabernet Sauvignon, Syrah, Merlot and Tempranillo, and white varieties such as Chardonnay and Sauvignon Blanc. Argentina has increased its vineyards surface (as shown in Figure 1.4), introduced new technologies, etc. However, in the first months of 2009 some consequences of the crises are observed. The quantity of hectoliters exported has declined by 27% Figure 1.6 shows this phenomenon.

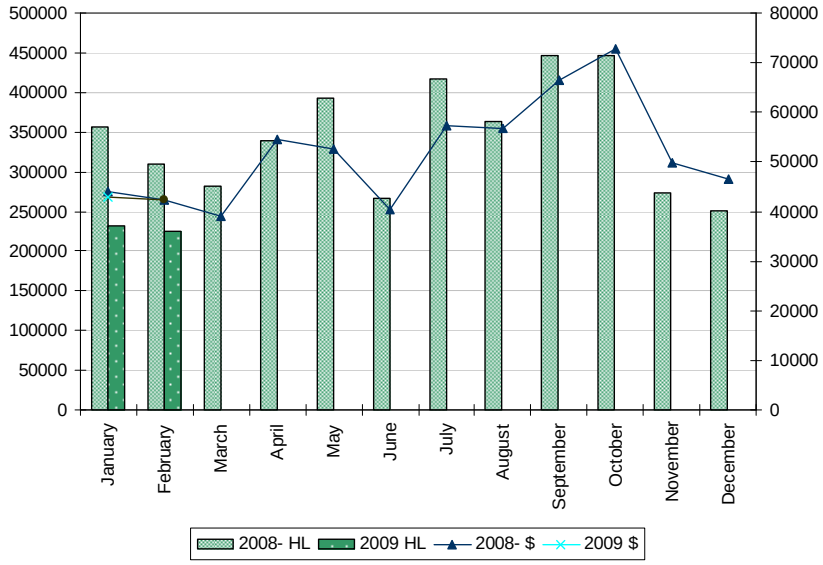


**Figure 1.6**: Argentine Wine Exportation 2008-2009.
Source: INV- Instituto Nacional de Vitivinicultura

Bottled wine exportations have decreased in volume but, on the other hand, they have a slight increase in dollars during the first months of the year. Due to this problem wineries in Argentina had decided to take actions to face the crisis, for example some of them find good strategy in being close to and to collaborate with the importer, listening to his necessities, and to find new opportunities. Others, for example, believe that the best strategy is to be close to the market, next to the sales point, and to work with importers at the same time. Some of them look at the crisis as an opportunity to grow through investment in new markets and technology. Another way to reach to consumers, importers and distributors is participating in wine fairs, and wine tasting, which increase the presence of wineries in markets[1]

The main markets of Argentine exportations are USA, considering money, and Russia, considering volume. Figure 1.7 shows USA as the main customer considering thousands of dollars, this means that for this country the exported product is more expensive than the product delivered to other countries, for example bottled wines is more expensive than bulk wine. Figure 1.8 shows Russia as the main customer considering hectoliters, this means that the product exported to this country is cheaper, but the quantities sold are higher.

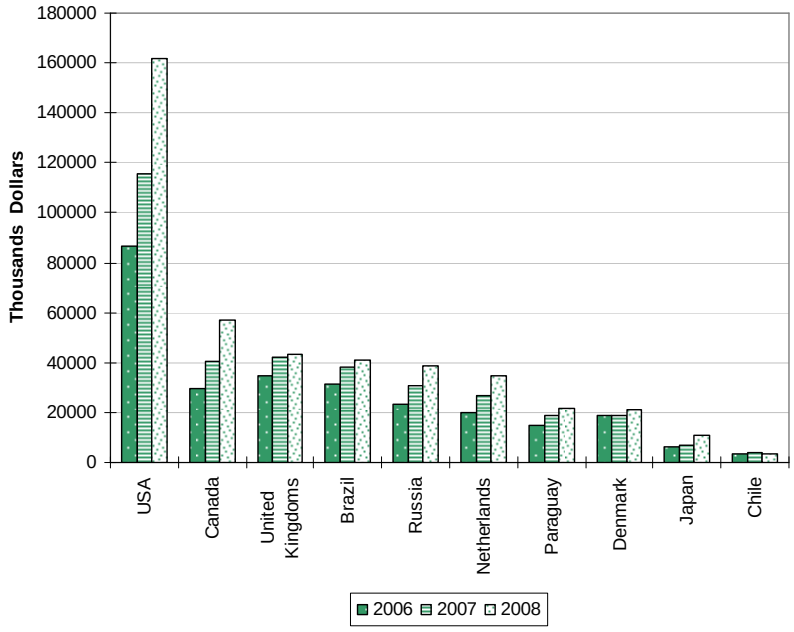


**Figure 1.7**: Destination of Exportations in thousands of Dollars.
Source: INV – Instituto Nacional de Vitivinivultura

[1] Note Published in Area del Vino, April 2009.

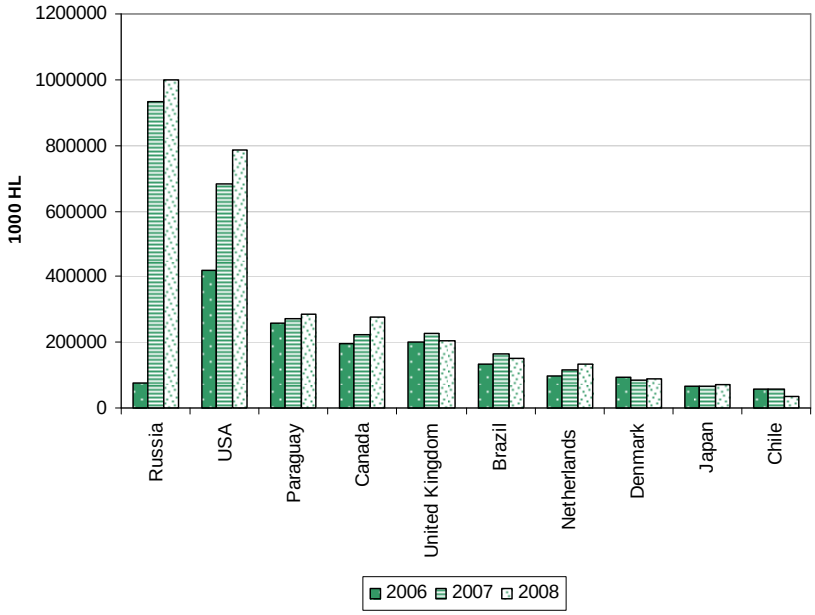


**Figure 1.8**: Destination of Exportations in Hectoliters.
Source: INV- Instituto Nacional de Vitivinicultura

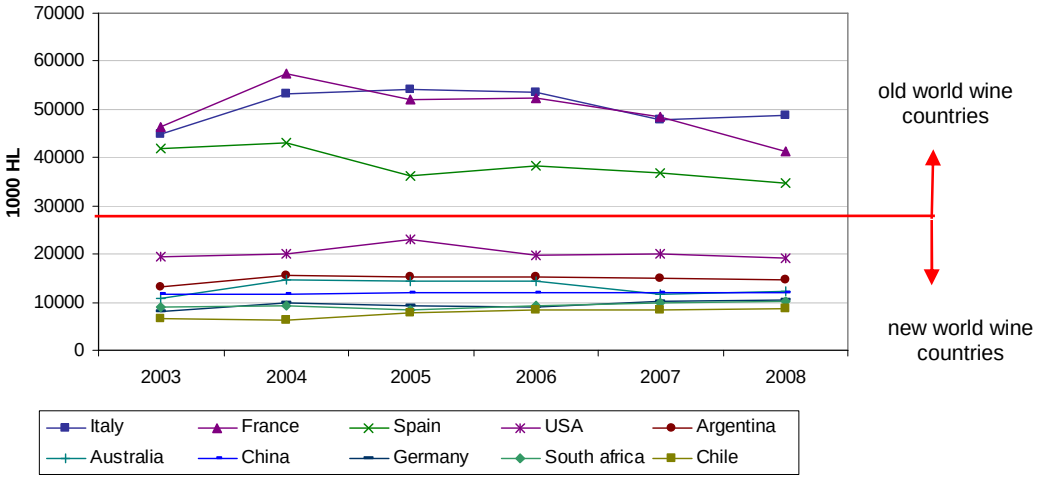


**Figure 1.9:** New/Old World wine countries productions

Considering the information shown in Figure 1.9 and Figure 1.10, some comments can be made. On the one hand, for countries of the old wine world there is a risk of loosing markets due to the reduction of consumption, the reduction of production, the price level of this kind of wine, and the quick growth of new world exporters.

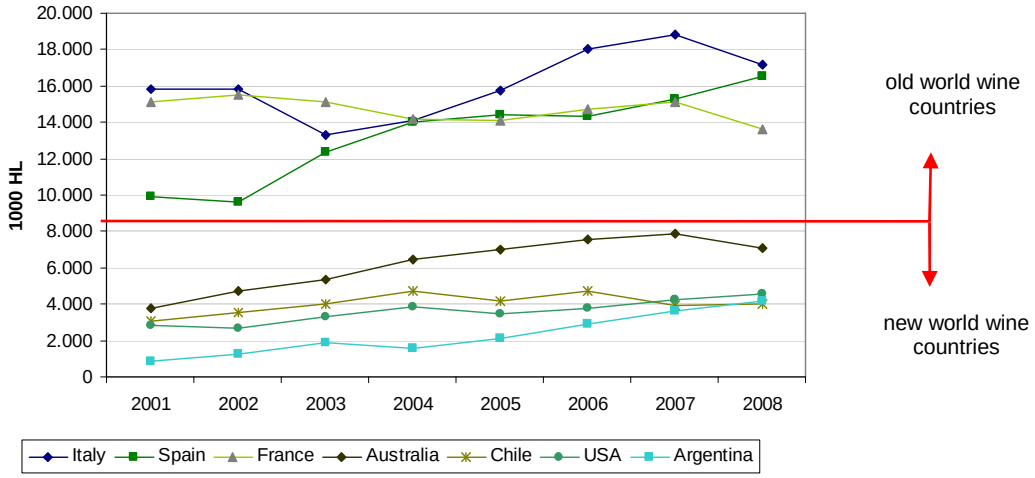


**Figure 1.10:** New/ Old World wine countries Exportations

On the other hand, as illustrated by the Figure 1.10, the production and exportations of new exporting countries tend to increase, mainly because of two causes: the *quality* of the wine, which is arriving to high levels, and the *price,* which is lower than those traditional and expensive of the old wine world.

For companies of the old wine world countries, it is necessary to find new opportunities to face the competition, and to enlarge the gap between them and these new competitors. Measuring their processes' performance and improving their SC and their operations is a way to face this situation. In addition, for new wine world exporters, it is an opportunity for improvement, and hence wineries should optimize their operations and their SCs, integrate with other members in the supply chain in order to take advantages of these opportunities to gain market.

## 1.3 Problem Statement

In order to optimize any SC it is necessary to know well all the processes, relationships between actors, roles, material and information flows interactions, levels of integration between actors and more important the potential problems that could arise during its operations.

In the particular case of the WSC, the dynamics is very complex not only due to the quantity of actors who participate to fulfill the customer's requirement, but also because the SC integration, which is different according to the culture, agricultural and industrial practices of each country.

In order to understand the WSC it is necessary to count with a model that represent its operations, its relationships and its dynamics. Through modeling it is possible to understand the SC complex relations, design new processes or improve those that are inefficient, to evaluate potential scenarios and reduce uncertainty through simulation, to facilitate decision making process, and to find opportunities to improve performance.

Global SC models are more complex than domestic SCs, particularly in agri-food SCs, where factors like quality, safety and weather conditions are very important [Ahumada, 2009]. A descriptive model of the WSC will help wine companies to understand their operations, to anticipate to potential problems and to reach a world-class standard by improving their logistics processes. Through the measurement of supply chains' performance, companies can find opportunities for improvement. Only through the control and measure of key logistics processes along the SC it is possible to determine the performance and to have a real diagnosis of the current situation. Once this is well known for companies, new goals and objectives can be defined to improve processes using fewer resources, incurring in lower costs and increasing customer satisfaction levels.

## 1.4 Objectives

This research aims at reaching these objectives:

- To provide a *model of the WSC* which represent its dynamics, its actors' relationships, and all material and information flows present in the SC.

- To obtain a *framework* to measure logistic performance along the SC

- To know the main *problems* that could arise along the WSC, their causes, and whenever is possible solutions and good practices to avoid or prevent problems.

In this thesis a descriptive model of the WSC is presented which includes a description of cycles and integration levels identified in the WSC, actors, roles integration, material and information flows representation and description, production strategies followed by wineries. Furthermore, a list of potential issues that may arise along the WSC is presented. A set of Key Performance Indicators (KPI) through which performance can be measured are also identified. A case of study of a winery of Argentina is presented, in which the model and the framework are applied. Finally, conclusions and future work are presented.

## 1.5 Thesis Organization

The organization of the following chapters of this thesis is as follows:

*Chapter 2: Theoretical Background:* This chapter presents some definitions of key business and managerial tools like Supply Chain Management, Supply Chain Models, and Performance Measurement of key processes along the SC. For each of these tools definitions, perceived benefits and previous works are presented. For the particular case of WSC previous works related to SCM, models and performance measurement are identified, in order to justify this research's objectives.

*Chapter 3*: *Supply Chain Descriptive Model*: In this chapter a model for the WSC is presented which includes a detailed description of all actors who participate to arrive to customers with the finished goods, grouping of actors, relevant scenarios in the WSC to describe material and information flows, all abstraction levels identified in the SC, a description of all roles integration, and the identification of activities present in all actors in the SC. This chapter also presents some particularities of the SC depending on the wine segment, and different production strategies followed by wineries.

*Chapter 4*: *Potential Issues in the Wine Supply Chain*: It includes a description of the most important problems that could arise all along the WSC, classified by performance attributes, causes and consequences and possible solutions or good practices to avoid or prevent these problems.

*Chapter 5*: *Performance Measurement in Wine Supply Chain*: This chapter includes a description of a logistic framework to measure performance in the wine industry, a deep description of KPI through which the potential problems can be measured in the SC and a methodology of implementation of the framework.

*Chapter 6*: *Case Study: Argentine Winery*: It includes a case study in which the model described and the framework to measure performance were applied. An Argentinean winery is used as a case study. A list of problems that actually happened during operations of the winery is presented, with a particular application of 2 KPI of the framework.

*Chapter 7*: *Conclusions*: In this chapter general conclusions and contributions of the research are presented along with and future works in the wine industry.

Appendices: includes questionnaires and statistics.

# Chapter 2: Theoretical Background

In order to understand the general context of this research some definitions, a literature review of the main topics and key business tools are presented in this chapter. Three sections compose this chapter. Section 2.1 presents definitions, benefits, importance and previous works related to SCM. In section 2.2 previously proposed SC models are described, along with previous works on modeling languages, types of models, perceived benefits, and importance of using models. Section 2.3 describes performance measurement definitions, importance, and benefits of performance measurement in SCs and previous works. Section 2.4 presents previous works related to SCM, performance measurement and modeling in the wine industry. The purpose of this chapter is to provide some insights of the relevant aspects related to the thesis topic, and to give and overview of previous proposals putting emphasis on the open issues that justified this work.

## 2.1 Supply Chain Management

Supply Chain Management (SCM) is the integration of key business processes from original suppliers to final customer that provides products, services, and information that add value for customers and other stakeholders [Croxton *et al.*, 2001]. In recent years, many authors have stressed the importance of implementing SC management. Companies of all industries are more and more recognizing this need and they are trying to integrate with trade partners in the SC. Individual companies no longer compete as solely autonomous entities; they must work as SCs [Lambert & Cooper, 2000].

SCM offers the opportunity to capture the synergy of intra- and inter-company integration and management. In that sense, SCM deals with total business process excellence and represents a new way of managing the business and relationships with others members of the SC [Lambert & Cooper, 2000]. Some consequences of SCM are [Mentzer *et al.*, 2001]:

- Lower costs
- Improved customer value and satisfaction, which leads to enhanced competitive advantage for the SC as well as each member firm.
- Generation of competitive advantages

Companies in particular and SCs in general compete more today on the basis of time and quality. Arriving to the customer with no-defect, good quality and reliable products is no more a competitive advantage but a requirement to be in the market. This global pressure and the competition based on high performance, combined with rapidly changing technology and

economic conditions, all contribute to marketplace uncertainty [Mentzer *et al*., 2001]. This uncertainty requires greater flexibility on companies and SCs.

There is an important distinction between *supply chains* as phenomenon that exists in business, and the *management* of those supply chains. The former is simply something that exists (often also referred to as distribution channels); while the latter requires overt management efforts by the organizations within the supply chain [Mentzer *et al*., 2001].

In order to achieve an efficient SCM, a conceptual framework should be identified. The SCM framework consists of three closely interrelated elements: the SC network structure, the SC business processes, and the SC management components. The SC network structure consists of the member firms and the links between these firms. Business processes are the activities that produce a specific output of value to the customer. The management components are the managerial variables by which the business processes are integrated and managed across the SC [Lambert & Cooper, 2000].

The implementation of SCM involves identifying the SC members with whom it is critical to link, what processes need to be linked, and what type/ level of integration applies to each process link. The objective of SCM is to create the most value, not simply for the company, but for the whole SC network including the end customer. A deeper analysis of these components will be carried out in section 3.1 where a description of the WSC is presented.

Three scope levels can be distinguished in a SC, [Meijer, 2002; Mentzer *et al*., 2001] as shown in Figure 2.1

1. *Internal supply chain*: the integrated flow of material and information within the business unit or corporation

2. *External supply chain*: the integrated flow of material and information within the business unit or corporation, including the direct supplier and direct customer.

3. *Integrated supply chain*: the integrated flow of material and information within the business unit or corporation, including multiple trading suppliers and customers.

These levels show how complexity of SC increases as the number of partners working in rises. Depending on the number of suppliers and customers at each level in the length of the chain, the complexity grows. The tendency in business management is to work and make decisions considering the integrated SC. In this way companies belonging to the network will improve their revenues and performance.

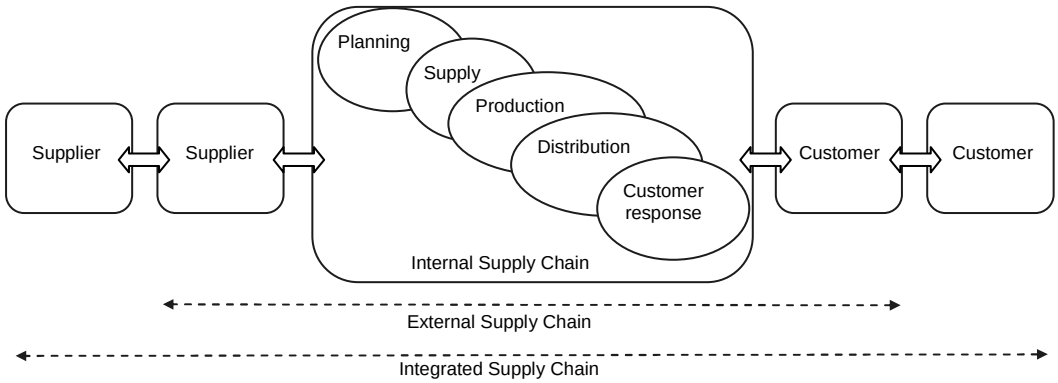


**Figure 2.1:** Scope levels of supply chains

In every level of the SC we found different cycles. Considering the SCOR Model [Supply Chain Council, 2008], five cycles are identified in the SC:

1. Planning cycle (Planning): in this cycle decisions are made related to the management of business rules, SC performance, data planning, etc.

2. Supply cycle (Source): it includes all activities related to supplies, purchase order processing, buying and payment, scheduling of products reception, incoming products verification, authorization of payment to suppliers, selecting supply sources when they are not predetermined, supplier's agreements, etc.

3. Production cycle (Make): includes production scheduling, production and testing, packaging, staging products and release products to deliver. All the processes related to waste disposal, in-process products, equipment and facilities, regulatory compliance for production, etc. are included in this cycle.

4. Distribution and sales cycle (Deliver): this cycle includes all the activities related to the orders, warehouse, and transportation management. Typical activities are order management, receiving, picking, loading, shipping, finished products inventory, transportation, import/export requirements, etc.

5. Customer Response cycle (Return): all the activities related to customer response are included in this cycle. It covers complaints reception, return of defective products or which need maintenance or reparation. This means identification of the product's condition, request of product return authorization, schedule of product shipment and delivery, reception and transfer of the product. All the activities must work to satisfy customer expectations [Frazelle, 2002].

These cycles or processes are present in all links or members in the SC as shown Figure 2.1.

Managing the SC cannot be left to chance. For this reason, executives are striving to interpret and to determine how to manage the company's supply chain network, and thereby achieve the potential benefits of SCM.

### 2.1.1 Previous Works on SCM

There is a lot of research works related to SCM, some of them aim at explaining and defining the concept [Mentzer *et al.*, 2001; Croxton *et al.*, 2001]; others propose alternatives to optimize the operation of the SC [Jung *et al.*, 2004; Lakhal *et al.*, 2001; Chen *et al.* 2004]. In addition many works of simulation have been done in SCs [Carlsson *et al.*, 2005; Stefanovic *et al.*, 2009; Terzia & Cavalieri, 2004]. A simulation brings a model to life and shows how a particular object or phenomenon will behave.

Other works present case studies of different SCs to evaluate a particular aspect, for example how the use of technology impacts the SC performance [Kelle & Akbulut, 2005; Lehtivvaara *et al.*, 2002; Garcia-Dastugue & Lambert., 2003], or how some SCs respond faster than others [Ferdows *et al.* 2003]. Others authors show different practices followed by countries [Chowa *et al.*, 2008] in order to optimize the SC.

To summarize, the potential benefits of SCM have been largely studied. In section 2.4 previous works on SCM research in the WSC are presented. Figure 2.2 presents a summary of the relevant aspects of SCM reviewed here.

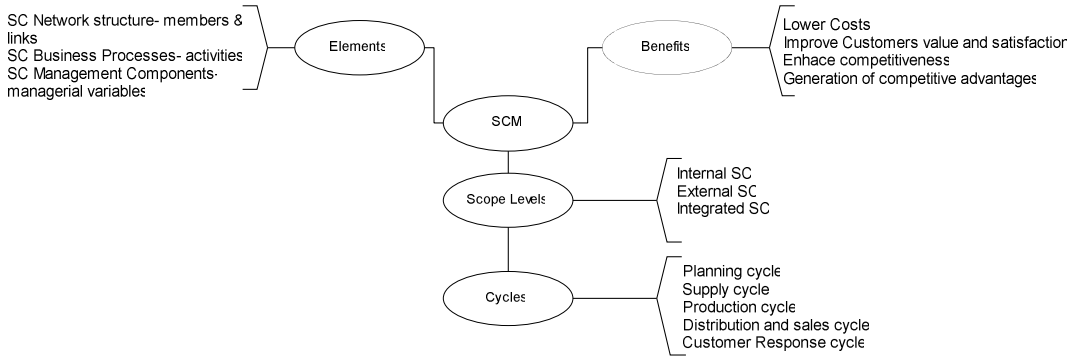


**Figure 2.2:** SCM summary

## 2.2 Supply Chain Models

A model in science is a physical, mathematical, or logical representation of a system of entities, or processes. It is a simplified abstract view of the complex reality. It is used to express information, knowledge or systems in a structure defined by a set of rules [OMG, 2004]. The main purpose of a model is to

understand the underlying dynamics of a complex system. However mathematical and operations research models, when modeling the SC dynamics, present limitations due to the complex reality immersed in SC, which includes many relationships, features, parameters, and constraints. These models start to make many assumptions that end being useless in such complex systems.

Numerous algorithms and tools have been deployed in SC modeling and problem solving. These are based on stochastic models, mathematical programming models, heuristic techniques, simulation, etc. In addition, there are lots of types of models: mathematical, stochastic models, software models, enterprise models, economic models, descriptive models, statistics models, etc.

### 2.2.1 Modeling languages

A modeling language is any artificial language used to express information, knowledge or systems in a structure defined by rules. The rules are used for interpretation of the meaning of components in the structure.

The modeling language can be graphical or textual. Graphical modeling languages use diagram techniques with named symbols, which represent concepts, lines, which connect the symbols and represent relationships, and various other graphical annotations to represent constraints. Textual modeling languages typically use standardized keywords accompanied by parameters to make computer-interpretable expressions

Some examples of modeling languages are:

- EXPRESS and EXPRESS-G (ISO 10303-11) is an international standard general-purpose data modeling language.
- Flowchart is a schematic representation of an algorithm or a stepwise process
- Petri nets is one of several mathematical modeling languages for the description of discrete distributed systems
- Unified Modeling Language (UML) is a graphical language for visualizing, specifying, constructing, and documenting the artifacts of a software-intensive system. The UML offers a standard way to write a system's blueprint, including conceptual things such as business processes and system functions as well as concrete things such as programming language statements, database schemas, and reusable software components [OMG, 2004].
- SysML supports the specification, analysis, design, and verification and validation of a broad range of complex systems. These systems may include hardware, software, information, processes, personnel, and facilities. [SysML 2008].

- EAST-ADL is a domain-specific modeling language dedicated to automotive system design.
- Energy Systems Language (ESL), a language that aims at modeling ecological energetic & global economics.
- Value Stream Mapping (VSM) is a visualization technique oriented to the Toyota version of Lean Manufacturing. It helps to see and understand the flow of material and information as a product or service makes its way through the value stream.

Modeling and analysis of SCs help to gain a better understanding of chains' dynamics and their complexity, to predict their performance and to design new or better networks. A large number of manufacturing and service organizations are therefore seeking modeling systems that can help to identify and implement strategies for designing and improving their SC networks. There is an ever increasing need for modeling SCs [Biswas & Narahari, 2004]. In order to meet SC management challenges and optimize its operations it is necessary to count with a model that represents its operations, its relations, actors, constrains, etc.

### 2.2.2 Previous works

Lots of works and researches have been done related to models in SC. Process approach is the dominant method in business and SC modeling. Many of today well-known business models and standard initiatives such as SCOR Model [Supply Chain Council, 2008] are based on the process approach. In SC literature common processes such as procurement, production, distribution, etc. are modeled separately. However these processes should be modeled together for improving the overall SC performance [Chandra & Fisher, 1994; Ahumada, 2009].

In the particular case of agri-supply chains (sc of agricultural products) their design and operation will be subject to more stringent regulations and closer monitoring, in particular those for products destined for human consumption (agri-foods). Many works have been developed in this area. These works can be classified in two groups, namely models for fresh agricultural products and non perishable agricultural products [Ahumada, 2009].

For the first group some authors have proposed a model of agricultural fresh products by formulating the plant growing process and the loss process of fresh products through mathematical tools, with the objective of maximizing the demand's satisfaction level [Widodo *et al*. 2006]. Others try to maximize revenues [Kazaz, 2004] through a model of crop planning with uncertain (stochastic) values which may support decision making of agricultural farm [Itoh *et al.* 2003]. Another model for maximizing revenues was formulated by linking pertinent chemical, biologic, and logistic

restrictions to the quality of the fruit to be harvested [Caixeta-Filho, 2006]. Another model for maximizing the expected gross revenue of a greenhouse by designing an appropriate marketing and planting plan is proposed in [Caixeta-Filho *et al*. 2002].

Furthermore, other authors aim to reduce losses by weather and overcapacity [Allen & Schuster, 2004]. A model's definition for the fruit industry is presented in [Masini, 2003] to optimize the SC planning of a typical fruit company. An improved harvesting and transportation planning approach using a modeling framework composed of sub models of parts of the system is proposed in [Higgins & Laredo, 2006].

For models of non perishable agricultural products, some authors propose to minimize total cost satisfying the customer [Apaiah & Hendrix, 2005], maximize the fruit obtained during harvest season [Jiao *et al*. 2005], increase utilization of land, labor, production and profits [Biswas & Narahari, 2004], etc.

Several works are related to SC in manufacturing [Gunasekaran, 1999; Gunasekaran, 2009, Smith *et al*., 2008, Özbayrak *et al*., 2007] considering environmental considerations along the SC [Tsoulfas & Pappis, 2008] and transportation and distribution aspects [Karabuk, 2007], as well as SC reengineering [Trienekens & Hvolby, 2001]. Other authors have developed decision support systems which help to make decision at all levels of the hierarchy in the SC and present case studies in order to apply the use of those tools [Biswas & Narahari, 2004; Longo & Mirabelli, 2008].

The literature on SCM Models which deal with strategies and technologies for effectively managing a SC is quite vast; however little works on modeling related to the particular case of the WSC have been found. In section 2.4 a more detailed description of existing works for the WSC is made. Figure 2.3 summarizes the relevant aspects related to SC modeling exposed.

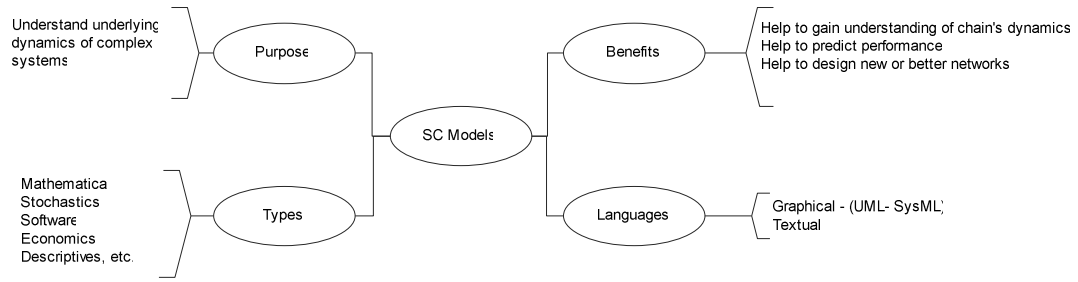


**Figure 2.3:** Supply Chain Models summary

## 2.3 Performance Measurement Systems

The ability to measure the performance of operations can be seen as an important prerequisite for improvement, and companies have increased the capabilities of their performance measurement systems (PMSs) over the last years. Performance measurement (PM) in the context of a supply chain becomes more important because companies start looking at ways to improve operational performance through a better integration of operations across subsequent links in the SC.

A performance measurement systems is a set of related measures [indicators], which correspond to one or various performance attributes [aspects or perspectives which are important to measure], for example quality, time, financial aspects, etc. There exist a lot of measurement systems; some of them applied to a single organization and some of them to a SC [Lo, 2005], for example: Tableau de Bord, The Balanced Scorecard (BSC), A Supply Chain Balanced Scorecard Framework, the SCOR-model, etc. In next section the case of BSC is presented as example, in order to describe the concepts needed to understand a measurement system.

### 2.3.1 Importance and Benefits: The BSC example

The Balanced Scorecard (BSC) is a business tool used as a measurement system in organizations. It translates an organization's mission and strategy into a comprehensive set of performance measures that provide the framework for a strategic measurement and management system [Kaplan & Norton, 1996]. It also provides managers with the instrumentation they need to navigate to future competitive success. Today, organizations are competing in complex environments so an accurate understanding of their goals and the methods for attaining those goals are vital.

The BSC is a strategic planning and management system that is used extensively in business and industry, government, and nonprofit organizations worldwide to align business activities to the vision and strategy of the organization, improve internal and external communications, and monitor organization performance against strategic goals.

The BSC measures organizational performance across four balanced perspectives: financial, customers, internal business processes, and learning and growth. It emphasizes that financial and non financial measures must be part of the information system for employees at all levels of the organization. In each of these perspectives key performance indicators are defined, to have a global diagnosis of the organization. Figure 2.4 shows BSC and perspectives.

### *The Customer Perspective*

This perspective typically includes several core or generic measures of the successful outcomes from a well formulated and implemented strategy [Kaplan & Norton, 1996]. Recent management philosophy has shown an increasing realization of the importance of customer focus and customer satisfaction in any business. The core outcome measures include customer satisfaction, customer retention, new customer acquisition, customer profitability, and market and account share in targeted segments. But the customer perspective should also include specific measures of the value propositions that the company will deliver to customers in targeted market segments.

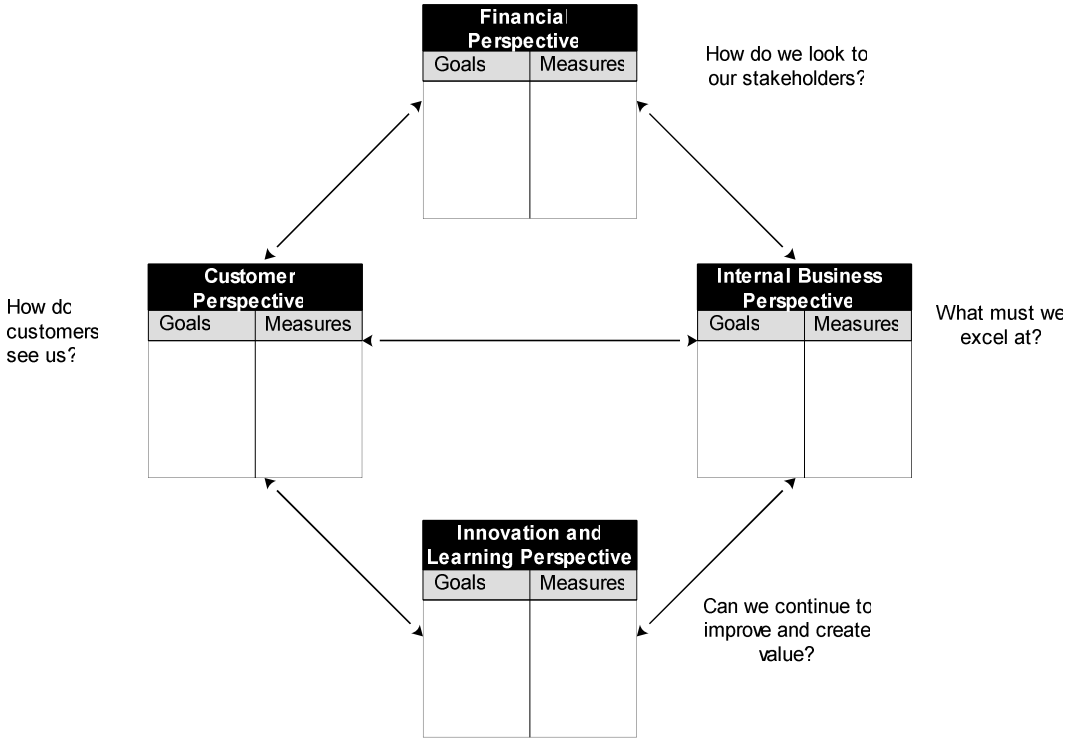


**Figure 2.4:** The Balanced scorecard. Adapted from Kaplan & Norton (1992)

### *The Financial Perspective*

Financial performance measures indicate whether a company's strategy, implementation, and execution are contributing to bottom-line improvement. Financial objectives typically relate to profitability measured, for example, by operating income, return on capital employed, or more recently economic value added [Kaplan & Norton, 1996].

### *The Learning & Growth Perspective*

This perspective identifies the infrastructure that the organization must build to create long term growth and improvement [Kaplan & Norton, 1996]. It

includes employee training and corporate cultural attitudes related to both individual and corporate self-improvement. In the current climate of rapid technological change, it is becoming necessary for knowledge workers to be in a continuous learning mode. Metrics can be put into place to guide managers in focusing training funds where they can help the most. In any case, learning and growth constitute the essential foundation for success of any knowledge-worker organization.

***The Internal Business Process Perspective***

This perspective refers to internal business processes. Metrics based on this perspective allow the managers to know how well their business is running, and whether their products and services conform to customer requirements. In this perspective executives identify the critical internal processes in which the organization must excel and at the same time they must focus on the internal processes, which will have the greatest impact on customer satisfaction and achieving an organization's financial objectives.

These four perspectives are not sufficient in different industries, but other ones can be added whenever it is necessary, for example logistics perspectives, in SC management.

In each perspective previously described, a set of KPI are defined and measured. This KPI are indicators (variables) or ratios, which represent a performance measure. It could be a measure of future situations, current situations and past events [Salgueiro, 2001]. Each indicator must have a name, to identify the indicator, a formula to obtain the result, the unit of measure and a description of the purpose of the indicator. An example is shown in Table 2.1.

**Table 2.1**: Example of KPI

| | |
|---|---|
| Name | Lead-time |
| Formula | End Production Process DateTime- Start Production Process DateTime/ Total Product Unit Produced |
| Unit of measure | Days |
| Description | Is the average time for producing a product |

Through the implementation of BSC and/or other measurement performance systems some benefits can be perceived:

- Through performance measurement of both individual organizations and integrated SCs, a diagnosis of the current situation is known by the managers considering all the perspectives defined [Irazabal, 2004].

- A tendency to future situations can be known in order to anticipate and to avoid future dangerous situations.

- This tool also helps organizations to establish strategic management systems, to improve productivity and efficiency in processes.

- It is useful to facilitate and make more agile the decision making process in organizations.

- It is a helpful tool to short term and long term planning [Salgueiro, 2001].

- It can also help organizations along the SC to improve their internal and external business functions.

- It is useful to improve the productivity and efficiency of the activities.

Performance measurement systems like BSC are important in many different functional areas of management, such as operations, marketing, sales, logistics, production, etc. [Kaplan & Norton, 1996]. The ability to measure the performance of operations can be seen as an important prerequisite for improvement, and companies have increased the capabilities of their performance measurement systems over the last years [Wouters, 2009]. The BSC has evolved from its early use as a simple performance measurement framework to a full strategic planning and management system.

In the context of SCs, performance measurement is very important, because companies of all industries want to improve their operational performance through an integration of processes along the partners in the SC. That is why more and more organizations are implementing performance measurement systems or defining their own key performance indicators to acquire knowledge about the organization's performance related to their competitors and to the industry's leaders. Many organizations have improved their logistics processes performance through the control and the measurement of their performance.

### 2.3.2 Previous Works

This topic has been studied by researchers specialized in different fields. The SCOR Model [Stewart, 1997; Supply Chain Council, 2008], was the first cross-industry framework for evaluating and improving enterprise-wide supply-chain performance and management. In some works, this model has been applied to particular cases, like manufacturing industry [Hwang *et al.*, 2008].

Development of frameworks [Kim & Kim, 2009; Gunasekaran *et al.*, 2001] and methodologies definitions have been done to improve the definitions of KPI in the organizations [Cai *et al.*, 2009; Chan, 2003].

In SCs, measurement of performance is very important. Lot of related works during the past years have been developed pursuing different objectives, such as increasing revenues at lower cost in small and medium sized enterprises [Bhagwat & Sharma, 2007], and measuring the performance of information systems activities following several perspectives [Martinsons, 1999].

Finding the exact performance evaluation of the SCM in inventory level, minimizing the total cost has also been studied [Kojima *et al.*, 2008], and performance measurement systems have been applied to particular cases, like manufacturing organizations [Lohman *et al.*, 2004]. Even though much research has been done related to performance measurement, in the Wine industry there are no integrated frameworks to measure performance. Some isolated measures proposed in previous works are presented in next section. Figure 2.5 summarizes the main ideas related to performance measurement systems.

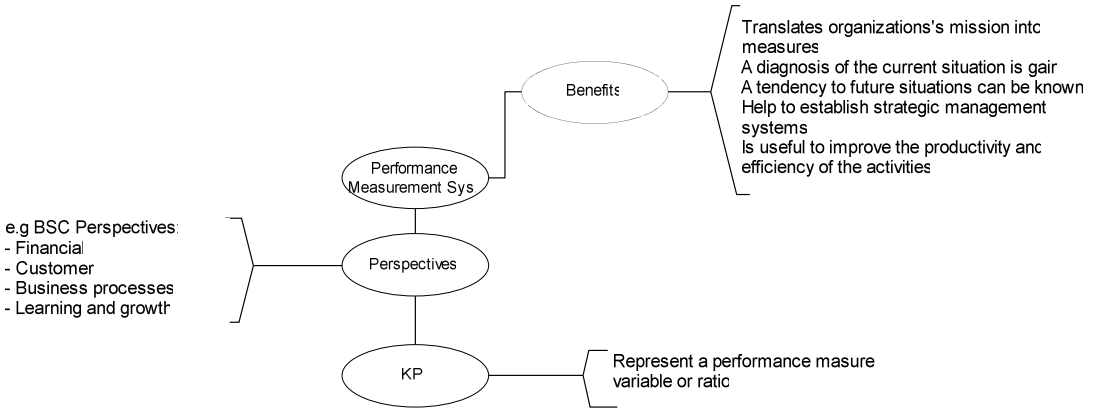


**Figure 2.5:** Summary of performance measurement systems concepts

## 2.4 Wine Supply Chain

WSC are complex due to several causes such us the nature of the product that is produced, the number of actors and the relationships between them, the multi tiers systems in distribution cycle of some countries, the exigencies and requirements of final customers, the continuous pressure of local and external competitors in the market, the legal constrains of distribution, etc. Considering this context it is more difficult for managers to make decisions which have no negative impact on others members along the WSC. In order to have a good comprehension of the SC, it is necessary to count with a formal and generic model of the SC, which represents all the possible instances. Through this model and a performance measurement framework,

a manager of an organization of the wine industry will count on powerful tools which would help him to make decisions properly and having complete information.

Little previous work has been found related to models and performance measurement. However, several aspects of the WSC have been studied separately. Related works are presented considering the cycles of the SC previously described.

In the supply cycle a model definition is presented to determine a plan for the optimal scheduling of the harvest of wine grapes, with the objective of minimizing operational and grape quality costs [Ferrer *et al.* 2008]. Another work is related to the effects on health and risk factors suffered by workers during hand harvest of wine grapes. Methods and alternative tools were proposed in order to reduce health problems, and increase workers' productivity [Duraj *et al*., 2000]. Along the SC, every link has its own supply cycle where several activities are performed. Supplying grapes and consumables in the right conditions is important, as well as providing a good service in delivering these products, respecting time, documentation, etc., aspects that are no considered in previous works.

In all production cycles, quality assurance of the product and costs reduction are some objectives pursued by all organizations. Some authors present methodologies to identify the causes of the absence of quality during wine elaboration process and propose correctives actions to solve these problems minimizing quality costs [Alturria *et al.*, 2008].

With the increased environmental concerns over the past years, there is growing recognition that issues of environmental pollution accompanying industrial development should be addressed simultaneously in the operational process of supply chain management [Sheu *et al*., 2005]. A related work in the wine industry considers the use of a carbon life cycle analysis to develop a model for quantifying carbon inputs in a bottle of wine minimizing its cost [Colman & Päster, 2007]. During the wine elaboration process there is a lot of waste generation. In order to minimize the quantity of waste and to increase the benefits in the wine industry, a study which proposes a qualitative approach for seeking feasible waste minimization alternatives is proposed in [Musee *et al*., 2007]. With this approach, waste minimization is addressed through the acquisition of process knowledge of winery operations. Other works aim at investigating various sustainability issues in the New Zealand wine industry. It includes what drives the industry to engage in sustainability practices, the role of stakeholders in the company's decision-making, and environmental practices related to water utilization, chemicals and waste management [Gabzdylova, *et al*., 2009].

Distribution of products is very important in WSC, due to the quantity of actors involved, the legal constrains of some countries, the closeness to the customer, etc. That is why this is an attractive topic for authors to investigate. Some recommendations for analysis, development and management actions for innovation in bulk wine transport management are presented in [Dunstall, 2008] for the Australian Wine Industry.

In the wine market there is a high level of competition, due to the growth of new wine world countries and the industrialization of winery processes. Some findings about the way the European wine industry has interpreted and reacted to globalization is uncovered in [Smith, 2008]. The French AOC[2] request process is outlined in [Barham, 2003] and its aspects are analyzed in detail to demonstrate how it opens markets. For the particular case of the Argentine Wine Industry an establishment of different scenarios of the Argentinean wines compared to other countries is presented in [Calderón & Blanco, 2005]. Another work aims at analyzing all the structural transformations registered in the ninety decade for the Argentinean wine industry, it describes the macroeconomic context, the situation of Argentina in relation to other exporters countries, etc [Aspiazu & Basualdo, 2001]. A complementary work pretends to examine the restrictions and the progress in the primary production and the industrial elaboration of the different wine products, along with the internal and external commercialization [Aspiazu & Basualdo, 2003]. An integrated work, in which the author aims to analyze how current trends in SCM are affecting the global WSC is presented in [Adamo, 2004]. The particular case of the Argentinean wineries that sell products in the USA market is presented as a case study.

As presented early, a lot of works have been made related to wine industry, covering several aspect and analyzing different countries, however, so far little attention has been given to the performance evaluation, and hence, to the measures and metrics of WSC. Only separated measures have been presented in [Bailey, 2003], but no integrated frameworks covering the whole SC have been found in the literature.

Control of processes in a WSC is crucial for improving performance and can be achieved through measurement. A framework to measure performance along the SC is proposed in [Garcia *et al*., 2009], which is used in next chapters to complement the study of the WSC.

In order to analyze these previous works and to identify opportunities for future research, a summary showing the impacts and necessities is presented in Table 2.2

[2] Appellation d'origine contrôlée (AOC)

**Table 2.2:** Summary of previous works in the WSC

| Objective | Description | Impacts |
|---|---|---|
| Improve harvest process through the implementation of new tools, or algorithms | Provides the means to evaluate the costs of specific harvesting decisions | Helps to improve harvest process, its performance and assure the quality of the grapes. |
| Identification of risk factors suffered during hand harvest | Helps to identify better conditions to develop hand harvesting and to improve its performance | Helps to gain better quality in grapes during harvesting. |
| Identification and minimization of quality problems and cost during elaboration process | Identify bad quality factors during elaboration process, calculating their cost. | Helps to decrease cost during elaboration process for factors that affect wine quality. |
| Environmental issues, waste minimization and sustainability practices in the wine industry | Identify and study processes that generate waste, proposing alternative solutions | Avoid the generation of waste during elaboration process increasing the quality of the wine. |
| Innovative actions to improve transport | Propose innovative alternatives to give an optimal transport, maximizing the revenues of the network, improving labor management | Inefficiencies in the transport impact financially and operationally on wine producers and transport operators. |
| Description of particular wine industries of different countries and comparison with others | Analysis of the macroeconomic variables and the strategies followed by wineries of different countries | It gives an idea of how wine companies adapt their operations in order to compete in the market. |
| Study of the members of the chain | Members of the WSC are studied with Porter's five forces analysis in order to understand the market, and the distribution channel for the Argentine wine industry | Gives an integrated general idea of the members of the WSC and the particularities of Argentine wine industry and the USA market. |
| Performance evaluation framework | Key performance indicators for transportation are proposed | No integrated framework to measure performance along the chain. Incomplete information for manager to make decisions which benefits all members. |

### 2.4.1 WSC Models and Performance Measurement benefits

In summary, from this analysis is possible to present a list of some reasons of why it is important for the wine industry partners to count with a model and a performance measurement framework.

Through models of the WSC it is possible:

- to better understand the WSC dynamics, which helps to have a full appreciation of the factors that affect its performance,
- to identify and innovate on strategies for designing high performance supply chain networks,
- to identify bottlenecks,
- to design new processes or improve those that are inefficient,
- to evaluate potential scenarios and reduce uncertainty through simulation,
- to facilitate decision making process

Counting with a framework to measure performance along the WSC is possible:

- to find opportunities to improve performance,
- to detect inefficiencies,
- to know the diagnosis of the wineries with respect to their competitors and the industry leaders which helps to develop new strategies to become more competitive,
- to understand the industry's best practices, through which it is easier for a winery to fulfill the customers' requirements,
- to close the performance gaps for each participant through the definitions of new goals to achieve excellence

In next chapter a model for the WSC is presented identifying the actors, material and information flows, and in the following chapter a framework for measuring performance in the WSC is presented in order to provide a complete set of tools to facilitate the decision making process

# Chapter 3: Supply Chain Descriptive Model

A model for the WSC is presented in this chapter. The objective of this chapter is to propose a complete description of the WSC in order to facilitate the understanding of its dynamics and to set the basis for future analysis and studies. In order to do this, SCM conceptual definitions explained in chapter 2 are adapted to the particular case of the WSC.

In section 3.1 definitions of the proposed conceptual framework for the SC are presented. It is important to identify and to understand three aspects in the WSC: the network, the scope levels present in this network, and the logistic processes that could be found in each of these levels. Section 3.2 presents the definition of actors, roles, a graphical representation of all relations between actors, and material and information flows. This is a static view of the WSC, where all actors and all possible relations are represented. It also includes a detailed list of all actors and the main activities performed by each actor. Two groups of actors are also presented in this section. A classification of all actors of the WSC is made, in order to identify those that are more important for the SC to be more manageable.

Section 3.3 shows different production strategies followed by wineries. Section 3.4 different scenarios are presented in order to complement the static model with dynamic views of material and information flows. Three scenarios are presented, which represent three of the most common instances of the WSC: the local market distribution, external market with 3 tier system in the distribution cycle, and sales in small quantities for the final consumer. A graphical representation and a description of each flow are made in order to complement the model with a dynamic and temporal representation.

In section 3.5 a description of roles integration commonly found in industry is exposed and 6 cases are presented as examples of integration. Finally in section 3.6 some particularities of the WSC as a network of relations and tiers are presented.

## 3.1 Conceptual framework of the Wine Supply Chain

Every SC spans from raw materials to manufacturing, distribution, transportation, warehousing, and retail involving a large number of participants. Processes are interconnected and are interdependent by the flow of materials, information, and money. At each node or actor (company), different types of processes can be performed (procurement, production, assembly, stocking, shipment, sales, etc.).

The network consists of a certain number of suppliers, manufacturers, wholesalers, and retailers who represent nodes in the supply network.

Certain processes are performed at each node. Processes are interconnected within a single node and also between the nodes. This way, a visual presentation of the SC as an array of elements connected with straight-lines is substituted with the network of linked elements. This enables us to model any supply network of any type (supply, production, distribution, etc.) and complexity (few or many nodes) [Stefanovic *et al*., 2009].

The implementation of SCM involves identifying the SC members with whom it is critical to link, which processes need to be linked, and what type/level of integration applies to each process link. In section 2.1 a conceptual introduction to SCM was presented. Considering the WSC, a deeper analysis of these concepts is made. Three interrelated elements compose this theoretical framework: the SC network structure, the SC business processes and the SC management components [Lambert & Cooper, 2000] as shown in Figure 3.1.

*The supply chain network* consists of the actors, the wine companies or firms and the links between these firms. Three structural dimensions are defined in this network. *Horizontal structure* refers to the number of tiers across the SC. The SC may be long, with numerous tiers, or short, with few tiers. A *vertical structure* refers to the number of suppliers/customers represented within each tier. The third structural dimension is the *company's horizontal position* within the SC. A company can be positioned at or near the initial source of supply, be at or near to the ultimate customer, or somewhere between these end points of the SC as can be observed in Figure 3.2.

*Business processes* are the activities that produce a specific output of value to the customer. Traditionally, both upstream and downstream portions of the SC have interacted as disconnected entities receiving sporadic flows of information over time. Operating as an integrated SC requires continuous information flows, which in turn help to create best product flows.

*The management components* are the managerial variables by which the business processes are integrated and managed across the SC, for example planning and control, work structure, organization structure, product flow facility structure, information flow facility structure, etc.

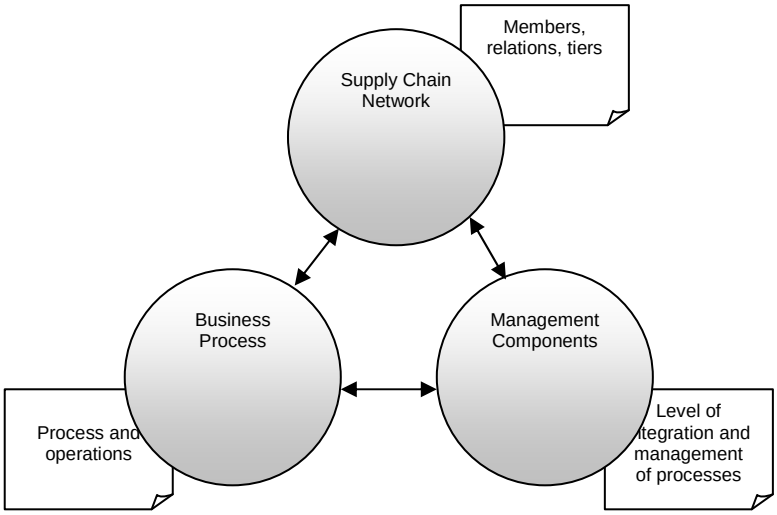


**Figure 3.1:** Conceptual Framework of a supply chain

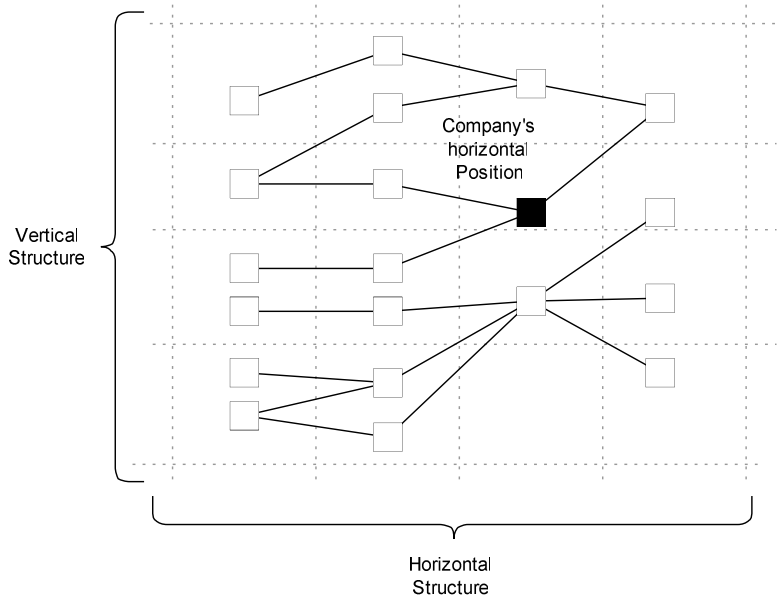


**Figure 3.2:** Network structure

### 3.1.1 Scope Levels of the WSC

Taking into account that the WSC is an agri-supply chain and the network structure is complex (several tiers with several suppliers and customers), the particular point of view of the winery (the principal actor) is used in order to adapt the general scope levels of the SC described in section 2.1 to the particular case of the WSC as follows:

- *Internal supply chain*: the integrated flow of material and information within the winery, from supplier toward the customer. It measures only the performance of the internal processes of the winery.

- *External supply chain*: the integrated flow of material and information within the winery from the direct supplier to the direct customer. It measures the winery's suppliers' performance and the performance of the winery related to its customers.

- *Integrated supply chain*: the integrated flow of material and information within the winery across multiples trading suppliers and customers. It measures the integrated supply chain performance, looking for mutual benefits, from the initial supplier to the final customer.

As it happens in any SC, in every level of the WSC different processes can be distinguished. Each logistics process corresponds to a function the enterprise must implement in order to provide some logistics service needed by its business. In order to identify which processes are present in every actor in the WSC two different approaches have been analyzed.

On the one hand, Frazelle [Frazelle, 2002] distinguishes 5 interdependent logistics processes: *"Customer Response", "Inventory Planning and Management", "Supply", "Warehousing"* and *"Transportation"*. The "Supply" process includes manufacturing and procurement. On the other hand, the SCOR Model [Supply Chain Council, 2008], defines 5 management processes in every organization as described in section 2.1: *"Plan", "Source", "Make", "Deliver"* and *"Return"*. The "Make" process involves several activities such as transforming raw materials into finished goods, and the "Source" process includes all procurements activities.

For this research a mixed schema is used, in which it is important to separate the wine production process from the supply process due to the number of important activities in the elaboration and bottling process. The logistics processes identified in the WSC are: "Supply", "Production and Bottling", "Inventory Management", "Warehousing", "Distribution and Transportation" and "Customer Response", which are described as follows:

- *Supply*: it includes all activities related to the supplies (e.g. corks, capsules and tops, barrels and casks, bottles, labels, chips, yields, etc). Another important supplier is the grape grower, who provides the grapes coming from the vineyards. This process also includes purchase order processing, buying and payment, scheduling of grapes reception, incoming products verification, suppliers payment authorization, identification and selection of supply sources (when not predetermined), suppliers' performance measurement and maintenance of related data, etc.

- *Production and Bottling*: it includes all the activities related to the elaboration process of the wine, production scheduling, weighting of the grapes, crushing, pressing, fermentation, clarification and

stabilization, aging in barrels or steel tanks, quality testing and also all the activities related to the bottling process, which includes the filling, covering, labeling, and packaging process. Wine aging is included because some decisions of aging are made during the elaboration process, like for how long a wine needs to be aged and where, in oak tanks, steel tanks, etc. During the aging process some quality tests are carried out.

- *Inventory Management*: it includes all the activities of planning, inventory administration (documentation, information processing, etc), inventory moving and accounting, and everything needed to assure efficient inventory levels. Some decisions referred to wine aging process are made, for example production forecasting taking into account the storage capacity.

- *Warehousing*: it involves all warehouse management from product reception and picking to loading of the container. It includes putting away process, storage, order picking, packaging, accumulation, and shipping. It can refer to raw materials and component warehouses, or finished goods warehouses. It includes only activities of manipulation of supplies when they arrive from the suppliers and the manipulation of finished goods when customer orders are required.

- *Distribution and Transportation*: It includes all the activities of distribution and transportation of the wine orders to arrive to the customer location. This includes the distribution to the local market and to the overseas market for wineries which export wine. For transporting the wine, multimodal transport is usually used, by land, by air or by sea. All the activities for preparing the transport, researching and planning the most appropriate route for a shipment, arranging appropriate packing, obtaining, checking and preparing documentation to meet customs and insurance requirements, packing specifications, and compliance with overseas countries regulations and fiscal regimes, are some of the activities included in this logistics process. Some examples of transport actors are: freight forwarder, the freight operator, importer, wholesaler and retailer.

- *Customer Response*: includes all the activities related to customer services, order entry, order processing, etc. The demand is the initial point for all logistics activities. All activities must work to satisfy customer expectations [Frazelle, 2002]. For effective performance measurement, SC metrics must be linked to customer satisfaction [Gunasekaran *et al.*, 2001]. A customer request may imply the bottling, packaging, preparation and delivery of the order when the winery follows a Make to Order (MTO) strategy, and it may imply the preparation and delivery of the order when the winery follows a

Make to Stock strategy (MTS) (these strategies are explained later in section 3.3).

## 3.2 Wine Supply Chain Actors and Roles

Every SC consists of several nodes which can be named as "actors" [Gigler, 2002]. Each actor is a character, a link of the chain, a part played by a performer. Examples of actors in WSC are: Raw material supplier (such as suppliers of corks, labels, bottles, capsules, etc), Grape Grower, Wine producer, Wholesaler, Retailer, etc. Figure 3.3 shows the actors of the WSC, who are connected through material flows (represented by continuous lines) and information flows (represented by dotted lines). Even though different products have different customer requirements and cannot be satisfied by a single SC strategy, a generic model of the WSC is presented, which means that it contains the more general SC, and it can be instantiated into many particular cases (these particular cases are described later in chapter 4).

### 3.2.1 Actors description

In this section a description of all actors and their main activities in the WSC is made.

- *Grape Growing Consumables Supplier:*

This is the first actor in the WSC. This actor provides all the consumables needed for the Grape Grower to make his activities. The main activities are:

- Receive the new orders from the Grape Grower
- Prepare the order
- Send the consumables to the Grape Grower
- Store supplies

Some of the products they supply are: Fertilizer, pesticides, seeds, nutrients, enzymes, etc. This actor delivers the supplies to the grape grower. Sometimes they are imported from different countries.

- *Grape Grower:*

The Grape Grower is responsible for the production and harvest of the grapes [GS1, 2005]. This node is one of the most important within the WSC because the final quality of the wine is directly related to the quality of the grapes [Ferrer *et al*., 2008]. From all the factors that influence wine quality, grapes are the most important, then the barrels where wine is aged, the winemaking method, the wine maker, the winery equipment, and the bottling plan [Adamo, 2004].

The main activities of grape growers are:

- Planting the grapes,

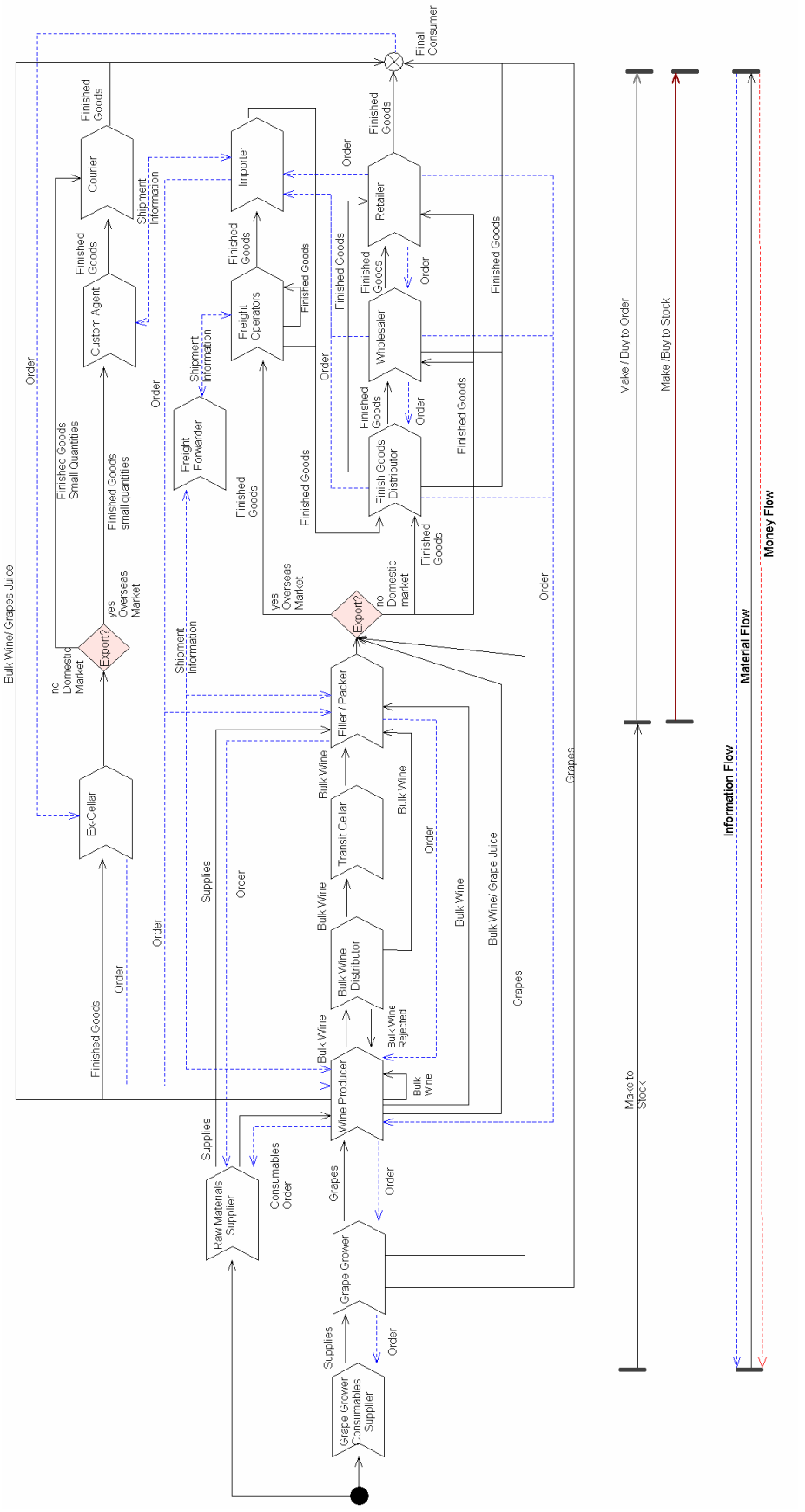


**Figure 3.3:** Wine Supply Chain Representation

- Cultivating and pruning the vines,
- Eliminating the inadequate vineyards,
- Fertilizing the vineyards,
- Controlling plagues,
- Harvesting grapes by machines or by hand (single or multiple grape varieties)

Grape Growers receive orders' information from wineries about the quantity and variety of grapes needed for the production. The harvest is made once a year, and it is an activity which requires great ability and it has to be done in the right time when the grapes are in their optimal maturity [Ferrer *et al.,* 2008]. After the harvest, grapes are transported to wineries using an internal or external means of transport. Grape Growers can also export grapes to foreign countries and they can sell grapes directly to final consumer.

♦ *Raw Materials Supplier:*

This actor provides Wine Producers and Fillers/Packers with all the supplies needed for winemaking or filling and packaging. This node is very important in the WSC, because supplies are critical and sometimes wineries suffer losses due to delays in supplies deliveries.

The main activities are:

- Receive new orders from Wineries and/or Fillers /Packers,
- Prepare orders, send supplies to the Wineries and Fillers /Packers,
- Store supplies

Some of the products they supply are: Corks, capsules and tops, barrels and casks, bottles, labels, chips, sticks, wine yeast, winery equipment, etc.

♦ *Wine Producer:*

Wine producers are responsible for receiving grapes, the elaboration, manufacture and/or blending of wine products. The transformation from juice to wine may require numerous steps, but the wine is always made using the same basic process [GS1, 2005]. Many procedures and operations are performed. Depending on the type of wine that is going to be produced the process is different [Llera & Martinengo, 2004]. In general the main activities to elaborate wine are:

- Receiving and weighing the grapes,
- Crushing, stemming and pressing juice,
- Addition of sulfite and decant,
- Addition of yeast,
- Fermentation,

- Refrigeration,
- Clarification and stabilization,
- Temperature control,
- Storage in stainless steels tanks, oak barrels, etc.,
- Filtration,
- Preparation for bottling, maturation in bottle,
- Bottling

Different wine segmentations can be made according to the quality of the wine, the market segment and the price of the wine. One classification is proposed in [Chiodo & Fantini, 2006] which helps to identify the level of the wine as basic (1.10 euros), premium (6 euros) super premium (15 euros). Another classification is presented in [Benson-Rea, 2005] who propose Icon, Ultra Premium, Super Premium, Premium, Commercial and Commodity levels but it does not mention the prices.

Another market segmentation is presented in [Korda Mentha, 2007], which propose Icons ($50), Ultra Premium (15-50$), Super Premium (10-15$), Premium (5-10$) and Basic (5$). In [Colman & Päster, 2007] "table" wines in the United States are those sold below $5, "premium" ($9 - $16 per bottle) and "ultra-premium" ($16+) wine.

Considering these classifications and the elaboration process, five quality levels of wine are obtained, depending not only on the activities performed during the elaboration process, but also, and more important, on the grapes quality. According to the definitions described before and those appeared in [Pompelli & Pick, 1999; Geene *et al.*, 1999] the wine goes from basic to icon wines:

- *Basic*: is the more basic wine, it does not take much time of aging. The grapes come generally from several vineyards (priced under $5 per bottle).

- *Premium*: the wine has been aged during a few months. The grapes come from different vineyards but they have better quality (priced from $5 to $7 per bottle).

- *Super premium:* Aged for a minimum of two years (at least 6 months in oak). Grapes come from qualified vineyards (priced from $7 to $14 per bottle).

- *Ultra premium:* is a quality wine, aged at least three years, one in an oak cask and two years in the bottle. It is made from top vineyards (priced from $14 to $50 per bottle)

- *Icons*: are aged at least two years in oak plus another three in the bottle. All great icon wines are made from exceptional vintages (priced above $50 per bottle)

It is very important to define the segment of wine that will be produced, not only because the amounts of resources used will be different depending on the segment, but also because the quality of the grapes is higher if the winery produces ultra premium wine than if it produces basic wine. Several aspects of the WSC will be different depending on the segment of wine produced [Adamo, 2004], such as the number and quality of vineyards, the number of suppliers, the quality of supplies, the packaging and labels of the wine, etc. This topic is explained in detail in section 3.8 where the WSC is seen as a network.

Wine can be sold either packed (bottles, bag in box, tetra pack) or bulk wine (flexitank, tanktainers, barrels, etc.) as shown in Figure 3.3. Wine Producers can also export grape juice which is a sub product obtained during the elaboration process, and also bulk wine. They receive orders from the Finished Goods Distributor, Wholesaler, Retailer, Ex-Cellar and the Importer. Bulk wine may be sent to a Filler/Packer for filling and packing, to another Wine Producer for inclusion as "top-up" (addition of this wine to another one) or for blending, or even to the final customer through the cellar door sales and/or to the Ex-cellar.

- *Bulk Wine Distributor:*

The bulk distributor is responsible for reception, storage, dispatch, processing, sampling and analysis of bulk wine [GS1, 2005]. The bulk distributor receives bulk wine from the Wine Producer. The wine is usually pumped into transport containers such as road tankers or barrels. When the wine arrives at the "tank farm", the bulk distributor checks the receiving documents and takes samples for tasting and analysis. He approves or rejects the wine (if rejected, the wine returns to the nominated source). Two distinct processes are then identified:

1. Storage and dispatch of bulk wine without any blending or any other processing.
2. Storage, blending of different wines and dispatch of the new bulk blended.

The bulk distributor sends batches of wine to the Transit Cellar or to the Filler/Packer.

- *Transit Cellar:*

The transit cellar is responsible for the reception, storage, dispatch, processing, sampling and analysis of bulk wine [GS1, 2005]. The transit cellar

can be part of the filler/packer company (geographically separated or not) or can be outsourced.

The transit cellar receives bulk wine from bulk distributors in different kinds of containers. During the transit cellar stage, the wine is prepared for onward sale and filling. It is loaded for transit to the customer and is accompanied by all the appropriate documents.

The Transit Cellar sends batches of bulk wine to the Filler/Packer. If the Transit Cellar is part of a complex cellar, then the wine is moved through pipes to the filling section, rather than in bulk containers.

- *Filler/Packer:*

Fillers/packers are responsible for the reception, storage, processing, sampling, analysis, filling, packing and dispatch of finished goods [GS1, 2005]. The filler/packer receives containers of bulk wine from the Wine Producer, the Bulk Wine Distributor or the Transit Cellar, and then the wine is filled into different kinds of packages. Consumer units, such as bottles, bag-in-box, tetra packs, etc. are produced from the wine batches supplied. The next step is the packaging of the consumer units into cartons and pallets or other logistic units. Examples of customer logistic units for the case of bulk wine are flexi-tanks, tanktainer, kegs or barrels, etc. The filler/packer dispatches logistic units to the Finished Goods Distributor or the Freight Forwarder/Operator, depending on the distribution strategy.

- *Ex-Cellar:*

This actor directly connects the final customer with the wine producer, cutting out the middle and the large intermediaries. The ex-cellar buys from different wine producers and sells to the Final Customer. If the customer is from an overseas country the ex-cellar utilizes a custom agent to deal with exportation/importation legal aspects and sends the orders through a Courier (usually by air) to the final customer. If the customer is local the ex-cellar sends the order directly to the final consumer.

- *Custom Agent:*

This actor negotiates with the ex-cellar the legal conditions, the payment, and the needed documentation to send the order to the destination country. He also controls the packages and delivers the finished goods to the courier.

- *Courier:*

This actor delivers small wine orders to the final customer. Couriers are distinguished from ordinary mail services by features such as speed,

security, tracking, signature, specialization and individualization of services and committed delivery times. As a premium service, they are more expensive. This actor is generally used in both overseas market for small orders and in local market, for orders sent directly to the final customer.

- *Freight Forwarder:*

A Freight Forwarder organizes the shipment planning, which is the process of choosing shipment frequencies and deciding for each shipment which orders should be assigned, it includes also the safe and efficient movement of goods on behalf of an exporter, importer or another company or person, sometimes including dealing with packing and storage. Taking into account the type of goods and the customers' delivery requirements, freight forwarders arrange the best means of transport, using the services of shipping lines, airlines or road and rail freight operators. In some cases, the freight forwarding company itself provides the service.

Typical activities include [Frazelle, 2002]: researching and planning the most appropriate route for a shipment (taking into account the nature of the goods, cost, transit time and security), arranging appropriate packing (taking into account climate, terrain, weight, nature of goods and cost) and delivering or warehousing of goods at their final destination. Other activities included are obtaining, checking and preparing documentation to meet customs and insurance requirements, packing specifications, and compliance with overseas countries regulations and fiscal regimes, offering consolidation services by air, sea and road, liaising with third parties to move goods (by road, rail, air or sea) in accordance with customer requirements, arranging payment of freight and other charges, or collection of payment on behalf of the client, etc.

- *Freight operators:*

They supply service for transporting goods from the Winery to the Importer or to other actors (Distributor, Wholesaler, Retailer, etc.), by air, through airline services, by sea through shipping lines or by road and rail through different operators. The courier could be an express/parcel carrier trucking company, an ocean liner, a railroad or an air carrier/integrator [Frazelle, 2002].

- *Importer:*

This actor buys goods from the Wine Producer and is responsible for the reception, storage, inventory management and dispatch of finished goods, which receives from the Freight Forwarder through the Freight Operator. The Importer sales and delivers finished goods to the Wholesaler or Distributor of the destination country depending on the distribution channel

of the country. The Importer receives orders from the Wholesaler, Retailer or Finished Goods Distributor and place orders to the wineries, based on the demand they receive from the customers and taking into account the current stock levels.

- *Finished Goods Distributor:*

The Finished Goods Distributor is responsible for the reception, storage, inventory management and dispatch of finished goods, as well as re-packing and re-labeling as required [GS1, 2005]. The Finished Goods Distributor receives pallets and cartons from the Filler/Packer at the domestic market and from the Importer if it is from external market. The Finished Goods Distributor may also re-pack and re-label the products as per specific customer requirements. This actor dispatches cartons and pallets to the Wholesaler or Retailer. This actor receives orders from the Wholesaler or Retailer and puts new orders to the Importer in the case of external market, and to the Wine Producer in case on domestic market.

- *Wholesaler:*

The Wholesaler receives pallets and cartons from the Finished Goods Distributor and picks and dispatches goods to the retails stores. The Wholesalers' sales staff visits the retailer and during the visit the seller goes through the retailer's inventory, suggesting replenishment of products as needed, and suggesting orders for new products in the case of small and mediums retailers. In some cases, for big retailers like supermarkets the communication is different due to existence of information systems. They put new orders to the Finished Goods Distributor, to the Importer and he may also buy directly from the winery.

- *Retailer:*

The Retailer receives finished goods from the Finished Goods Distributor or the Wholesaler depending on the distribution channel. The retailer sells consumer units (bottles, cartons) to the Final Consumer. The different sales' channels are: hyper/ supermarket, liquor store, drugs stores, specialist store, HORECA (Hotels, restaurant, catering), clubs, etc. The retailer must send the order to the Wholesaler taking into account the inventory and the demand of the market or he may directly buy from the winery.

- *Final Consumer:*

This is the final customer of the SC. Final customers may buy finished goods directly from some wineries, or they can make an indirect order of new products when they go to the store or supermarket and chose some kind of

wine. These orders are almost always placed in-site during the customer's visits to the retailer's shop [Adamo, 2004].

### 3.2.2 Grouping of actors

In order to make a very complex network more manageable, it seems appropriate to distinguish between primary and supporting members. Primary members of a SC are all those autonomous companies or strategic business units who carry out value-adding activities (operational and/or managerial) in the business processes designed to produce a specific output for a particular customer or market.

In contrast, supporting members are companies that simply provide resources, knowledge, utilities, or assets for the primary members of the SC. For example, supporting companies include those that lease trucks to the manufacturer, banks that lend money to a retailer, the owner of the building that provides warehouse space, or companies that supply production equipment, print marketing brochures, or provide temporary secretarial assistance [Lambert & Cooper, 2000].

In the particular case of the WSC there are primary and supporting actors as shown in Table 3.1.

**Table 3.1:** WSC Actors Classification

| Actor | Primary | Supporting | Cycle |
|---|---|---|---|
| Grape Grower Consumables Supplier | X | | Supply |
| Grape Grower | X | | Supply |
| Raw Material Supplier | X | | Supply |
| Wine Producer | X | | Production |
| Bulk Wine Distributor | | X | Production |
| Transit Cellar | | X | Production |
| Filler Packer | X | | Production |
| Freight Forwarder | | X | Distribution |
| Freight Operator | | X | Distribution |
| Importer | X | | Distribution |
| Finished Goods Distributor | X | | Distribution |
| Wholesaler | X | | Distribution |
| Retailer | X | | Distribution |
| Ex- cellar | X | | Distribution |
| Custom Agent | | X | Distribution |
| Courier | | X | Distribution |

The complete WSC presented in section 3.2 can be divided in 3 parts or cycles as was defined in section 2.1. Each actor belongs to a particular cycle of the SC. The *supply cycle* involves the Grape Grower Consumables Supplier, Grape Grower, and Raw Material Supplier; the *Production Cycle*

includes Wine Producer, Bulk Wine Distributor, Transit Cellar and Filler/Packer; the *Distribution Cycle* which includes the Freight Forwarder, Freight Operator, Importer, Finished Goods Distributor, Wholesaler, Retailer, Ex-Cellar, Custom Agent and Courier as shown in third column in Table 3.1. These cycles are used in the next section to exemplify different instances of the generic model proposed.

### 3.3 Production strategies in the WSC

From the point of view of the relationship between order arrival and production release, production systems can be classified into make to stock / buy to stock (MTS/ BTS) or make to order/ buy to order (MTO/ BTO). For a MTS system, finished or semi finished products are produced to stock according to the forecasts of the demands. In a MTO system, work releases are authorized only according to the external demand arrivals [Zaerpour *et al*., 2008].

In the WSC there are different production strategies in different stages due to the nature of wine making process. Two stages are identified considering the activities along the SC. One covers from the Grape Grower until the Filler /Packer and the other from the Filler /Packer to the Final Consumer as shown in Figure 3.3

During the first stage, a MTS strategy is followed by the Grape Grower because grapes are harvested once a year [Adamo, 2004]. They cannot be harvested on demand. After the vintage, grape growers have specific time windows in which they can sell their production. Also Wine Producers during elaboration process follow this strategy because fermentation process has to be done after the harvesting. This makes it impossible to implement MTO strategies in the first part of the SC.

In the second stage from the Filler/Packer forward, which is the distribution cycle, two strategies can be followed:

- MTO/BTO: For a certain wine, wineries can have different labels and packaging due to the customer's demands and the destination country, which represents different Stock Keeping Units (SKUs). Because of this, sometimes wineries delay filling and packing activities until the moment the order arrives, following a MTO strategy [Adamo, 2004]. This has some consequences: it increments the lead-time for an order when it enters the system, it lowers the financial operational cost and inventory of finished goods, it is simpler to customize an order that has labeling requirements, or packaging requirements, for example for exportation, where the wine is the same, but the packaging and labels are different, etc. With respect to

the following actors in the WSC (Importer, Distributor, etc.), they can put their purchase orders when they receive customers' orders.

- MTS / BTS: in contrast, for most ordered wines, actors can have stock of bottles which are delivered when the order comes. Actors of distribution cycle buys and stock bottles and then they can push these wines to the market through the different sale channels.

Wineries act as a buffer between these two stages, and can follow different strategies when the order comes, depending on the product to elaborate, the destination country of the customer, the moment of the year, etc. A combination of them can be an alternative for searching better lead times. Different alternatives, shown in Figure 3.4, are described as follows:

a. *Bottle to order:* this process includes the filling, covering, labeling, packing, preparation and delivering of the order when it comes in.

b. *Label to order:* in this case the wine is already bottled and covered but when the order comes in, the labeling and packing processes begin and finished goods are delivered.

c. *(Re)Pack to order:* in this case the wine is already bottled and labeled, and when the order comes in the only thing to do is to pack the bottles and deliver them. Another alternative is that bottles are already packed in cartons, and they must be repacked when a special product-mix is required.

d. *Prepare and Deliver to order:* in this case bottles are already filled, labeled, covered, packed and ready to be picked and delivered.

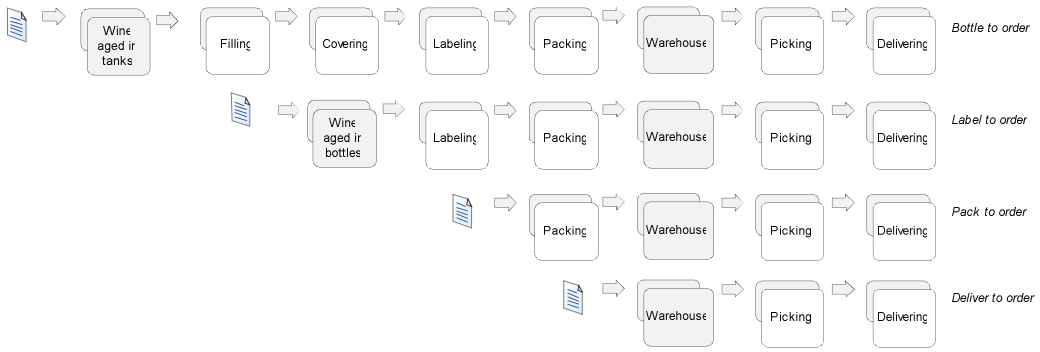


**Figure 3.4:** Winery's elaboration strategies

## 3.4 Special scenarios of the WSC

From the generic model of the WSC presented in Figure 3.3, it can be observed the high complexity of the SC due to the number of actors, the relations between actors, the different ways of distribution in local and external market, etc. There are a lot of possible scenarios in the WSC. For a better understanding and for analyzing in detail their dynamics, in this section three different scenarios are presented: a SC which distributes in the local market; a SC which sells to overseas market with 3 tiers system in the distribution cycle and a SC which sells to the final consumer in small quantities. These three selected cases are the most common, the most representative and those which are important to be analyzed. For each case, static and dynamic representations are presented, in order to complement the analysis.

### *1- Local market distribution*

For this case, in the distribution cycle there are 8 possible ways of distribution as shown in Figure 3.5. Supply and production cycles in this particular case do not change with respect to the way they appeared in the generic model. Only distribution cycle for the local market is shown in this figure.

These 8 cases correspond to distribution through:

1. The 3 tiers system composed of
   - Distributor -> Wholesaler -> Retailer->Final Consumer
2. Wholesalers and Retailer
   - Wholesaler->Retailer-> Final Consumer
3. Retailer
   - Retailer->Final Consumer
4. Direct distribution from Finished Goods Distributor
   - Distributor->Final Consumer
5. Finished Goods Distributor and Retailer
   - Distributor->Retailer->Final Consumer
6. Distributor and Wholesaler
   - Distributor->Wholesaler->Final Consumer
7. Wholesaler
   - Wholesaler-> Final Consumer
8. Direct sales to Final Consumer
   - Cellar door sales->Final Consumer

### *1-A) Make/Buy to stock strategy*

A dynamic representation of information and material flows is presented in Figure 3.5. In this figure a sequence of the information and material flows between primary actors is shown in order to better understand and

complement the static view and the model proposed. In this case there is a roles integration between the Wine Producer and the Filler/Packer to simplify the graphical representation. Two strategies can be followed in each particular case: Buy/make to stock or buy/make to order.

Figure 3.6 shows a Make/Buy to stock strategy. It shows the order of the information and material flows that are exchanged when actors in the distribution cycle, follow this strategy. This is a common strategy followed in distribution cycle because some actors have long lead-times and it is better to have stock to respond to demand than to wait for the order to arrive.

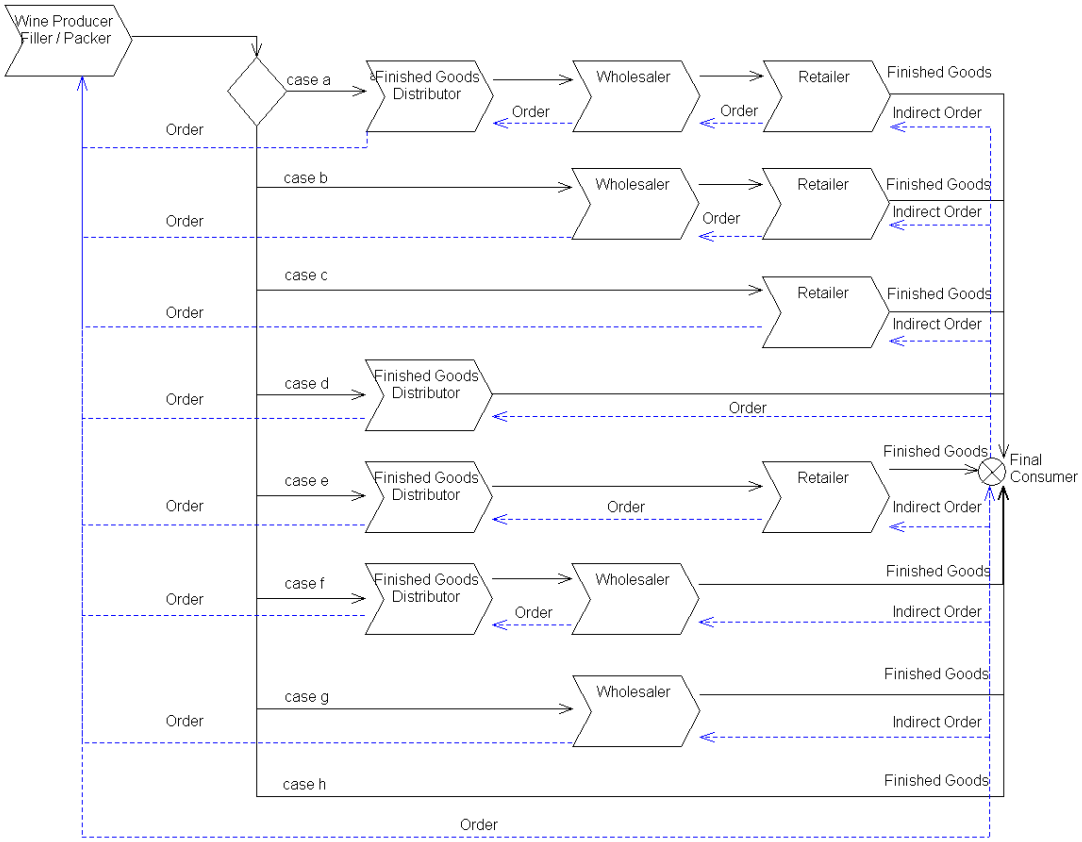


**Figure 3.5:** Local market distribution

Depending on the case (a-h) the figure shows how flows take place during time, in order to respond to market's demands. As an example case "a" is described. Each actor of the distribution cycle holds stock in their warehouses. In the case of Retailers, when the final consumer buys wines the stock level is reduced. Depending on the stock management strategy, the retailer decides when and what to buy from wholesaler to recover the stock level of the sold wines. Sometimes wholesalers visit the retailers' stores in order to offer new wines, brands, etc.

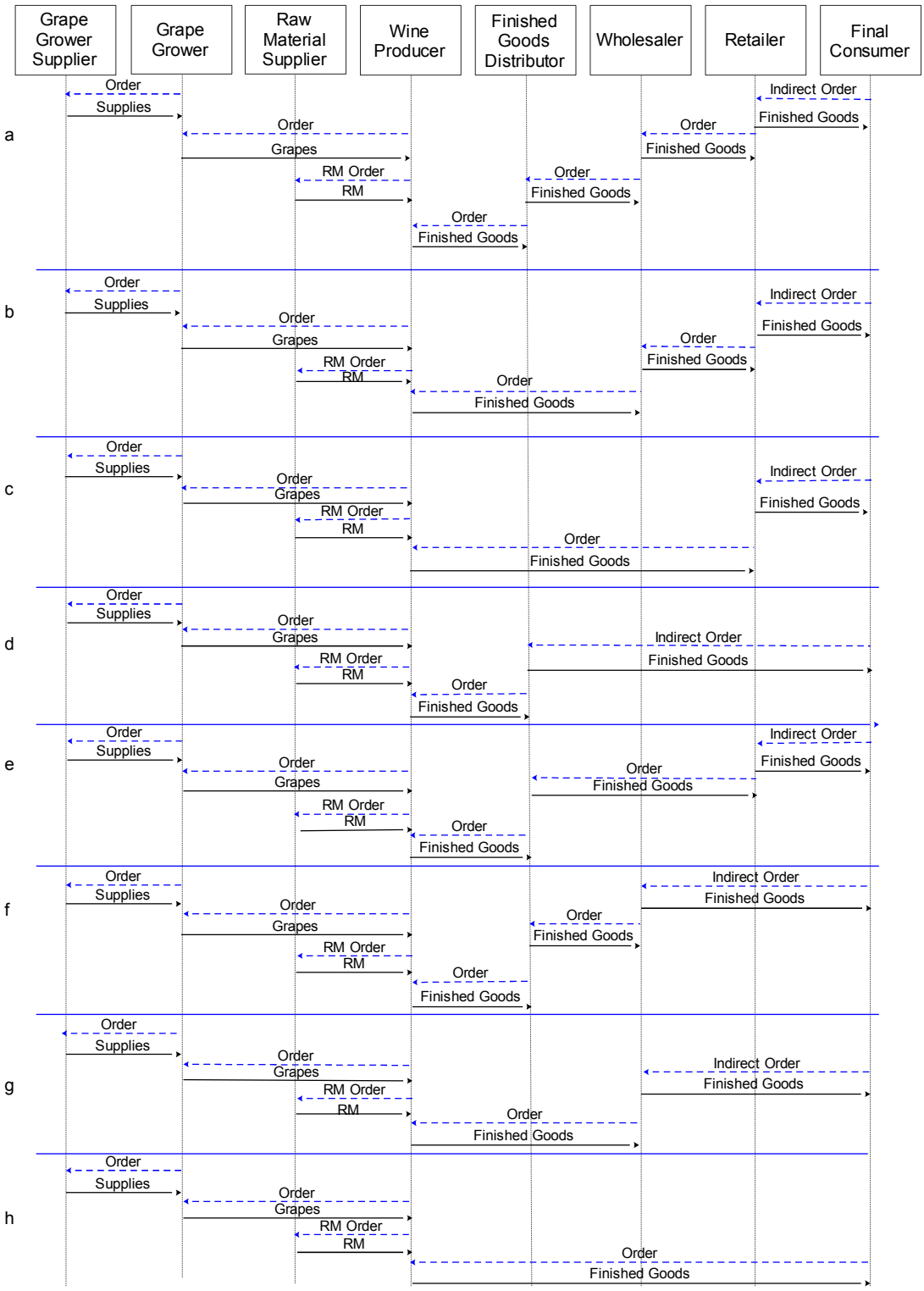


**Figure 3.6:** WSC Distribution to Local market. Buy /Make to stock strategy

The wholesaler follows the same process. Whenever he considers that it is necessary to increment its inventory, he places the order to the finished goods distributor to reach the desired stock level; he always satisfies the

client with products in stock. Similarly the Finished Goods Distributors places the order to the wineries, whenever the stock level goes below the desired level.

When Wineries receive orders, they may respond differently depending on the production strategy and the product ordered. In the case of a make to stock strategy, they will deliver the order already bottled and packed. Generally bottles are staged waiting for customers' order to start preparation process in the warehouse of the winery.

***1-B) Make/Buy to order strategy***

In Figure 3.7 a buy/make to order strategy is represented. This strategy is not common in the distribution cycles due to the nature of the product and the long delivery lead times of actors. Considering the definition of APICS[3], the lead-time is:

1- A span of time required to perform a process (or series of operations).
2- In a logistics context, the time between recognition of the need for an order and the reception of goods [APICS, 2008].

If a retailer has to wait the arrival of the order from all the tiers, he would lose sales. However this strategy could be followed by other actors if they can appropriately manage the lead-times of the other actors of the WSC. In Figure 3.7 the information flow can be observed. Each actor puts the order to the upstream actor in the WSC as soon as the order from its customer comes in. Wholesalers define the order quantities based on retailers' demands and their own forecasts based on experience. Finished goods distributor defines the order quantity based on the actual demand from wholesalers, and forecasts mostly based on their own experience [Adamo, 2004]. In the case of the winery, when the order comes from the Finished Goods Distributor, it may follow different strategies:

- *Bottling to order and delivery*. The wine is staged in barrels and the process of bottling (including filling, labeling and packing) is made following customer specifications.

- *Labeling to order*. Bottles are already filled and the labeling process is made following customers requirements.

- *Packing to order*. Bottles are already filled and labeled; packaging process is made following customer specifications.

[3] The *APICS Dictionary* is the standard for defining terms used in the operations management field

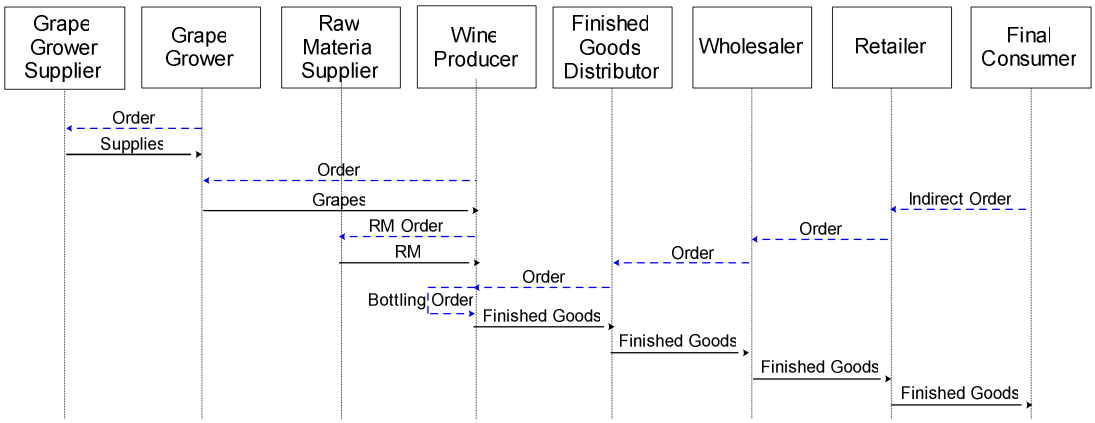


**Figure 3.7:** WSC Distribution to Local market. Buy / Make to order strategy

## 2- *External Market with 3 tier system in distribution cycle*

In this case the wine is distributed to external market through the importer. The importer buys wine from different wineries and sells it using the 3 tiers system for delivering, which is composed of finished goods distributor, wholesaler, and retailer. The winery uses the service of a freight forwarder to coordinate the shipment. The freight forwarder, in turn, uses the services of a freight operator to transport the wine. Figure 3.8 shows the static diagram of actors, material and information flows.

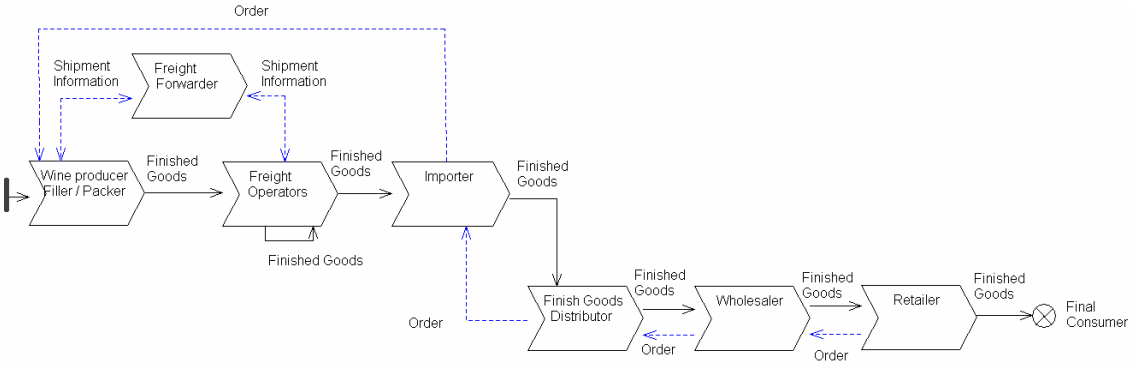


**Figure 3.8:** External Market with 3 tier system

In Figure 3.9 a dynamic diagram of material and information flow is presented. In this case a mixed make/buy to stock and make/buy to order strategy is depicted. In this case, each actor of the distribution cycle holds stock to respond to the demand, while the winery bottles wine to order.

It is important to note that Finished Goods Distributors, Wholesalers and Retailers could eventually apply both strategies (MTS-MTO) depending on the objectives of each actor. The case of the Importer, on the other hand, is special: this actor should always implement buy to stock strategy, due to the long lead-times of wineries from overseas countries. Generally the lead-time of distribution of the wine from producing countries to importers is very

long. As a consequence, an alternative must be used by importers to respond to demand while expecting the freight.

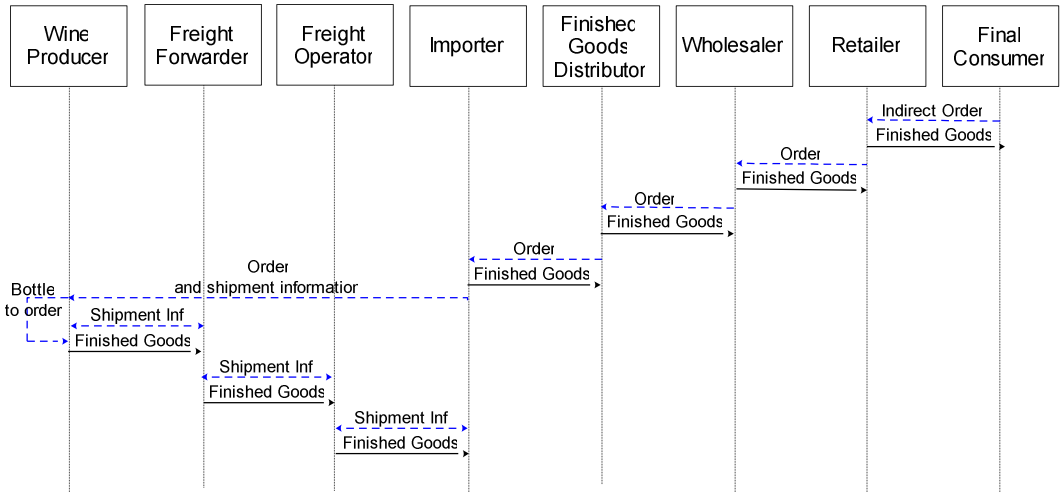


**Figure 3.9:** Make or buy to stock/ - External market with 3 tier system in distribution cycle

When the winery receives the order, it can perform some of the following actions, depending on the strategy:

- Deliver the order (MTS)
- Pack and deliver the order (PTS)
- Bottle and deliver the order (BTS)
- Label, pack and deliver the order (LTS)

### *3- Sales in small quantities for final consumer*

In this case a SC of ex-cellar is represented in Figure 3.10. The ex cellar sells directly to final consumer different kinds of wines, from several wineries, through web pages, but in small quantities. This is a way to get closer to the consumer, and to avoid many intermediaries.

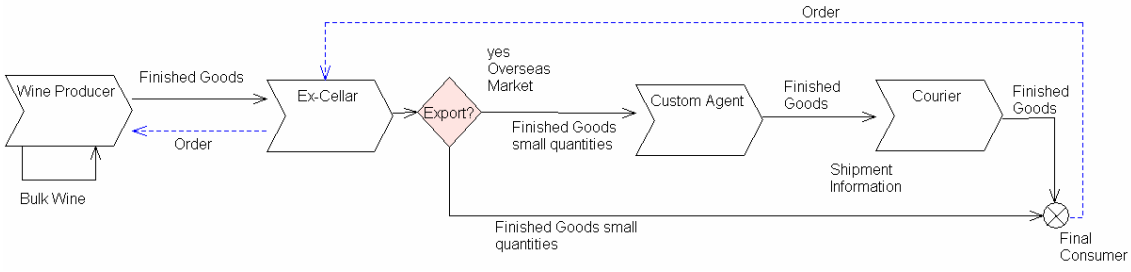


**Figure 3.10:** Ex-Cellar supply chain

In Figure 3.11 a dynamic representation of information and material flows are presented for the case of the ex-cellar SC. In case "a" an exportation is made using the services of the custom agent and the courier that is generally made by plane. If the consumer is from local market any local distribution mean may be used (e.g. truck). In both cases the final consumer makes the

order directly avoiding intermediaries, through web pages to the ex-cellar which will buy in small quantities to several wineries to complete the order and it will send the products by courier.

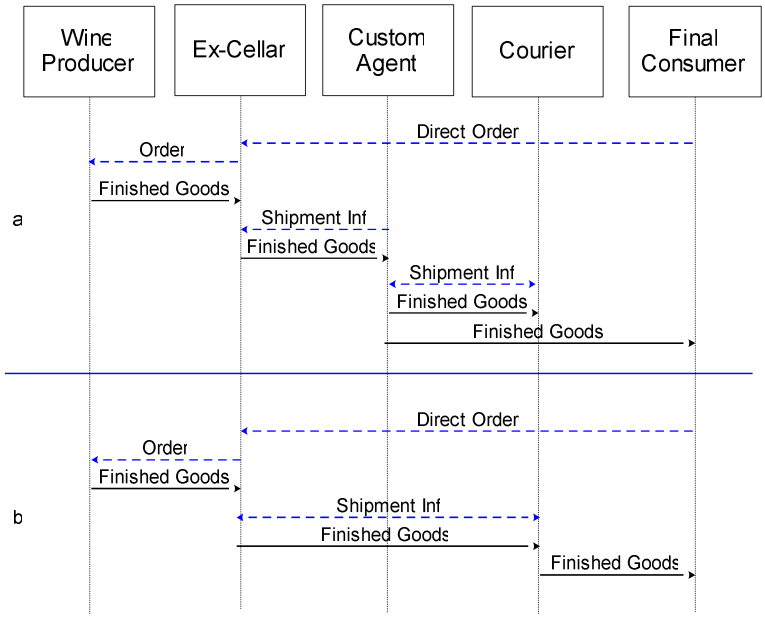


**Figure 3.11:** Ex-Cellar for external and local distribution

## 3.5 Roles Integration

In the WSC the same actor can play more than one role. Because of this role integration, one actor can cover two, three or more links in the SC. Here are some examples of roles integrations in the WSC:

1- *Grape Grower/ Wine Producer Integration*: Wine Producers can have their own vineyards destined to top quality wines, and their own means of transport to move grapes. Another situation is backward consolidation from the side of wineries by buying complete grape productions from grape growers. There also exist forward integrations from the side of grape grower by creating cooperative wineries [Adamo, 2004].

2- *Wine producer/ Bulk Wine Distributor Integration*: The Wine producer can have his own means of transport to carry the bulk wine to the transit cellar

3- *Wine producer / Bulk Wine Distributor / Transit Cellar Integration:* In the same facility the winery ages the wines, with no need to transport the wine to other place.

4- *Wine producer / Bulk Wine Distributor / Transit Cellar/ Filler Packer Integration:* The Wine Producer can do in the same facility the filling and packing of the goods with no need of transporting the goods to a transit cellar.

5- *Grape Grower/ Wine producer / Bulk Wine Distributor / Transit Cellar/ Filler Packer Integration*: Sometimes the company can have the vineyards at the winery, the production plant, and make in the same place the filling and packing of the bottles, with no need of transporting the wine.

6- *Freight Forwarder / Freight Operator integration*: In the case of external markets, instead of using an external freight operator, the freight forwarder may provide the physical transportation service of goods to destination countries.

In previous section a description of all actors in the WSC was made. It is important to have in mind when determining the network structure that is necessary to identify who the members of the SC are. Including all types of members may cause the total network to become highly complex, since it may explode in the number of members added from tier level to tier level. The strength of the relationship at different points in the SC will differ according to strategic alliances or negotiation forces. Management will need to choose the level of partnership appropriate for particular SC links [Lambert & Cooper, 2000]. Not all links throughout the SC should be closely coordinated and integrated. The most appropriate relationship is the one that best fits the specific set of circumstances.

### 3.6 The WSC as a network.

The WSC can be seen as a network of relations between the actors who participate in the SC. Considering this view and the definition of wine's segments previously described, each wine segment has its own WSC, which means that the number and instantiation of actors will be different depending on the segment of wine the winery produces. For example if a winery only produces basic wine, the number of grape growers will be larger than for the case of another winery that only produces ultra premium wines and has its own vineyards. The difference in the wine quality is the result of the steps through which the wine has passed and the quality of the grapes used.

Some particularities are present in this section considering these wine segment differences. In basic wines SCs:

- Wineries buy grapes form a large number of vineyards of low or basic quality.

- The wine producer receives grapes (could be already crashed) from different and various grape growers, which means that they can receive different qualities of grapes. They may also buy wine to blend it with their own production or label it under different brands [Adamo, 2004].

- The number of raw material suppliers is large, most of which are from local market, and the quality of the supplies is low; the customization of new products is limited.

- There are many small wine producers that produce basic wines and has low level of IT communications and technology in industrialization. Small producers can not access to big systems (ERP, OLAP, etc.).

- During the wine making process a variety of qualities of grapes participate.

- Most of the wine produced is delivered to the local market.

- There are a lot of wholesalers and retailers.

- Long time relationships between grape growers and wine producers are not critical.

- Wineries produce large volumes of wine using less capital.

On the other hand, in premium, ultra premium and icons wines SCs:

- Premium wineries need to be able to control grape production process.

- Each winery which produces premium, icons or ultra premium wines has its own vineyards or they establish strong and long time relationships with grape growers, because the quality of the grapes is essentials for the wine quality.

- Sometimes the wineries help their grape suppliers to improve the quality of the vines, they work together with long terms goals like what to plant, how much to plant, etc.

- The geographic region of the vineyards is very important to the quality of the grapes, like the climate, and the proximity to the winery in order to avoid spending too much time during transportation.

- During the wine making there are processes of quality assurance to obtain in each step of the production the best quality of the wine. Most of the wineries that produce high level wines certify international quality standards (HCCP, GMP).

- There is a higher technology level in these wineries. For the bottling process there are automated machines with high capacity of filling, covering and labeling.

- The integration of roles is large. The wineries make the filling and packing in the same facility or enterprise, and they age the wine in the same place.

- There is a lot of exportation of wine to overseas countries.

- In some cases cork suppliers are from foreign countries.

Considering the wine segment aspect, these are some of the main differences observed in the WSC structures. The number of integrations also is related with the capital of companies (e.g. smaller producers have to outsource activities due to the size of the company).

# Chapter 4: Potential Issues in the Wine Supply Chain

The objective of this chapter is to identify and formalize the potential problems that can arise along the WSC and to analyze the causes of these problems. Section 4.1 defines performance attributes according to which potential problems are categorized. Section 4.2 presents the potential problems identified, classifying them following performance attributes, then an analysis of the causes of problems is made and finally possible alternative solutions are proposed wherever it is possible.

The WSC is very complex due to several factors, which should be correctly managed in order to realize benefits for all members of the supply chain. These factors are the number of actors who participate to fulfill the customer's requirements, the nature of the product produced, SC's operation which includes among other things the culture, agricultural, and industrial practices and legal issues of each country, the segment of the wine to be produced, the destination country, the means of transportation, the isolation during transportation, etc. Considering these characteristics, there are potential problems that could arise to fulfill final consumers' demands. In order to understand each problem it is necessary to define performance attributes which are used to classify the problem.

## 4.1 Performance Attributes

Performance attributes represent aspects through which performance can be measured and through which potential problems can be identified. Since every business competes on the basis of financial performance, productivity performance, quality performance, and cycle time performance, measures should fall into those same categories. Four performance attributes are identified related to logistic processes in the WSC [Garcia *et al.*, 2009]:

1. *Quality*: both the quality of the product and of the processes are important to accomplish the customer service level. Consumers expect really good level in wines; it is easy for them to switch from one brand to another if they are not satisfied with the cost-quality relation. To reach desired quality levels, all logistics processes involved in production, preparation and delivery of the product must work over a minimum defined efficiency level. Measuring the logistics processes and products quality performance is the way to improve these processes and at the same time ensure that customer's satisfaction levels are met.

2. *Timeliness*: in the dynamic environment in which an organization has to compete, it is important to measure the response time of the SC to

satisfy the customer's requirements. It is particularly important for the wineries, which export wine to different countries, where the time and the quality of the products can make the difference between success and failure in a market.

3. *Logistics Costs*: measuring and improving logistics financial performance helps to improve corporate financial performance [Frazelle, 2002]. The purpose of this research is not to get involved in details of financial indicators, but only to recognize that there are logistics costs that must be taken into account at the moment of defining the measurement systems and the indicators in any organization.

4. *Productivity and Capacity*: : the amount of logistics resources, their utilization and the capacity required to provide the desired customer service level, must be measured to improve the productivity and to increase the customer's satisfaction. Capacity utilization directly affects the speed of response to customer's demands. By measuring capacity, gains in flexibility, lead-time and delivery will be achieved [Gunasekaran *et al.*, 2001].

## 4.2 Potential Logistics Problems in the WSC

Within the WSC, there are problems are controllable, which means that companies can do something to avoid or reduce them, and others are uncontrollable, like weather problems. A list of the most relevant potential problems in the WSC is presented grouped according to the performance attributes previously described. In order to have a better idea of the sources of these problems, an analysis was made and a description of the possible causes for each one is presented. In the next sub-sections different problems classified by performance attribute are presented.

### 4.2.1 Problems Related to Quality

It is very important to assure not only the quality of the products, but also the quality of logistic processes involved along the supply chain of the wine. There are some problems related to the quality of the products or supplies, and there also exist problems related to the quality of the processes.

The quality of grapes has a high impact on the quality of the produced wine. There are some problems related to the quality of the grapes, for example when grapes do not reach optimal conditions due to climate, like humidity or environmental pollution. This will have economic impacts, as wines which should have been of good quality need to be degraded to inferior ones. This sequential degradation process of the grapes results in loss of revenue for the business, since the profit of a premium wine is much higher than one

obtained by the bulk wine [Ferrer *et al*., 2008]. In addition, grapes which have been infected (for example by botrytis), are very susceptible to oxidation, and hence it is recommendable to use only healthy grapes for winemaking [Dharmadhikari, 2008a]. This is attributed to weather conditions and environmental factors. This is usually a measurable problem. Lot of research has been done in order to fight weather problems affecting the vines (like hail), and some solutions have been proposed, such as anti-hail mesh, which are being used in some vineyards.

Another cause of bad conditions in grapes is related to pickers' training, because grapes are broken when picked what deteriorates the quality of the grapes. This is a problem that is controllable by grape growers but it is not measurable with an indicator in the proposed framework. A low ability in pickers can be solved with training, but costs are high for grape growers as the number of pickers is large.

Bad grape conditions can also be attributed to out of time harvest. Grapes are not necessarily harvested at their optimal maturity, which may imply the potential deterioration of the grapes and subsequent effect on the quality of the wine. This could be attributed to lack of information systems which shows the level of maturity of the grapes. No planning or scheduling tools are used to support harvesting decisions of vineyard administrators and enologists. An alternative of solution is proposed in [Ferrer *et al.*, 2008] which proposes a practical tool for optimally scheduling wine grape harvesting operations taking into account both operational costs and grape quality. This could be a measurable problem.

Another problem related to quality of the wine are the conditions to which grapes are exposed during transportation. They suffer long waiting time at wineries reception facilities when arriving. Grapes can be exposed to unfavorable conditions, like high temperatures, which affect their quality. This problem is a consequence of the lack of planning of the reception of the grapes in the winery reception facility. There are some wineries that have sufficient parking available while waiting to unload the grapes, but in other cases trucks block the entrance and the streets of the winery while waiting for unloading. This is an extra problem that should be taken into account. This is a controllable and measurable problem, since the capacity of the winery can be measured and considering this indicator reception planning could be made.

Another source of problems is supplies (bottles, corks, labels, cartons, etc.) delivered in bad conditions due to transportation means, bad or wrong packaging, incomplete or out of time delivery and/or incorrect documentation. This affects directly the wine presentation and conservation. Corks, bottles and labels are critical supplies. A good delivery in time and in form contributes to succeed in the quality of the wine. Corks prevent the air

to come into the bottle avoiding the wine oxidation, labels must contain special data like destination country in the appropriate language, the specifications of the wine, the varieties, etc. Counting with labels already printed, ready to be stuck is an important part of the supply cycle. In the same way bottles are critical in bottling process. Counting with good supplies and in the right moment at the right quantity is a way to assure quality in wine packaging.

In some cases finished goods are delivered in bad conditions, including damages, incomplete, out of date or in a different packaging and this could be attributed to many reasons such us bad planning of activities, bad decisions, the shortage of the supplies, problems during elaboration process, etc. This affects the quality of the wine with the risk of uncover the bottle and oxidation of the wine (wine oxidizes when exposed to air, causing a distinctive sherry-like off-odor and brownish tint that is increasingly recognizable with wine consumption experience [Dharmadhikari, 2008a]). All these factors could affect the relation with customer, and may lead to market loss. For all companies along the WSC the objective is to fulfill the customer requirements, at lowest possible cost, with the lowest possible resources and the most possible revenues, but if the customer does not receive the finished product "in form" and "in time" some objectives are not totally fulfilled. This problem could be a bad management of the order, when picking the order, when transporting the order, when delivering the order. Measuring and controlling these processes is the way to prevent and to take actions to minimize this problem.

Another problem which affects wine quality, (visual and sensory changes) is the temperature fluctuations over the shipments across distribution channels. Generally wineries take all the precautions to maintain wine in the appropriate conditions, such us refrigerated chambers, subsoil caves, etc, but sometimes from the moment the wine leaves the winery, temperature fluctuations can affect the quality. To guarantee optimal quality of wine, it should be stored in a constantly cooled environment, since exposing wine to temperatures over 25 degrees for long durations, and over 40$^{o}$C for short durations affects wine quality. This is a common problem which wineries are not totally aware of. During delivery of finished goods, particularly in the cases of oversea markets, the shipments go through different temperatures fluctuations which are not good for conservation of the wine. Some research has been made in order to control these fluctuations during transportation of the wine [Weiskirche, 2008]. This is a measurable and controllable problem.

In Figure 4.1 all problems related to quality presented here are shown. In the figure it can be seen the place of the WSC where the problems referred to quality are located. Grape grower's activities and wine producer's activities are both very important to assure quality of the products, and then it follows the quality of supplies and delivery conditions.

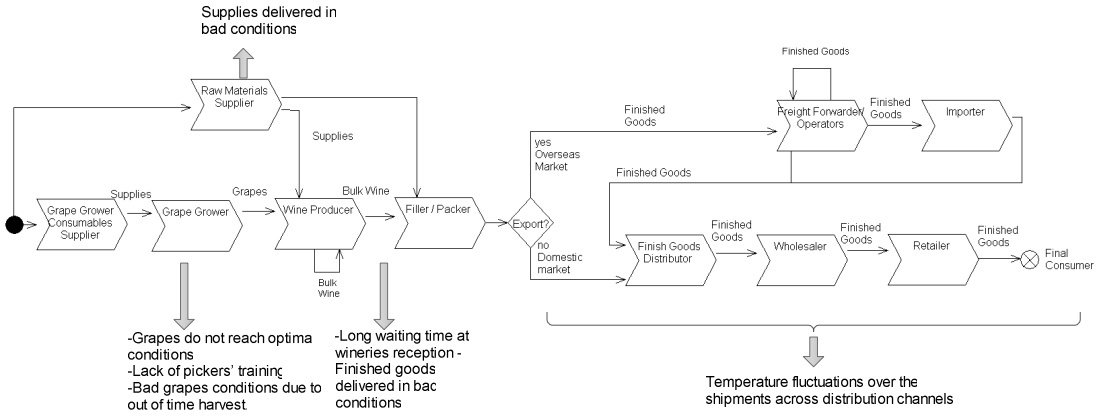


**Figure 4.1:** Problems Related to Quality

### 4.2.2 Problems Related to Timeliness

Some problems which affect the time of response of the WSC for arriving to the customer, fulfilling arranged times, have been identified.

Supplies sometimes are not available at the moment of order preparation, which is especially important in the MTO strategies. Two critique supplies are bottle and labels, which need to be purchased following several requirements, e.g. specific delivery time, specifications of the printed product, etc. When suppliers suffer delays in deliveries it could imply retards in elaboration process or bottling process, which produces long lead-times in delivery the order. In some cases suppliers have delays in deliveries because of many reasons, problems during transportation, problems during elaboration process of supplies, etc, but for wineries a delay in supplies may imply a delay in wine elaboration or bottling process, which will have a negative effect in customer deliver lead time. This is a measurable problem.

Bottles suppliers are not flexible enough to produce new designs fast (and in small quantities). This could influence in long lead-times and in changes in customer requirements because they have to adapt to the available products. In some cases the time of response of these suppliers to wineries' new demands is very long, and sometimes impossible to accomplish, because of the big demand of other clients (other companies), or because these suppliers are not developed enough to respond to these new requirements. This is a measurable problem. In the case of the argentine wine industry there are few bottles suppliers. This could influence in long lead-times and problems of the activities during elaboration and bottling process.

Quality testing is a crucial process during elaboration, because it assures the quality of the wine, but sometimes this could be a bottleneck due to the required time consumed to make the tests. This is not a problem it self, but sometimes it may imply a bottleneck due to the time consumed to finish the test. Special measures of quality are necessary during elaboration process,

but the purpose of this research is to consider only logistics processes and performance attributes. However, it is important to mention that a whole system of wine quality should be available.

During elaboration process there are lots of set ups of machines, this includes washing machines, place in an right position, change particular parts of the machine, activities which could imply long setup times. Excess of setups may produce waste of time during bottling process. This could be measured as well as all capacity problems.

Bad management of scheduling of bottling and other activities could produce long lead-times, wasting capacity and productivity inefficiencies, in machines as well as in labor. In some cases there are no IT systems available which help companies to schedule bottling process. This could imply inefficiencies during bottling process and wasting capacity, at the same time it could imply longer lead-times. This could be measured and controlled by the company.

Another problem which produces long distribution lead-times is related to some operational inefficiencies such as congestion, bad coordination of containers transport, lots of inspections and certificates that may happen when exporting. This could be attributed to the constraints in the transportation when exporting wine, in some cases there are a few shipping companies to work with, which limit options and increase costs. Lots of inspections and certificates are sometimes required, which complicates and delays the distribution cycle. This is a measurable problem and sometimes it is not controllable by the company.

The distribution system of some destination countries (e.g. the three tier system of USA), works as a wall which reduces the visibility between the wine producer and the final customer, this may influence in long lead times, a lot of legal constraints, impossibility to know the final consumer demands, etc. In some cases the legal constraints in destination country add delays and extra documentation treatment, which implies longer lead-times and adds the possibility of errors in documentation and also forces each actor in distribution cycle to hold inventories to satisfy demands. This is not measurable in the framework proposed.

Another common problem is the low visibility in the SC due to lack of IT Technologies and information sharing between members in the WSC. This increments order cycle times, inventory levels and transportation costs, and at the same time reduces accuracy and efficiency of receiving operations and customer service and satisfaction levels. This problem is attributed to lack of information systems in companies; most enterprises manage the information using basic tools that does not allow sharing information as integrated systems. Lack of IT systems may be caused because some companies

consider expensive to incur in technologies and information systems ignoring the potential benefits of using this kind of tools.

In Figure 4.2 problems related to timeliness are distributed along the WSC. It can be observed that Wine Producer / Fillers Packers as well as all actors in distribution cycle influence a lot in cycle time performance. The majorities of problems are in wineries' processes, in distribution channel and in third place the suppliers' processes.

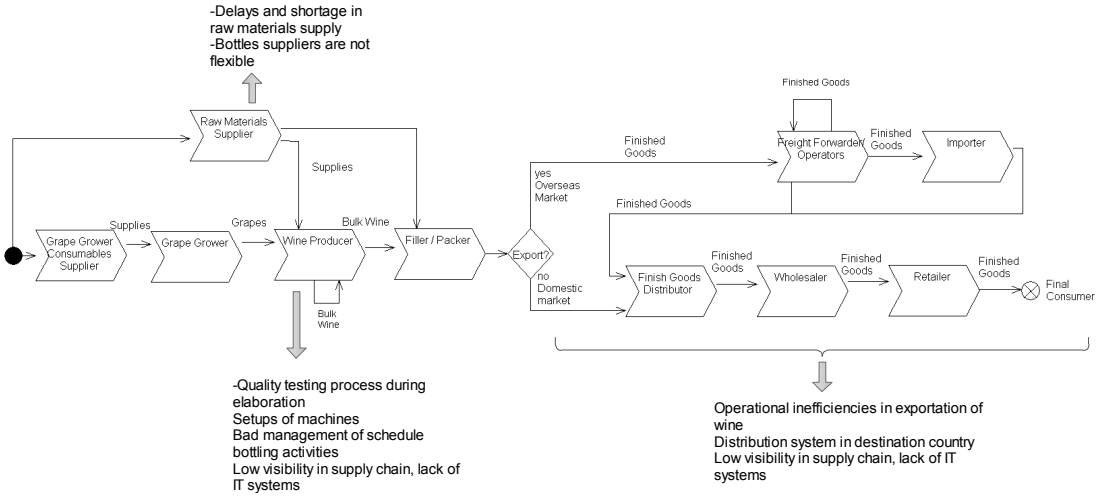


**Figure 4.2:** Problems Related to Timeliness

### 4.2.3 Problems which influence Logistics Costs

There is a lack of understanding of the impacts of logistics costs in all members of the WSC due to inefficiencies in SCM. Not every partner knows the impact that thier decisions have on the other partners in the SC, which produces high costs and lack of trust between each other. This problem can be attributed also to the lack of information sharing between partners, and lack of decision making tools which facilitate the decision making process based on real, updated, secure and integrated information.

In WSC there are high inputs cost such as bottles, corks, cartons, barrels, yeast, fertilizers, pesticides, etc., which is worst for small producers. The low number of suppliers and monopolistic industry makes uncontrollable the prices of the supplies. In some cases the number of suppliers does not satisfy the demand, prices are increased and there is a necessity of importation of supplies, which implies high costs and long lead times. This is not considered in the framework proposed as a particular indicator, but a general logistics costs indicator is presented.

The great separation of vineyards owners and wineries implies high costs on long time relationships that result from the lack of confidence of the actors on each other. In some cases wineries have to make long time relations with

grape growers to assure the quantity as well as the quality of the grapes. This is not measurable in the proposed framework.

In the distribution cycle there is low visibility between partners in the transport. Low communication and collaboration among its trading partners may be attributed to lack of IT systems and technology or lack of interest from the members. As a consequence, each actor of the distribution channel holds inventory and in some cases there are productions of non-requested products which leads to higher cost, lower precision in the forecasting, long lead-times etc.

In the majority of the members there is observed a low usage of IT tools for decision making, planning and forecasting, which implies problems in scheduling activities, making bad decisions or that will have negative impact on the rest of the members of the WSC. Companies do not want in some cases to invest in technologies and information systems, due to the high costs, and they use separated tools, ignoring the benefits of information sharing and integration between other partners.

For wineries, having their own vineyard involves more financial risks (e.g. due to weather problems such as hail, maintenance, etc.). However, for companies which produce premium, ultra premium and icons wines the quality of the grapes is the most important factor. Hence, in order to assure this quality, lots of wineries must invest in land to plant and maintain vineyards.

For wineries which produce premiums and ultra premiums wines the volume of grapes needed to elaborate the wines is larger. The more premium the wine, the lager the volume of grapes needed, which imply higher costs. During elaboration process the juice obtained from the first batch of grape juice is designated to high level quality wines, the other batches are designated to lower quality wines [Dharmadhikari, 2008b].

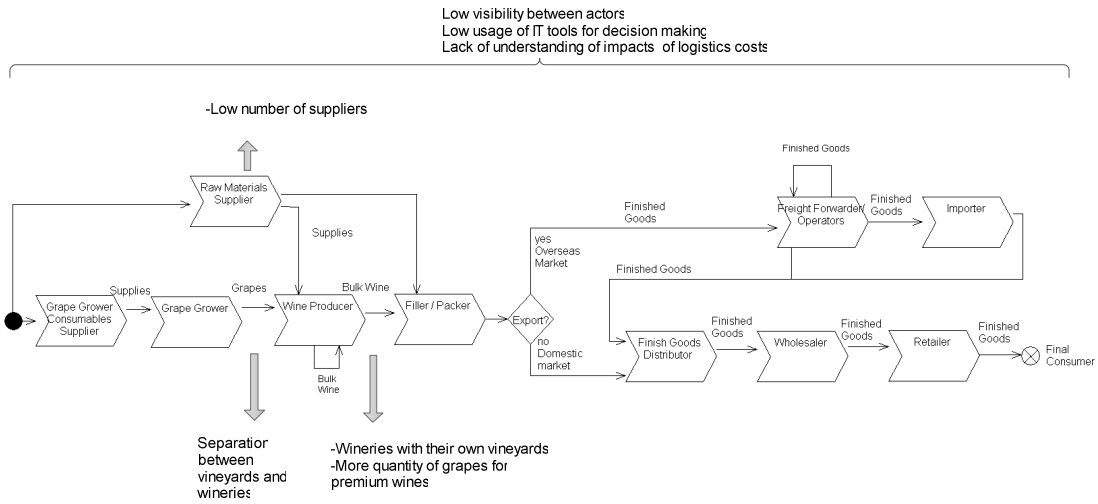


**Figure 4.3:** Problems which influence Logistics Costs

In Figure 4.3 all logistics costs problems are shown. It is observed that the majority of the problems cover the complete supply chain, which means that logistics costs are increased due to bad management all along the SC.

### 4.2.4 Problems Related to Productivity and Capacity

Sometimes the reception capacity of the winery is not considered when transporting grapes into the winery, producing long delays. This causes that wines which should have been of a certain quality, need to be degraded [Ferrer *et al*., 2008]. This also applies to finished goods and supplies. Scheduling and rescheduling the capacity of the cellar needs to be considered as well as counting with tools which help to plan and schedule capacity and transportation of grapes and finished goods. This problem could be measured and it is controllable by companies.

Another way of wasting capacity is in trucks when transporting grapes, and wasted capacity of containers when transporting finished goods. This wasted capacity produces higher costs. This is attributed to the lack of planning and scheduling of transport trips and loads. This could be measured and controlled by the company.

Another problem is the capacity wasted by filling/packing machines. In some cases machines are not used in their maximal capacity, which produces higher costs and low productivity during bottling process. This could be attributed to a lack of planning. This could be measured and controlled by the winery.

In some wineries it is a common activity to re-pack bottles for accommodating customer specific needs. This means that after bottles are packed at the end of the production and bottling line, a repack is made (manually or automatically) in order to accommodate to customer requirements, which produces wasted resources, time, labor, etc. This could also be attributed to a lack of planning and scheduling of activities. This could be also measured in the framework. Only controlling these activities possible optimizations could be made.

Another activity which produces wasting of time and resources is the re-palletizing of cartons, which implies longer lead times, higher costs, etc. These problems are also attributed to lack of planning and scheduling of activities. This, as the majority of capacity problems are controllable and could be measured by companies.

Whenever a blend of wines is needed, some movement of wines between vats or tanks is needed, and this may cause wasting time and losses of the product in the movement process, problems in the quality of the wine, etc.

This problem could be attributed to a lack of planning considering the cellar capacity and forecasts. This could be controlled and measured, along with other losses of resources, like boxes, labels, corks, etc.

In Figure 4.4 problems related to capacity and productivity are shown, the winery is the one who concentrate the majority of these problems. Wineries must pay attention to this kind of problems in order to improve processes and gain efficiency.

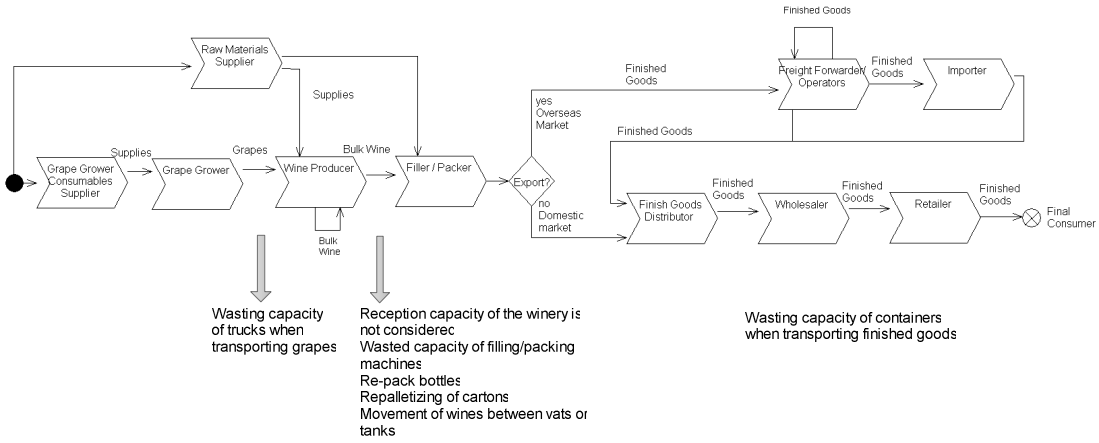


**Figure 4.4:** Problems Related to Productivity and Capacity

In Table 4.1 a summarized list of these problems is shown. The third column shows whether the problem is measurable or not, which indicates if it is possible to define an indicator to measure the performance of the process in order to detect and to avoid the problems.

In the next chapter, for each measurable problem, an indicator is proposed in the framework to count with the tools needed to control the process. By measuring the performance of the company through the 4 performance attributes previously described, it is possible to pay attention and to avoid or at least minimize the occurrences of these problems.

**Table 4.1:** Potential problems in WSC classified by performance attribute.

| Performance Attribute | Impact | Measurable |
|---|---|---|
| **Quality** | | |
| 1. Grapes do not reach optimal conditions | Degradation to inferior quality wines, loss of revenues | √ |
| 2. Lack of pickers' training | Deteriorates the quality of the grapes. | X |
| 3. Bad grapes conditions due to out of time harvest. | Deterioration of the grapes | √ |
| 4. Long waiting time at wineries reception | Affects the quality of wine | √ |
| 5. Supplies delivered in bad conditions | Affects the wine presentation and conservation. | √ |

| | | |
|---|---|---|
| 6. Finished goods delivered in bad conditions | This affects the quality of the wine | √ |
| 7. Temperature fluctuations over the shipments across distribution channels | These fluctuations can affect the wine quality | √ |
| **Performance Attribute** | **Impact** | **Measurable** |
| **Timeliness** | | |
| 8. Delays and shortage in raw materials supply | Produces long lead-times | √ |
| 9. Bottles suppliers are not flexible | Long lead-times and problems scheduling activities | √ |
| 10. Wasted time during quality testing process during elaboration | Produces bottleneck in elaboration process | √ |
| 11. Setups of machines | Long lead-times and waste of time during bottling process | √ |
| 12. Bad management of schedule bottling activities | Long lead-times, wasting capacity and productivity problems. | √ |
| 13. Operational inefficiencies in exportation of wine | Long lead-time in distribution | X |
| 14. Distribution system in destination country | Low visibility, decrements forecasts precision, long lead-times | X |
| 15. Low visibility in supply chain, lack of IT systems | Increments order cycle times, inventory levels, transportation costs, etc | X |
| **Performance Attribute** | **Impact** | **Measurable** |
| **Logistics Costs** | | |
| 16. Lack of understanding of impacts of logistics costs | High costs, lack of trust | √ |
| 17. Low number of suppliers. | High input costs | X |
| 18. Separation between vineyards and wineries | High costs on long time relationships | X |
| 19. Low visibility between actors | High costs in inventory, long lead times | X |
| 20. Low usage of IT tools for decision making | Problems in scheduling activities, make bad decisions | X |
| 21. Wineries with their own vineyards | Involves more financial risks | X |
| 22. More quantity of grapes for premium wines | High costs | X |
| **Performance Attribute** | **Impact** | **Measurable** |
| **Productivity and Capacity** | | |
| 23. Reception capacity of the winery is not considered | Degradation of the grapes and hence the wine | √ |
| 24. Wasting capacity of trucks when transporting grapes, and of containers when transporting finished goods | Produces higher costs and waste capacity | √ |

| | | |
|---|---|---|
| 25. Wasted capacity of filling/packing machines | Produces higher costs, and low productivity | √ |
| 26. Re-pack bottles | Produces wasted resources, time, labor, etc | X |
| 27. Repalletizing of cartons | Long lead times, higher costs | X |
| 28. Movement of wines between vats or tanks | Wasting time, losses of the product, problems with quality of wine | √ |

# Chapter 5: Performance Measurement in Wine Supply Chain

In this chapter a framework for measuring performance in the WSC is presented. This framework complements the WSC model presented, by providing a performance measurement tool for quantifying potential problems across the whole WSC.

In section 5.1 a generic description of the framework is presented; in section 5.2 a hierarchy of three levels of indicators is proposed; in section 5.3 a detailed list and description of all first level indicators is presented along with the formula of each indicator to compute its value; in section 5.4 a description of different ways of using the framework are presented; section 5.5 explains relationships between indicators; section 5.6 shows how to use relations between these indicators to interpret information; section 5.7 shows which indicator can be used to measure the problems presented in chapter 4, and finally a methodology to apply the framework is described in section 5.8.

## 5.1 Description of the Logistics Performance Measurement Framework

In order to define a set of key logistics performance indicators for the WSC, it is important to specify classification dimensions for these indicators. These dimensions are the *performance attributes* and the *logistics processes* presented in previous chapters. Both attributes and processes are guides to apply the relevant framework indicators for any particular situation or market segment. The indicators will be classified considering where they would be most appropriate.

Considering logistics processes presented in section 3.1 (supply, production and bottling, Inventory Management, Warehousing, Distribution and Transportation and Customer Response) and performance attributes described in section 4.1 (Quality, Timeliness, Logistic Costs and Productivity and Capacity), some definitions can be reviewed here. The *performance attributes* are aspects present in every enterprise's logistics processes and represent aspects through which performance can be measured. Each *logistics process* corresponds to a function the enterprise must implement in order to provide some logistics service needed by its business.

Figure 5.1 shows how a performance attribute could be measured in each logistic process. For example, timeliness can be measured along all the processes:

- in the supply process a lead time of suppliers' response time could be measured,
- in production and bottling the lead time of elaboration and bottling can be measured,

- in distribution and transportation the lead time could be measured.

As mentioned in the example, in each process, an aspect or performance attribute can be measured.

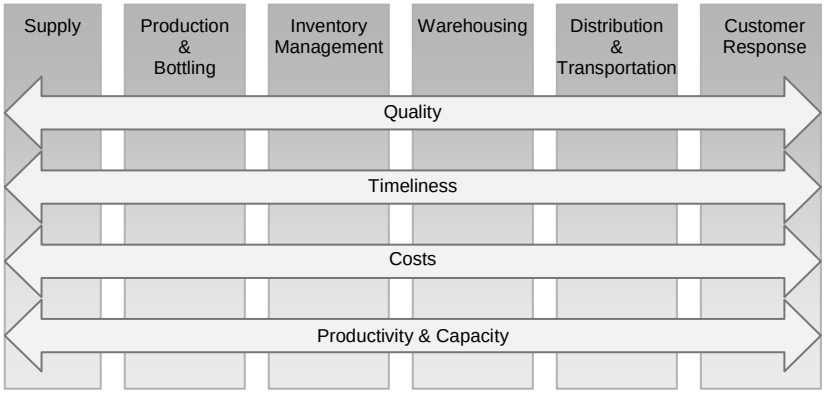


**Figure 5.1:** Logistic Processes and Performance Attributes

## 5.2 Key performance indicators hierarchy

A description of the hierarchy of indicators is made in this section. Considering the complexity of the WSC, the number of actors and its dynamics, in order to make the framework manageable, the winery point of view is considered.

In the proposed framework, the generic catalog of indicators is structured in a hierarchy of three levels, as follows:

- The first level contains indicators that reflect the global performance of the winery as well as the whole SC. It includes some indicators that measure performance of integrated activities along the SC. These first level indicators will show the result of the efficiency of several activities performed along the WSC by different actors. These indicators may also show high level aggregated results. The combined use of these indicators will help to further understand the overall logistic performance of the enterprise taking into account quality, costs, time, and productivity. It includes 14 key logistics indicators distributed along the logistics processes and performance attributes described in previous section. This level is oriented to facilitate the analysis of global SC information.

- The second level contains indicators to measure performance of the enterprise in the four categories previously described (quality, costs, time and productivity) but the information is shown in more detail than

the higher level. It shows the result of several processes. This level is composed by 70 indicators, distributed in all the logistics processes and performance attributes identified. Each indicator of first level is related to one or more indicators of second level, although this is not a taxonomic decomposition (the lower level indicators give more details of high level indicators, but they do not define they directly).

- The third level is related to the internal SC, and it measures the performance of the operations of the winery. This level is related to the every day operations of the enterprise, with the purpose of improving its performance. This level is composed of 80 indicators. As the previous level, the lower indicators give more detail of high level indicators.

This generic catalog is compound in total of 164 indicators. This does not mean that every actor of the WSC will use the whole hierarchy. Each actor will instantiate the framework depending on the strategy of the enterprise and the horizontal structure of its SC, that is, the place in the SC this company occupies.

In this research only the first level of the hierarchy is presented because further details on the second and third levels of the hierarchy are given in another Master thesis, which complements the study of the WSC and the framework. Some KPI of the framework have been adapted from different authors' frameworks [Frazelle, 2002, Supply Chain Council, 2008] and others have been defined specifically for measuring the integrated WSC performance.

Figure 5.2 shows the KPI hierarchy, including the three abstraction levels, the four performance attributes defined, and the six logistics processes performed within the winery where each indicator must be measured. It also shows the indicators' relation from one level to the other. For example for measuring the time consumed in warehousing processes there is one key performance indicator in the first level who shows the average time of the process, and if a deeper analysis is required, the second and the third level indicators can be analyzed to find the causes of the performance problems. One first level key performance indicator can be related to one or more second level indicators (though this is not a taxonomic decomposition), and the same applies to the second and third levels of the hierarchy.

## 5.3 Key performance indicators

In order to help understand the framework, the first level of the hierarchy is described in this section. Some comments of the second and third level are included to explain the hierarchy and relations of indicators among different levels.

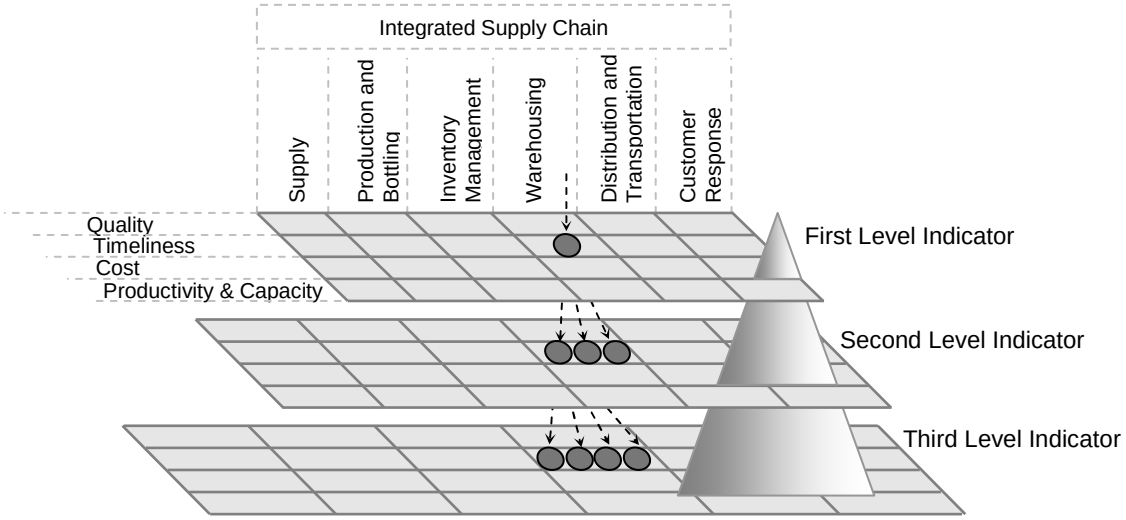


**Figure 5.2:** Key Performance Indicator hierarchy

An important factor to consider due to the nature of the wine is the seasonality, which has a major influence on operations in the wine industry. This factor must be taken into account when establishing the time base over which measurements are taken and compared. For instance, performance measures within a winery or vineyard will be totally different during vintage when compared to non-vintage time. It is therefore important when applying the framework to qualify the measurement with the period to which it is relevant.

Table 5.1 shows the first level of the hierarchy. Each indicator is classified into one logistics process and one performance attribute. Some indicators are integrated, that is, they cover some aspect of more than one logistic process, for example *Total Logistic Cycle Time* which covers time elapsed during all logistic processes. Indicator's description and formulas are presented later in this section.

The description of each first level indicator is made following the order of performance attributes and logistics functions shown in Table 5.1:

- *Quality*

1- *Supplier performance index*: it is an overall indicator of a supplier's performance. It measures the degree to which winery's specifications are being satisfied through the supplier's activities and quality in the deliveries. This could be measured by the average of claims made by the winery to the supplier in relation to quality of the supplies, delays in the deliveries and costs. The more quantity of claims made to a specific supplier, the lower the performance index of this supplier will be, since the quantity of perfect purchase orders received from this supplier will be lower.

**Table 5.1** First level KPI classification

| Logistic Process / Performance Attribute | Supply | Production & Bottling | Inventory Management | Warehousing | Distribution & Transportation | Customer Response |
|---|---|---|---|---|---|---|
| **Quality** | Supplier Performance Index | Right quality Grapes Percentage<br>Production Performance Index | Inventory Performance Index | Warehousing Performance Index | | Customer Satisfaction Index |
| | Perfect Order Percentage | | | | | |
| **Timeliness** | New Demand Response Time | Total production cycle time | | | Delivery Cycle Time | |
| | Total Logistics Cycle Time | | | | | |
| **Costs** | Total Logistics Cost<br>Total Logistics Cost Contribution | | | | | |
| **Productivity & Capacity** | Resources Utilization Percentage | | | | | |

2- *Right quality grapes percentage*: it measures the average quantity of grapes obtained with the right quality during harvest. The bad quality of the grapes may be attributed to different factors such as:
   - Bad weather conditions,
   - Problems occurred during harvesting, obtaining the grapes when not in the right maturity, bad methods of harvesting the grapes,
   - Bad treatment of the grapes during transportation (they could be exposed to great temperature variations, or spend to much time under undesirables conditions),
   - And it may also be attributed to the storage conditions when they arrive to the winery.

3- *Production Performance Index:* this indicator is defined as a separated indicator due to the importance of counting with a special measure of production performance. It is an average of perfect produced units. It gets its value considering the percentage of units perfectly produced, that is, produced as planned, without failures or rejections from quality tests.

4- *Inventory Performance Index*: as mentioned earlier, the indicators are arranged in a hierarchy; the inventory performance is measured by averaging different points of view of inventory management, including forecasts accuracy, product obsolescence, inventory accuracy and stockouts. This indicator shows the global performance

of all activities of inventory. If some of them has a bad performance the global index will show this decrement.

5- *Warehousing Performance Index*: this indicator is related to the performance of all activities of warehousing processes. It includes receiving and putting away of supplies, picking accuracy and shipping accuracy of finished goods. Performance of these activities is measured by taking into account both the damage percentage and mistakes made during all warehousing activities

6- *Customer satisfaction index*: it is an overall indicator of customer's satisfaction. It describes the perception the winery has with respect to each customer's satisfaction, through the percentage of perfect orders and claims received from them. It is important to note that it does not measure the customer's perception but the winery's one. It measures the degree to which customer specifications are being satisfied by the winery. For this indicator, satisfaction percentages for each customer are calculated and then averaged, resulting in an average for individual customer satisfaction level. The second level of this indicator includes the measurement of claims from the customer, taking into account the cause of the claim, quality, time or cost (i.e. it presents more details on the causes of the value of customer satisfaction level).

7- *Perfect Order Percentage:* Is the percentage of all orders whose supplies were perfectly purchased, and that were perfectly produced, bottled, filled, covered and packed, that arrived on time, without damages, with perfect documentation, at the right location, with each line item request completely fulfilled, with the correct item in the correct quantity, with no claims from the customer. Unlike the previous indicator, for which individual customer's satisfactions are calculated and averaged, this indicator measures the global customer satisfaction level achieved by the winery, without considering which customers are better or worst satisfied. Lower levels of the hierarchy show how the perfect order is composed. A perfect order must be:

   a. *Perfectly Purchased:* It measures the performance of all activities involved in procurement of supplies, placement of the order to the supplier, shipment of the order, reception in the winery, and also includes the documentation associated to the order. In this case grape growers' performance as well as raw material suppliers' performance is measured.

   b. With its *Product Unit Perfectly Bottled:* it measures the performance of all activities of bottling, filling, covering, labeling, packing, and

it also includes all possible damages that could happen during bottling processes.

c. *Perfectly Fillable:* considering the number of orders requested it measures the number of orders completely satisfiable without substitution or backorder with the available resources at the moment of fulfilling the order.

d. *Perfectly Picked and Packed:* it measures the performance of warehousing activities such packing, and picking without damages during these activities.

e. *Perfectly Delivered:* it measures the performance of delivery. It includes transportation performance, and all activities involved in the correct delivery of the order. It considers, among other factors, if the documentation of the order is correct and complete, if the orders have left the warehouse on time, if the orders have arrived to the customer location on time, if the orders have not suffered any damages, if there were no claims from the customer, if there were damages due to fluctuation of temperature during the transportation, if the orders were not delivered in full the first time, etc.

f. *Perfectly Received*: it measures the performance of all the winery's activities related to the customer, such as the order entry, the average quantity of orders delivered on time and in full and without rejection from the customer, etc.

- *Timeliness*

8- *New demand response time:* it is the average time the supplier takes to respond to demand of new supplies. It considers only demand of new products, not previously purchased to that supplier. For example whenever a winery wants a new model of label or bottles a new requirement is sent to the supplier. This indicator measures the effectiveness with which the supplier prepares and delivers the new demand.

9- *Total Production Cycle Time (production lead-time):* this indicator is an average of the time needed for elaborating and aging the product, including also the quality tasting time, and bottling time. This is a separate indicator because it is important to measure the time needed to elaborate wine or for bottling the order. When a winery follows a MTO (Bottle to order/Label to order) strategy this indicator is very important because it includes this part of the cycle.

10- *Delivery Cycle Time*: it is the average freight transport time. It is the average time between the moment the order is ready in the warehouse and its reception by the customer. It can be measured both in overseas and local market. Overseas lead-time includes the time the freight is moving from the winery's location through the freight operator (going through the frontiers), to the importer location, and the time the order is delivered to the customer in the importer's country. The local market's lead-time is the time elapsed since the freight leaves the winery or warehouse to the moment the freight arrives to the customer, passing in some cases through a wholesaler and a retailer.

11- *Total Logistics cycle time:* it is the average time elapsed between the customer order placement and the moment the order is delivered in the customer's location. It includes:

   a. *Order processing,* is the average time the customer's order takes to entry to the winery systems.

   b. *Purchase cycle time*, if the supplies are not available from stock and a purchase is needed it measures the average time of the procurement process.

   c. *Bottling time,* it measures the average time needed for bottling the wine. It includes the scheduling, filling, covering, labeling and packing of the order.

   d. *Warehouse processing time*, it measures the average time required to prepare the order in the warehouse, including picking, packing (optional) and shipping (checking orders, preparing shipping documents, weighting shipments, loading trunks).

   e. *Delivery time*, it includes waiting for loading, travel time and unloading time in the customer's site.

   f. *Return time,* it includes the return time when there are any returns from the customer, from the moment the customer makes the claims to the moment the orders are taken in the customer location.

   g. *Backorder Duration:* it includes the time to fulfill the order, in those orders that were not completed the first time.

- *Logistics Costs*

12- *Total Logistics Cost:* it is the aggregated cost of all logistics activities. It includes supply logistics cost, production logistics cost, inventory logistics cost, warehouse logistics cost, transportation logistics cost, logistics cost of returns from customers, customer response logistics cost.

13- *Total Logistics Cost Contribution:* It is the contribution of the Total Logistics Cost to the enterprise's total operational costs (this excludes raw material costs, investments on machines and infrastructure, etc.). In lower levels of the hierarchy there are indicators which show the contribution that each logistics process makes to the Total Logistics Cost.

*Productivity and Capacity*

14- *Resources Utilization Percentage:* it measures the average utilization level of the winery's resources, within a specific period of time, as compared with the total capacity of each resource. This indicator includes the reception capacity, the utilization of production machines, warehouse utilization, material handling equipment utilization, transport productivity, etc. It also includes wine losses, filtration losses, packaging losses, etc.

Table 5.2 shows the formula of each of the 14 first level indicators described above.

**Table 5.2:** Key Performance Indicators

| Indicator Name | Formula |
|---|---|
| Supplier performance index | ∑ Number of perfect purchase orders/ Number of placed purchase orders |
| Right quality grapes percentage | ∑ Quantity of grapes of right quality obtained / Total quantity of grapes obtained |
| Production Performance Index | ∑ Orders produced as planned without failures and rejections for quality tasting / Total orders from customer |
| Inventory Performance Index | ∑ Lower level indicators performance / Total number of lower level indicators |
| Warehousing Performance Index | ∑ Numbers of items received or put away or picked or shipped correctly and without damages/ Number of items manipulated |
| Customer satisfaction index | ∑ [ ∑ Quantity of perfect customer $_I$ / Total orders entered for customer $_I$ ]/ Number of Customers |
| Perfect Order Percentage | ∑ Quantity order without any problems / Total orders |
| New demand response time | ∑ [Reception date – New demand confirmation date]/ Total number of new demands |

| | |
|---|---|
| Total Production Cycle Time | ∑ Quality tasting cycle time + Elaboration Cycle Time + Aging Cycle Time + Bottling Cycle Time / Total number of order produced |
| Delivery Cycle Time | ∑ [Reception date by customer – Order ready date in the Warehouse] / Total number of delivered orders |
| Total Logistics cycle time | ∑ [Reception date- Transaction confirmation date] / Total number of orders |
| Total Logistics Cost | Supply Logistics Cost + Production Logistics Cost + Inventory Logistics Cost + Warehouse logistics cost + Transportation Logistics Cost + Logistics cost of returns from customers + Customer Response Logistics Cost |
| Total Logistics Cost Contribution | Total Logistics Cost / Total Operational Cost |
| Resources Utilization Percentage | ∑ Utilization % of Resource $_i$ / Number of Resources |

## 5.4 Different uses of the framework

In the previous section a description of the hierarchy of the framework was presented. In this section different uses of this framework are described in order to show its benefits and how it can be simplified depending on the actor who applies the framework and the strategy followed by the actor.

In the proposed model several SCs can be instantiated. For example a winery that delivers in the overseas market under a FOB schema, has a particular SC, as shown in Figure 5.3.

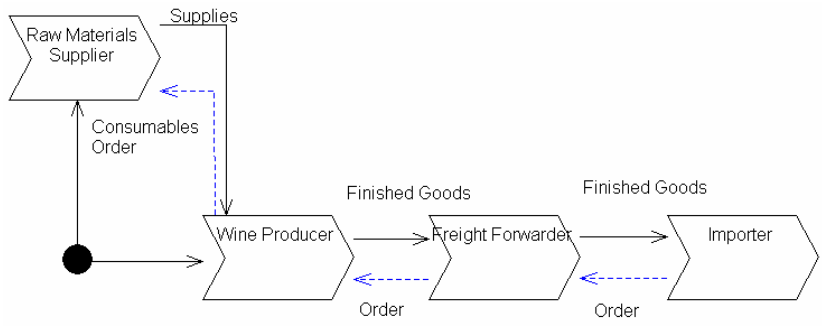


**Figure 5.3:** Winery's supply chain

Another example can be the SC of the Wholesaler shown in Figure 5.4, on which visibility is restricted to the Importer (the wholesaler usually has not access to information and material flows between wineries, freight operators, etc.)

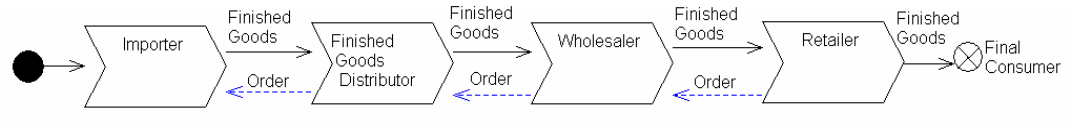


**Figure 5.4:** Wholesaler's Supply Chain

This shows a great difference between the wine producer and the actors in the distribution cycle. For the wholesaler the application of the framework is different than it is for the winery. For example if the lead-time is measured considering the wholesaler's SC it will cover the importer and finished goods distributor cycle times in order to arrive to the wholesaler's warehouse. For the winery's SC, the lead-time covers the lead-time of the winery, the freight forwarder and importer cycle times in order to deliver the product to the importer (which is the customer for the company because it follows a FOB sale strategy).

Figure 5.5 shows an overall schema of how the framework is instantiated for different actors of the WSC. The framework is the same for all of them, but depending on the actor and its strategy, the instantiation is different. Some indicators will be useful by some actors, while others will be useful for other actors. The key is that the hierarchy counts with several indicators in the three levels, which depending on the actor and the strategy followed will be "activated" (be meaningful) on each case. In some cases the majority of these indicators are use together following the relationships that exist between them (later described in section 5.5) in order to facilitate the decision making process and to have a better understanding of the processes as a whole.

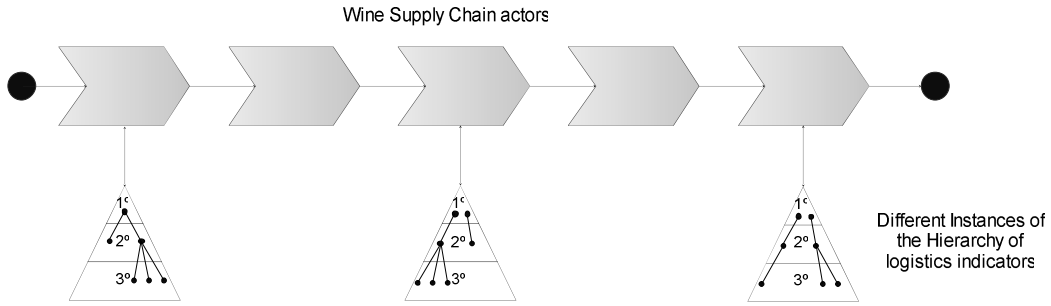


**Figure 5.5:** Framework instantiation for different actors along the WSC

### 5.4.1 Example of the application of the framework

In this subsection a concrete example of instantiation is shown in order to clarify the application of the framework. Considering the winery's SC and the wholesaler's SC previously described (figures 5.3 and 5.4), two first level indicators are instantiated: Lead-time and Resource Utilization percentage.

For the Winery's SC:

- Lead-time includes:

  - Production Cycle Time: lead-time of activities inside the winery such as bottling, packing, picking, preparing, loading.
  - Freight forwarder and freight operator Cycle Time: it includes the elapsed time for order processing, freight consolidation, etc. It also includes the time required to transport the freight to the origin port and time required to move the freight from origin port to destination port.
  - Importer Cycle Time: is the elapsed time during transportation of the finished goods to the warehouse of the importer. This is includes in the winery's SC because according to the FOB strategy followed, the Importer is the winery's customer.
- Resource Utilization percentage will measure
  - Usage of machines used for production, bottling, etc.
  - Used warehouse capacity, cellar capacity, etc.

For the Wholesaler's SC:

- Lead-time includes:
  - Final Distributor Cycle Time: which is the elapsed time from the moment the finished goods leave Distributors' warehouse until they arrive to wholesaler's facility.
  - Wholesaler Cycle Time: which is the elapsed time from the moment the finished goods leave wholesaler's warehouse until they arrive to retailer's facility.
  - Delays suffered during transportation, etc.
- Resource Utilization percentage will measure
  - Wasted capacity in truck and containers.
  - Warehouse capacity, warehouse density, etc.

## 5.5 Performance Indicators Relationships

In practice, most of the KPI in a SC are correlated and have cause–effect interplays [Beamon, 1999; Kleijnen & Smits, 2003]. It is common that the improvement of one KPI cause extra cost or effort for another one [Cai, *et al.*, 2009]. In the first level of the proposed framework there exist different kinds of correlations between the indicators. These correlations can be positive, (which means that the increment of the value in one KPI increments the value of another one), or negative, (which means that the increment of the value in one KPI decrements the value of another one).

Cause-effect relations [Kaplan & Norton, 1996] should cross through all logistics processes and performance attributes. As an example, consider an organization that has a very short lead-time, far from the average of the industry. In this case, its Total Logistics Cost indicators could show a high level, since this could be achieved by working in a make-to-stock strategy (what usually rises warehousing costs), or because a fast (but expensive)

means of transport is being used. This example shows how one indicator's performance may influence or affect the performance of others.

In the proposed framework, beginning with one indicator's result, there is a sequence of relations that can be followed to detect problems (in this work only the first level of the indicators hierarchy is considered). That sequence is different depending on the organization's strategy (the cause and effect sequence is different). For example, for an organization for which the customer satisfaction is one of its priorities, to achieve a high *Customer Satisfaction Index* it is necessary to obtain a high percentage of Perfect Orders.

A perfect order means arriving to the location accorded with the customer, with the right items in the right quantities, on the committed date, etc., which is measured trough the *Perfect Order Percentage*. Obtaining a high value in this indicator can make the customer satisfaction level be high. This relation can be translated into a cause and effect sentence as follows: "if the winery increases the quantity of perfect orders for each customer, it will increase the customer satisfaction index".

Once an indicator whose value is out of the desired range is found, it is possible to follow these associations between the indicators to find the root causes of the problem. Since the proposed framework is intended to be hierarchical, it is possible then to go in depth into the hierarchy of indicators to find a fine-grained cause of the problem. The relations between the logistics indicator are shown in Figure 5.6.

In Figure 5.6 there are 4 indicators that may be the beginning of the sequence in the search of deviations, namely *Customer Satisfaction Index*, *Total Logistics Cost*, *Supplier Performance Index,* and *Resource Utilization Percentage*. Even though any indicator may be used to star the analysis of the values is recommended to use these four indicators because on the one hand these indicators are related to the organization's performance with respect to the external environment through the measurement of the customer satisfaction level and the suppliers' performance, and on the other hand they are related to the internal performance through the measurement of its logistics costs and use of the resources.

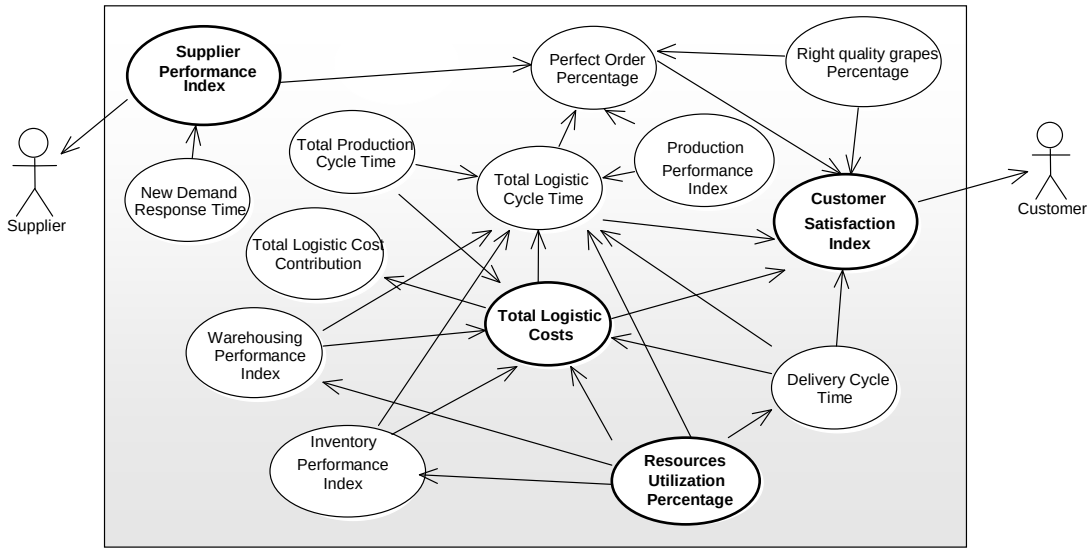


**Figure 5.6:** Key Performance Indicator Relationship Map

## 5.6 How to use relations between indicators to interpret the information

In order to understand how to use these existent relations between indicators, a simplified example is presented. Figure 5.7 shows the map of indicators and relations used in the example, which is a subset of that presented in Figure 5.6. Suppose that a winery uses the framework and the most important goal of the winery is to achieve a high *Customer Satisfaction Index*. In order to do that, the winery has to achieve a high percentage of Perfect Orders (*Perfect Order Percentage)*.

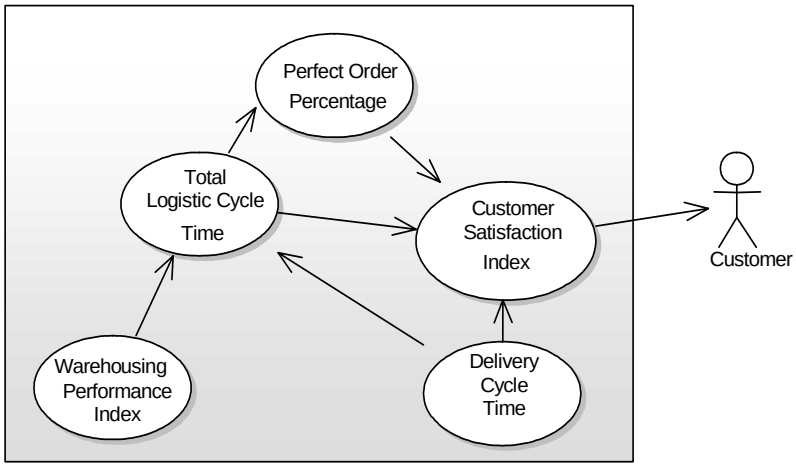


**Figure 5.7:** Relevant indicators and relationships for the example

For arriving on time to the customer location, it is necessary to reduce all the wasted time that each process may introduce to the full cycle. Time is especially important in the WSC because in some markets there is high

competition. In some countries the winery exports to, there exists competence with both other countries and local wine production. That is why the lead-time is very important to the winery. By measuring the *Total Logistics Cycle Time* it is easy to determine which processes or activities contribute the most on delaying the full process. The performance of production (*Total Production Cycle Time*) is especially important since it is directly controllable by the winery and it is the principal process of the whole process.

When following a MTS strategy, the Total Logistics Cycle Time is highly impacted by the *Delivery Cycle Time*. This measures the time of distribution and transportation of the wine once it leaves the warehouse until it arrives to the customer. This performance is independently measured because in the distribution for overseas market several actors participate, but the winery must assure the correct delivery until the final customer. By knowing the distribution performance, some decisions can be made, such as changing the shipping company if it is not good, changing the port through which the finished goods are dispatched, using another transport means not considered until that moment, or even more radical decisions such as having warehouses in most important destination countries.

Another indicator that impacts the Total Logistics Cycle Time is the *Warehousing Performance Index*. Warehousing activities are essential since the time taken by expedition contributes to the total lead-time. A low value for this indicator may be caused by products stored in wrong locations, high rate of mistakes in picking, lack of verification of the orders completeness, too many damages during the manipulation of the finished goods, not enough material handling equipment, etc. An example of decisions that could be made with this information is adding resources to speed up the order preparation.

By knowing the cycle time of each process, it is also possible to make global decisions if one of them has poor performance. Examples of these decisions are changing the production strategy for specific products and markets, and making collaborative forecasting to assure stock levels. As shown in this case study, relations present between KPI can be exploited by the winery to find processes or activities to be improved and align its operations to achieve its objectives.

## 5.7 Measuring potential problems in the WSC

Considering the potential problems defined in section 4.2 and the framework proposed in section 5.2 and 5.3, a list of measurable potential problems along with a KPI through which performance could be measured is presented in table 5.3. (not measurable problems are not considered in this table).

**Table 5.3: Relations between WSC problems and KPI**

| WSC Problem | KPI | Description |
|---|---|---|
| **Quality** | | |
| 1. Grapes do not reach optimal conditions | Right quality grapes percentage | This indicator gives the percentage of grapes which have not suffered any kind of problem affecting quality, such us bad transportation conditions of grapes, grapes storage problems, problems during harvest, bad weather conditions, etc. |
| 3. Bad grapes conditions due to out of time harvest. | Right quality grapes percentage | |
| 4. Long waiting time at wineries reception | Resources Utilization Percentage | Through this indicator the winery's reception capacity can be measured. |
| 5. Supplies delivered in bad conditions | Supplier performance index Perfect Order Percentage | The performance of the supplier is measured considering quality of the supplies, costs, and fulfillment of the delivery requirements. Perfect purchase order will measure if the order did not suffer any problem during purchasing cycle, for example in placement of the order, the shipment, the reception of products, the documentation, etc. |
| 6. Finished goods delivered in bad conditions | Perfect Order Percentage | Through this indicator aspects like the level of fulfillment, without errors during picking, packing and delivering of the orders can be measured. |
| 7. Temperature fluctuations over the shipments across distribution channels | Perfect Order Percentage | Through this indicator, problems due to temperature fluctuations can be measured. |

| WSC Problem | KPI | Description |
|---|---|---|
| **Timeliness** | | |
| 8. Delays and shortage in raw materials supplies | Supplier performance index/ Perfect Order Percentage / Total Logistics cycle time | To detect this problem some combination of measures can be applied, including the performance of the supplier, the lead time in distribution cycle, and the performance of the purchase orders of each supplier. |
| 9. Bottles suppliers are not flexible | New demand response time | This measures the response time of suppliers to fulfill the wineries' demands of new products. |

| | | |
|---|---|---|
| 10. Wasted time during quality tasting process in elaboration | Total Production Cycle Time | It measures the time needed for quality tasting during elaboration process along with other delays. |
| 11. Setups of machines | Total Production Cycle Time | This measure includes the time required for machines setup activities during elaboration process. |
| 12. Bad scheduling of bottling activities | Total Logistics cycle time<br>Total Production cycle time | Through these two indicators it is possible to know the performance of bottling process and if there is a bad scheduling of activities. |

| WSC Problem | KPI | Description |
|---|---|---|
| **Logistics Cost** | | |
| 16. Lack of understanding of impacts of logistics costs | Total Logistics Cost / Total Logistics Cost Contribution | With these two indicators it is possible to know how each logistic process contributes to the global logistic costs. |

| WSC Problem | KPI | Description |
|---|---|---|
| **Productivity and Capacity** | | |
| 23. Reception capacity of the winery is not considered | Resources Utilization Percentage | Through this indicator the reception capacity of the winery can be measured. |
| 24. Wasted capacity of trucks when transporting grapes, and of containers when transporting finished goods | Resources Utilization Percentage | This indicator involves measuring (among other factors) the average percentage of full-load trailer/container capacity utilized |
| 25. Wasted capacity of filling/packing machines | Resources Utilization Percentage | This indicator includes the utilization capacity of production machines. |
| 26. Re-pack bottles | Resources Utilization Percentage | This indicator also helps to measure the percentage of repacked bottles from the total of bottles packed. |
| 27. Re-palletizing of cartons | Resources Utilization Percentage | This indicator also helps to measure the percentage of re-palletized bottles as a percentage of the total number of pallets. |
| 28. Movement of wines between vats or tanks | Resources Utilization Percentage | This indicator measures the percentage of losses during elaboration process, such as wine losses, filtration losses, packaging losses, etc. |

Using these first indicators is possible to detect the problems, but using the second and third level of the hierarchy is possible to understand the causes of these problems.

## 5.8 Methodology for applying the framework

Considering the hierarchy of the framework, these indicators could be use to analyze the information from several levels of abstraction, due to the level of aggregation of the indicators. Once the first levels indicators have values, if some extra detail is needed it is possible to disaggregate one indicator to inspect the value of the corresponding indicators of second level of aggregation. This is possible also with those indicators which have a third corresponding level of indicators. Whenever it is needed, another indicator's value can be observed. This relation between levels is shown in Figure 5.8.

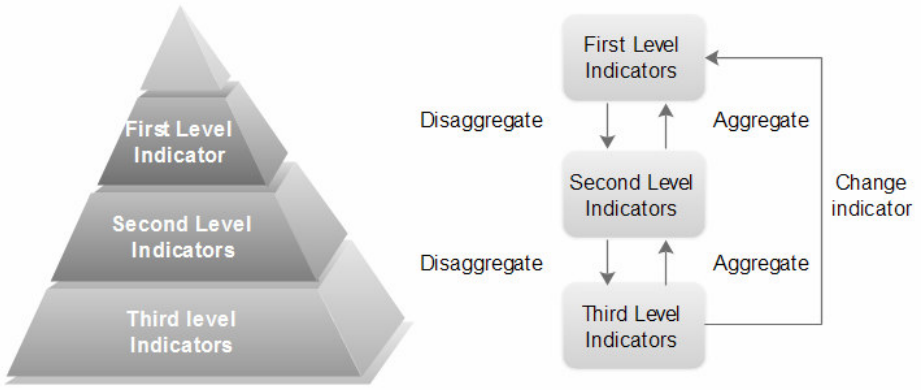


**Figure 5.8:** Levels of indicators

In order to make more understandable this aggregation/disaggregation method, an example using *Total Logistic Cycle Time* (lead-time) is presented for a hypothetic winery. The logistics manager of this winery wants to know why the lead time for the USA when using bottle to order strategy, is longer than the competitor's one. The more abstract indicator shows a lead time of 76 days, but this is not enough information to understand what process is producing this delay. If this manager uses the second level of indicators he can observe that there is a lot of delay before the shipment arrives to the origin port. This second level of indicators shows the contribution of more specific processes to the first level indicator. This is shown in Figure 5.9. If more detail is needed another disaggregation can be made to know how each sub-process influences each individual lead-time (order processing, bottling, warehousing, etc).

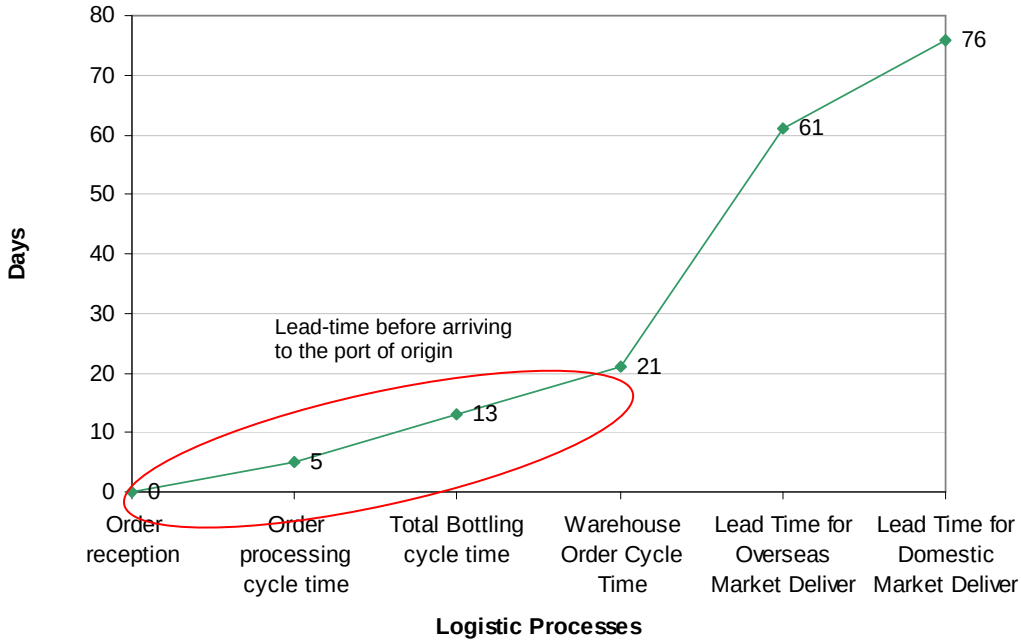


**Figure 5.9:** Lead-Time accumulated since order reception until delivering

# Chapter 6: Case Study: An Argentine Winery

The objective of this chapter is to present a case study of a specific real winery in order to instantiate a particular case of the model proposed and to apply the framework to measure logistics performance. In section 6.1 a general description of the winery of the case study is provided, section 6.2 presents the instance of the model for the particular case of the winery and the graphical representation; section 6.3 presents the problems which arise in the winery's SC that were identified; finally section 6.4 presents the application of the measurement framework to the winery of the case of study.

## 6.1 General Description of the Winery

In order to validate the model and to apply this framework, questionnaires and interviews were applied to a particular winery.

This winery is situated in Mendoza, Argentina. Founded in 1897, it is one of the oldest and most traditional wineries. This region is considered a zone for high quality wines. This winery has invested in the highest technology to guarantee excellent quality wines. It has its own vineyards and produces only through these vineyards, in order to maintain the quality of wines. For lower wines' elaboration, in some cases grapes are bought to other grape growers. It counts with four vineyards situated in different parts of the province making in total 210 hectares. These zones have the appropriate characteristics such us altitude and temperature amplitude for planting vineyards. For transporting the grapes from the vineyards to the winery an outsourced company is used.

This winery has a medium volume of production. It has an annual production of 1 million liters, with a wine cellar capacity of 2.3 million liters. The wine is staged in the same winery, using 500 French and Americans oak barrels. It has a filling line with capacity of 2000 bottles per hour which fills, and covers the bottles. It also has a labeling line with a capacity of 2500 bottles per hour, which labels and packs the wine. It commercializes its products in both internal and external market. It is certified in HCCP and GMP standards. The winery produces different segments of wines, namely icon, ultra premium, super premium and premium, 80% of them being red wine and 20% being white wine. It exports 60% of its production, and its main customers are from the USA, Brazil, Denmark, United Kingdom, Mexico and Colombia. The USA is the most important customer considering revenues.

This winery buys supplies to local and foreign suppliers. Bottles, capsules and labels are bought to local suppliers. Yields, barrels, corks and other

supplies are from international suppliers. To store the supplies it has a raw material warehouse. It also has a separated warehouse where the finished goods are stocked to respond to demand when necessary.

The winery receives new orders from the Importer when exporting to overseas markets. It does not receive orders from final consumers. Considering the local market, it receives orders from Wholesalers and Retailers. This winery follows different strategies once an order comes in from external market and based on forecasts on sales and capacity of the cellar (these strategies were described in section 3.3):

- Make to stock: the wine is already filled, labeled and packed waiting for the order to arrive.
- Labeling to order: the wine is already filled and the labeling and packing begins when the order arrives.
- Bottling to order: the wine is bottled, covered and labeled when the order arrives.

The most important customer has a 3 tier systems for distribution, composed of distributors, wholesalers and retailers. For transporting the freights, the winery uses the port of Valparaiso situated in Chile, and the port of Buenos Aires in Argentina. For the distribution of the finished goods for overseas market, the winery works with a freight forwarder, who manages all the movements of goods using the services of shipping lines as freight operators. The freight forwarder is the responsible for dealing with the importer in the destination country.

This winery faces the challenge of controlling and improving its SC operations. In this section only the external market is represented and studied in order to facilitate the analysis of the framework. For this winery it is more important to count with detailed information referred to external market because of the big percentage of exportations, and the managerial interests (company's vision and strategy).

## 6.2 Supply Chain Structure

The winery's SC is depicted in Figure 6.1, which shows all the actors who participate in the particular SC of the winery. As can be observed in this figure, there is an integration of roles between several actors. The winery produces grapes from its own vineyards and it has in the same facility the filling line, so it covers Grape Grower, Bulk Distributor, Transit Cellar and Filler/ Packer roles. Only the main external market country is represented in this figure.

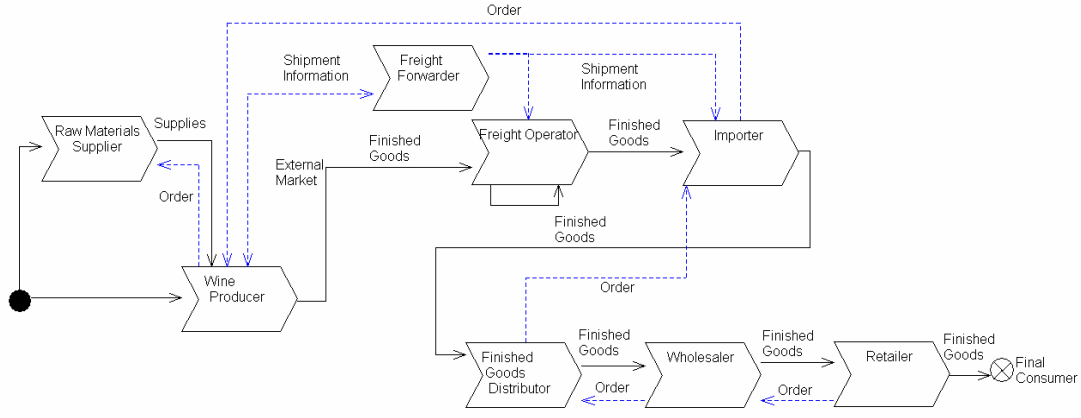


**Figure 6.1:** Winery's Supply Chain structure

For the external market, the winery sends shipments through the freight operator using Valparaiso's port or Buenos Aires's port, and sometimes transshipments are made in a port in the middle of the route. The winery sells following the FOB (free on board) strategy which, considering the definition from the INCOTERMS[4], means that the winery sells and delivers the finished goods to the ship in the port of boarding, which will be transported to the destination country. For the winery, even though the use of this strategy does not forces it to respond for events beyond the port, it is very important that the quality of the wine as well as the distribution to the final consumer in the destination country be performed adequately. If problems occur during transportation, which degrade the quality of the wine, it is the winery who should respond to the customer (at least indirectly, by loosing sales). This means that even tough the importer sells to the local market in the destination country, the complete supply chain is important for the winery, with which the brand and product identity are associated.

## 6.3 Identification of Logistics Problems in the Winery

In section 4.2 a list of potential problems that could arise in the SC were described. Some of these problems actually occur in the operations of the winery's SC. This information was obtained through interviews and questionnaires made to the winery employees.

The most important problems identified are:

1. Bottles suppliers have long delays to arrive to the winery, due to the shortage of stock. This sometimes causes delays in bottling and labeling activities, because the product is ready and the process is delayed due to late arrival of the supplies.

[4] The Incoterms are formulated and updated for the International Chamber of Commerce which regulates the norms, obligations and rights, and the prices.

2. In some cases supplies are delivered in bad conditions, this produces rejects, delays and sometimes produces problems of conservation of the final product.

3. Lack of IT technologies for integrating information with suppliers and customers, which impacts on the SC's visibility. This has other consequences, e.g. increase of order cycle times, high safety stocks on each actor, increase of costs, etc.

4. The 3 tiers system composed of the finished goods distributor, wholesaler and retailer that exists in the main overseas market produces a low visibility forward in the WSC, causing risk of bullwhip effect, forecast accuracy reduction, etc.

5. Sometimes there are some problems on scheduling elaboration and bottling activities. This could produce wasted capacity and low productivity.

6. In destination countries there are a lot of legal constraints for alcoholic beverages, which adds delays at delivery cycle time.

7. During transportation of the goods, depending on the place where the container is placed in the ship and the insulation type (or its lack), the wine may suffer temperature fluctuations.

8. The lead time within the destination country, when compared to that of other wineries, is very high. This is problem is important because wineries do not consider delivery in the destination country as its responsibility, but it may cause the loss of markets.

## 6.4 Application of the Performance Measurement Framework

The model of the winery's SC and the identified problems allow the winery to use the performance measurement framework previously defined, for improving its performance by setting new goals and implementing best practices where necessary. In order to facilitate this application only some indicators will be used to measure the performance of those processes which the winery considers more important. However, this is just for illustrating the application of the framework to the case study, and in a real study all the first level indicators should be evaluated in order to detect global problems.

The most important goal of the winery is to achieve a high *Customer Satisfaction Index.* In order to do that, the winery has to achieve a high percentage of perfect orders. A perfect order means arriving to the location accorded with the customer, with the right items in the right quantities, on

the committed date, etc., which is measured trough the *Perfect Order Percentage*. Obtaining a high value in this indicator can make the customer satisfaction level be high.

For arriving on time to the customer location, it is necessary to reduce all the wasted time that each process may introduce to the full cycle. Time is especially important in the WSC, because in some markets there is high competition. In the destination country, the winery competes not only with wine companies from other countries but also with local wine companies. That is why the lead-time is very important to the winery. By measuring the *Total Logistics Cycle Time* it is easy to determine which processes or activities contribute the most on delaying the full process. By measuring the *Resource Utilization Percentage* a better understanding of the use of resources is gained and some decisions can be made for improving productivity and efficiency.

Two first level indicators are presented, using data of the case study winery. These two indicators are *Total Logistic Cycle Time*, and *Resource Utilization Percentage.* It is particularly important for the winery to know the lead-time of production and bottling activities and delivery cycle time and the measurement of productivity and capacity of several resources in the winery is also important. In this particular case the capacity of utilization of bottling machines, the cellar and warehouse utilization capacity are resources which the winery considers important in order to improve its productivity.

### 6.4.1 Lead-time

If the manager of the logistic sector of the winery observes a lead-time of 48 days, he would say that it is a high number, but it is necessary to make a detailed analysis to find out what processes contribute the most to that number and, what is more important, why.

Total cycle time is composed of several activities where performance can also be measured, some indicators of second level of the hierarchy which measure these activities are: *Total Bottling Cycle Time*, *Delivery Cycle Time*, *Purchase Order Cycle Time* etc. Total Bottling Cycle Time is the time needed to complete the bottling cycle, as shown in Table 6.1 Delivery Cycle Time is referred to the time required to transport the finished products to the customer's place. Purchase Order Cycle Time is referred to the time elapsed between the purchase order placement and the moment the supplies arrive.

This winery, as previously described, follows a Label to Order strategy. In Table 6.1 all sub activities which are performed from the moment the (customer's) order is placed until the order is bottled are shown.

**Table 6.1:** Total Bottling Cycle Time composition

| Indicator Name | Description | Elapsed Time (days) | Accumulated Time (days) |
|---|---|---|---|
| Order Scheduling Cycle Time | Average time from the moment of the confirmation of the order until the order is entered into the system. | 1 | 1 |
| Order Waiting for bottling Cycle Time | Average time from the moment the order is scheduled until the moment the bottling process begins | 10 | 11 |
| Filling Cycle Time | Average time to fill the order | 2 | 13 |
| Covering Cycle time | Average time to cover the order (put corks and capsules) | 2 | 15 |
| Labeling Cycle time | Average time to label the order | 2 | 17 |
| Packing Cycle Time | Average time to pack the order | 0.5 | 17.5 |
| | Total Bottling cycle time | | 17.5 |

The bottling process is composed of several sub activities. In order to estimate the elapsed time from the moment the order is confirmed by the customer until the moment the order is packed, a sum showing the accumulated time is needed. This sum is shown in the fourth column of the table.

Figure 6.2 represents the data shown in Table 6.1. It shows the lead-time accumulated along bottling activities. It can be observed that the activity which contributes the most to the delays is the time the order has to wait to begin with the bottling process once the order is placed in the system of the company. During this period some activities are performed, for example labels re-printing. Labels' suppliers have an average lead-time of 20 days to deliver the labels printed with the specifications required by the winery. In many cases the wine is the same, only the label is different depending on the language and requirements of the destination country. Therefore, in order to reduce the impact of the high suppliers' lead-time, the winery buys the labels with basic information printed, and re-prints them when the order arrives. The total bottling cycle time is hence 17.5 days as shown in Figure 6.2.

Considering this information, the winery should define different alternatives of solution, for example search for suppliers with lower lead-times, invest in technology for print their owns labels, print basic labels and then when special data is needed a re-print may be done in quicker and smaller printers, etc.

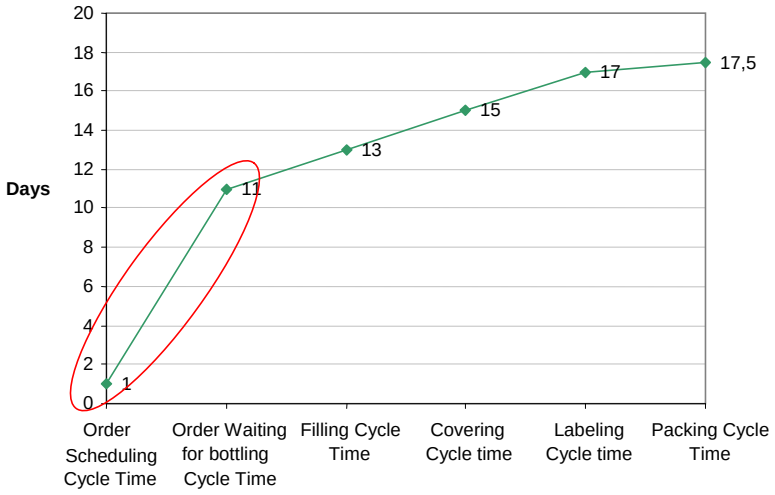


**Figure 6.2:** Accumulated Lead-time in bottling cycle time

Another important part of the *Total Logistic Cycle Time* is the time elapsed from the moment the order is ready in the warehouse until the order arrives to the customer's arranged place. Because of the FOB strategy followed by the winery, the customer is the importer, and that is why the lead-time for the winery in this case is only until the finished goods arrive to the Importer. Table 6.2 shows the delivery cycle time. It is composed of several sub activities. Each activity has its own delay, which when accumulated along the processes shows the total delivery cycle time. This accumulated time is shown in the third column of the table. Delivery Cycle time is 31 days.

**Table 6.2:** Delivery Cycle Time

| Indicator Name | Elapsed Time (days) | Accumulated Time (days) |
|---|---|---|
| Lead Time for Overseas Market (from winery to Importer CT) | 30 | |
| Freight Operator Cycle Time (Winery to Port) | 5 | 5 |
| Port to port cycle time (Port of origin to port of destination) | 20 | 25 |
| Importer Cycle Time (Is the elapsed time from the moment the freight departures to the port until arrives to the importer warehouse) | 5 | 30 |
| Vehicle load/unload time | 1 | 31 |
| Total Deliver Cycle Time | | 31 |

Considering total bottling cycle time and delivery cycle time, an estimated average of Total Logistic Cycle Time for the winery of the case study is of 48.5 days as shown in Table 6.3.

**Table 6.3:** Total Logistics Cycle Time

| Indicator Name | Elapsed Time | Accumulated Time |
|---|---|---|
| Total Bottling cycle time | 17.5 | 17.5 |
| Deliver Cycle Time | 31.0 | 48.5 |
| Total Logistics Cycle Time | | 48.5 |

Figure 6.3 shows the accumulated time from the moment the order is ready in the warehouse to the moment the order arrives to the customer place, including the time used for loading/unloading the container. An important factor that can be seen in this figure is the required time to arrive from the winery to port and the time elapsed for arriving to the importer. Considering the distance, it is a large number of days wasted to arrive to the port of origin. It means there is a problem during this cycle, it could be attributed to lots of certificates, inspections, waiting for consolidation with other shipments, wasted time due to weather conditions, etc. An alternative for this problem could be counting with a warehouse of finished goods near the port of origin or in destination country, in order to reduce freight operator lead-time. Another alternative is to make collaborative forecasting with the importer in order to respond to market's demand.

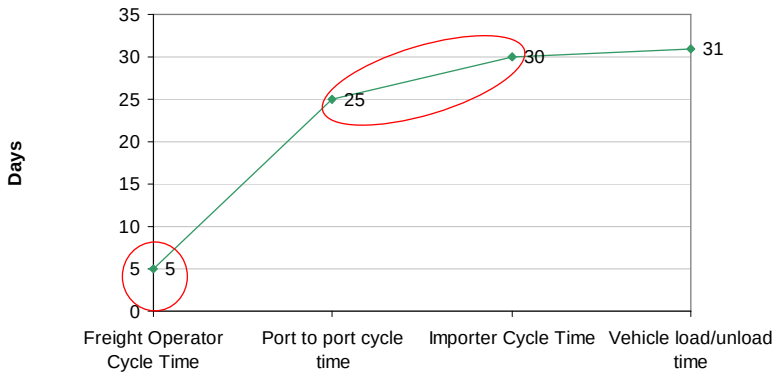


**Figure 6.3:** Delivery Cycle Time

In Figure 6.4, the winery's SC and the lead-times are shown. Through this information is possible to determine the processes which are delaying the delivery of finished goods to customers. As can be seen in Figure 6.4 the importer is the last actor in the WSC the winery has direct contact with. This means there is a lack of visibility forward in the SC, which may produce bullwhip effect, higher costs (especially warehousing) and it forces actors to hold inventories, decreasing the precision in forecasts. The lead-time of the suppliers is not accumulated in the total sum because the winery does not wait an order to make the purchase order, but it buys basic labels and then it reprints when necessary saving time. This is also shown in figure 6.4.

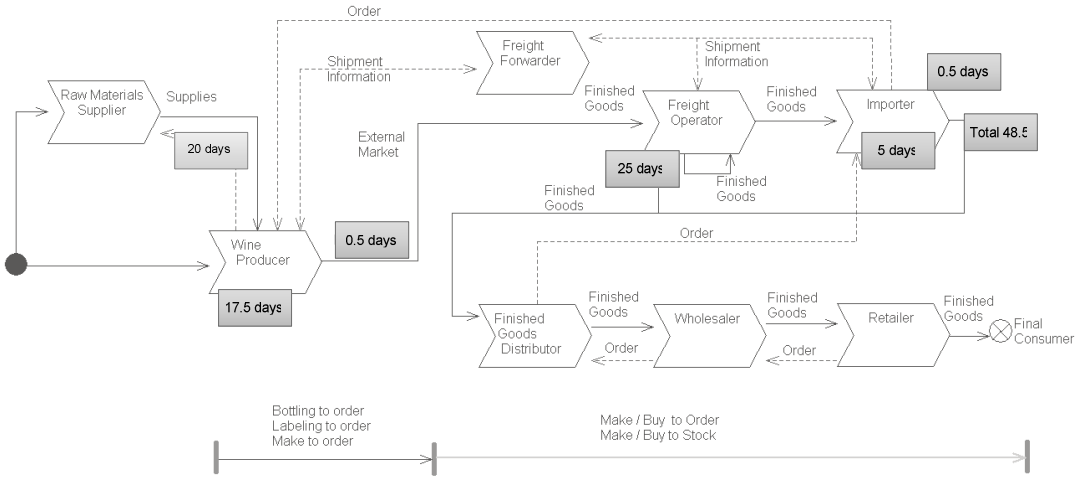


**Figure 6.4:** Total Cycle Time

### 6.4.2 Resource Utilization Percentage

Another indicator which is very important for the winery is the *Resource Utilization Percentage*. In order to improve productivity and capacity in the winery it is necessary to know how machines are producing and whether the space in warehouses and cellars is used appropriately or wasted. There are several indicators to measure productivity. In order to facilitate the decision making process for the winery, the percentage of utilization of resources is presented in Table 6.4.

**Table 6.4:** Resource Utilization Percentage

| Indicator | Available capacity | Used Capacity | Utilized Percentage | Wasted Capacity |
|---|---|---|---|---|
| **Production Machines Capacity Utilization** | | | 75% | 25% |
| Capacity of utilization of filling machines | 2000 Bottles / hr | 1800 Bottles / hr | 90% | 10% |
| Capacity of utilization of labeling machines | 2500 Bottles / hr | 1500 Bottles / hr | 60% | 40% |
| Average percentage of working time consumed in setups of machines | -- | -- | -- | 10% |
| **Warehousing Capacity Utilization** | | | 80% | 20% |
| Cellar capacity | 500.000 Bottles | 350.000 bottles | 70% | 30% |
| Warehouse capacity | 100 positions (pallets) available | 80 positions (pallets) occupied | 80% | 20% |

Considering the percentage of resources utilized there is a percentage of wasted capacity in machines as well as in the warehouse and cellar. At the

same time there is wasted time due to setups of machines. The labeling line works 60% of the full capacity during a year. Filling line is better used considering the annual capacity; this line also covers and packs the wine. It is necessary to know if there are some orders that have been delayed because of this wasted time, or if there have been complaints from the customers. A better administration of the resources is possible in order to avoid these problems and improve efficiency. Regarding to warehousing, considering the forecasts, the annual production, the capacity of cellar and the level of customers, an alternative solution is to produce more high quality wine to profit from the space. Costs must be considered in this case for making appropriate decisions.

Taking into account both measures, lead-time and resource utilization percentage, the managers of the winery could take some actions in order to avoid future problems and to reduce costs and response time to customers. Examples of decisions are:

(1) Changing the production strategy for specific products and markets and making collaborative forecasting to assure stock levels if cycle times are too long.

(2) Changing the shipping company if it is not good, or changing the port through which the finished goods are dispatched, or using another transport means not considered so far if the distribution cycle time is too large.

(3) Adding or changing resources to speed up the order preparation or to reduce lead times in bottling and packing processes, etc.

# Chapter 7: Conclusions

This last chapter summarizes this thesis, identifies contributions made to the wine industry and proposes future research in the area of WSC modeling. It is divided into 4 sections. Section 7.1 summarizes all the important points included in this thesis. Section 7.2 comments theoretical and practical contributions. Perceived benefits of the research are presented in section 7.3 and finally section 7.4 suggests possible areas for future research.

## 7.1 Summary

In order to support the contributions of this thesis, the general context of the global wine industry including the new wine world countries, and especially the situation of Argentina, was presented.

After having summarized the relevant concepts and previous works on the three basic management tools on which the contributions of this thesis are based, namely SCM, SC modeling and performance measurement, a descriptive model of the WSC was presented. This model includes a description of three aggregation levels, five processes along the SC, and a representation of all actors who work to arrive to the final consumer in time and in form. For each actor in the SC, a description of the main activities and roles integration were presented, and actors were classified in primary and supporting actors. Material flows and information flows were identified along the WSC and presented in the most common scenarios: local market distribution, external market distribution with 3 tier system, and sales through ex cellar in small quantities. Some particularities referred to different SCs, depending on the wine segment produced, were presented. Different production strategies followed by wineries were exposed. A list of common and potential problems was identified and presented, classifying each problem according to 4 proposed performance attributes. The identification of causes and alternative solutions were described whenever was possible.

Furthermore, in this thesis a first approach to a logistic performance framework was proposed for the wine industry. The purpose of this framework is to define the means through which logistics performance measures can be taken in the wine industry. This framework defines a hierarchy of indicators of three levels. Four performance attributes and six logistics processes were defined to classify the indicators. For each indicator of the first level of the hierarchy a description and a formula were presented to obtain its result. Additionally, different relationships between these indicators were presented, which can help to detect inefficient processes or potential problems. An example of a winery was used to explain these relations between indicators. Relations between potential problems along the WSC and the proposed KPI were identified and presented in order to explain

how these indicators help detect and prevent potential problems in the WSC. In order to appropriately apply the framework of logistics indicators a methodology was presented.

Finally, a case study was presented of a real winery from Mendoza, Argentina, in order to illustrate the model instantiation, the application of the performance measurement framework and to explain how to utilize each relevant indicator taking into account the winery's strategy.

## 7.2 Contributions

The main contributions of this research can be summarized as follows:

1- *The identification and formalization of a model of the WSC*. This model includes actors, relations, material and information flows description, etc. Through this model, companies of wine industry may have a better understanding of its complex dynamic, the SC's operations, relations between actors, etc. This will help companies to design better strategies, better networks, and improve performance of key logistics processes.

2- *The identification of potential problems that could arise in the operations of the WSC.* Knowing which problems could arise during operations, companies may make appropriate decisions in order to avoid or minimize these problems.

3- *The definition of a generic catalog of key logistics performance indicators for the wine industry* structured in a hierarchy of different levels of complexity. Counting with a catalog of key performance indicators along logistics processes will permit to control these processes, measure them and improve their performance and efficiency.

4- *The relation between KPI and the defined problems along the WSC.* This includes the identification of which indicator should be used for measuring performance of each process, in order to avoid common problems that arise in the WSC. Through the implementation of the KPI, it is possible for wine companies to know which indicator allows detecting and preventing a potential common problem in the WSC, which will have benefits and decrease negative impacts.

5- *The definition of some relations between the indicators and different ways of analyzing the framework to detect deviations.* The use of existent relations between indicators helps to interpret the performance information derived, going from observable problems to the root causes by navigating related indicators through the identified relations.

6- *A set of guidelines were described as part of the case study* in order to illustrate the kind of decisions that could be made by using the information contributed by the overall model proposed. Through the presentation of real cases and real problems it is easier to prove the benefits of the theoretical model and framework, and that they help to interpret important information.

7- *The development of questionnaires which will be useful to carry out a validation of the model through different wineries.* Through these questionnaires it is possible to validate the framework in different wineries, even in different countries. This will help to complement the model with practices and strategies unknown yet.

## 7.3 Benefits of the research

With the application of the proposed model, companies of the wine industry can have a better understanding of all relations and the complex dynamics present in the WSC. This model will help them to focus on inefficient processes and gives them the possibility to set new strategies or goals. Furthermore, knowing the model of the SC it is possible to optimize and maximize resource utilization and to increment final consumer's satisfaction levels at the lowest cost possible.

The indicators of the proposed framework can further be used to compare the performance of different wineries and to obtain a diagnosis of each winery related to industry leaders' performance. It is possible to find the logistics processes in which an organization is better or worse than the others and the causes of these deviations. The hierarchy of indicators is useful because a first level measurement can be made to find a general diagnosis of the logistics performance within the wine industry, and if a deeper analysis is required then other levels of the framework can be used to find the causes of the deviations found the first time. Using this framework a logistics benchmarking study could be carried out which may permit to obtain the industry best practices. These practices can be implemented in the wineries to improve their processes performance to reach success.

## 7.4 Future research

The proposed framework is a first approach to a SCM framework within agro-industry supply chains, and especially to the wine industry. However, further research is needed in several areas. Future work may include the following topics:

1. *Deeper description of the performance measurement hierarchy and its indicators, including their definitions and formulas*. Even thought the first level of the hierarchy is useful to obtain a fast and general idea of the performance of the enterprise, it is necessary to count with a complete second and a third level of indicators to disaggregate the information as needed. For each indicator of the hierarchy, a description and a formula will be developed, as well as a methodology for using them.

2. *Comparison of the WSC of different countries*. In order to show the variety of instances and diversity of operations of different countries, a comparison of the SCs will be performed. Agricultural practices, legislations, market requirements, wine segment, industrial practices differentiate supply chains form different countries. These SCs will be identified and formalized.

3. *Development of a formal mathematical model of different logistics aspects based on this descriptive model*. Mathematical models represent complex behavior and complex systems using mathematical formalisms to express relations, variables, parameters, entities, and relations between variables. Through these mathematical models it is possible to simulate different scenarios and to optimize inefficiencies present in the WSC.

4. *Simulation based on this WSC model*. In order to evaluate different scenarios, experiment with new strategies, and prevent unfavorable situations, simulation can be applied. Simulating and studying new processes, new strategies, or simulating the reality of the operations, some unfavorable situations and negative impacts could be prevented.

5. *Development of questionnaires to implement benchmarking in the wine industry*. Based on the proposed indicators, questionnaires will be developed in order to facilitate the collection of information and perform a benchmarking study in the wine industry.

6. Deeper comprehensive analysis of the correlations between the indicators, in order to allow a better understanding of WSC dynamics through the quantification of the specific relations between criteria.

7. *Use of Multicriteria Decision Making Tools (MCDM)* for identifying which indicators are more important for a winery according to its strategy, market segment, the wine segment, etc. These tools may also be used for determine how a set of indicators influence the value of a target indicator.

8. *A study of logistics benchmarking in the wine industry will be performed* by *applying the proposed framework, the model of the WSC and the questionnaires*. In order to know and formalize the wine industry best practices, a

benchmarking study will be performed, which will provide a diagnosis of wineries of Mendoza, and the average and the best of the industry.

9. *A deeper description of material flows and information flows will be developed*. In order to understand and optimize flows in the WSC, a full appreciation of the relations between actors is needed. Detailed descriptions of information flows (i.e. contents of documents and data exchanged) as well as legislation constraints are needed in order to have a deep understanding of the impacts of changes (optimizations) in the WSC.

10. *Extrapolate the measurement framework to other agro-industries.* In order to evolve the framework and to cover needs observed in other agro-industries an extension (and adaptation) of the indicators could be done to consider them.

# Appendix A

## Questionnaires

Two questionnaires were developed in order to validate the model and the framework. The first questionnaire was made to several wineries for obtaining data for creating the WSC model, while the second one was only used with the winery of the case study, for applying the performance measurement framework.

## Questionnaire to validate WSC model

The first questionnaire is used to validate the actors and relations in the WSC. It is composed of three parts. The first part is referred to supply cycle. In this part questions to validate the actors who participate in the supply cycle are made and also questions to identify potential problems in these activities. The second part of the questionnaire is referred to the production cycle, whose purpose is to identify all actors and common problems that could arise during elaboration and production processes. Another important cycle is the distribution cycle, which is considered in the third section of the questionnaire. In this part of the questionnaire questions are made in order to identify problems and strategies during distribution cycle in local and overseas market. Through this questionnaire it was possible to recognize all actors and the relations between actors in the WSC. It was also useful to identify potential problems during the operations.

**Modelado de la Cadena de Abastecimiento del Vino**

**Cuestionario**

El cuestionario esta divido en tres secciones, ciclo de abastecimiento, ciclo de producción y ciclo de distribución. Entre paréntesis de cada pregunta tiene las opciones con las que debe contestarse en el recuadro de respuesta. Las preguntas no son mutuamente excluyentes, por lo que deben contestarse cada opción con la respuesta que corresponda indicada entre paréntesis.

| 1 Ciclo de abastecimiento | Respuesta |
|---|---|
| 1.1 Utilizan viñedos propios? (si / no) | |
| 1.2 Compran uvas a terceros? (si / no) | |
| 1.3 Ocurren problemas con la calidad de la uva cosechada en mal momento? (si / no) | |
| 1.4 Ocurren largas esperas en la recepción de la bodega de los camiones con la uva, debido a una mala planificación de arribos? (si / no) | |
| 1.5 Compran vino elaborado para fraccionar? (si / no) | |
| 1.6 Para el transporte de la uva tienen:<br>a- Flota de transporte propio (si / no)<br>b- Flota de transporte contratado (si / no) | |
| 1.7 Los proveedores de insumos para elaboración (botellas, corchos, cápsulas, etc.) son: | |

| | |
|---|---|
| a- Nacionales? (si / no)<br>b- Internacionales? (si / no) | |
| 1.8 Cuales son los problemas más notorios durante el abastecimiento? | |
| a- Demoras de los proveedores (si / no)<br>b- Mala calidad (si / no)<br>c- Pedidos incorrectos (si / no)<br>d- Documentación incorrecta (si / no)<br>e- Poca personalización de insumos (botellas, etiquetas) (si / no) | |
| 1.9 Los pedidos se realizan al proveedor:<br>a- Usando sistema informático integrado al proveedor (ERP) (si / no)<br>b- Vía telefónica o E-mail (si / no)<br>c- Cuando el proveedor manda un vendedor (si / no) | |
| 1.10 Donde se compran las botellas? (indicar país y/o provincia) | |
| 1.11 Donde se compran los corchos? (indicar país y/o provincia) | |
| 1.12 Donde se compran las capsulas? (indicar país y/o provincia) | |
| 1.13 Donde se compran las etiquetas? (indicar país y/o provincia) | |

| **2 Ciclo de producción** | **Respuesta** |
|---|---|
| 2.1 Una vez producido el vino<br>a- Se estiba en la misma bodega? (si / no)<br>b- Se transporta para estiba en otros establecimientos? (si / no) | |
| 2.2 Si el vino se transporta, se usa:<br>a- Transporte propio (si / no)<br>b- Transporte Contratado (si / no) | |
| 2.3 Se fracciona y empaca:<br>a- En la misma bodega (si / no)<br>b- En un centro de fraccionamiento externo? (si / no) | |
| 2.4 Cuales son los problemas más comunes durante la elaboración del vino<br>a- Insumos no disponibles en tiempo y forma (si / no)<br>b- Perdida de tiempo por set ups largos de las maquinas (si / no)<br>c- Largos test de calidad atrasan el proceso de elaboración (si / no)<br>d- Problemas en la programación de las tareas en elaboración (si / no)<br>e- Problemas en la programación de las tareas en embotellado (si / no) | |
| **3 Ciclo de distribución** | **Respuesta** |
| 3.1 Con que mercado trabajan:<br>a- Local? (si / no)<br>b- Internacional? (si / no) | |
| 3.2 Aproximadamente, que porcentaje de la producción se exporta? (%) | |
| 3.3 Que medio se utiliza para recibir pedidos?<br>a- Sistemas informáticos integrados (ERP) (si / no)<br>b-Vía telefónica o E- Mail (si / no) | |
| 3.4 Cuales son los problemas más notorios en la entrega de los productos<br>a- Lead times muy largos (si / no)<br>b- Mala calidad en los productos (si / no)<br>c- Documentación incorrecta (si / no)<br>d- Largas demoras por cuestiones legales? (si / no) | |
| 3.5 Existen problemas de variación desfavorable de la temperatura durante la distribución del producto? (si / no / no sabe) | |
| **Si trabajan con mercado internacional** | |
| 3.6 En los países de destino, como se llega al consumidor final?<br>a- A través de 3 niveles (distribuidor, mayorista, minorista) (si / no)<br>b- Sólo Distribuidor (si / no)<br>c- Distribuidor y Mayorista (si / no) | |

| | |
|---|---|
| d- Distribuidor y Minorista (si / no)<br>e- Mayorista y Minorista (si / no)<br>f- Entrega directa al consumidor (si / no) | |
| 3.7 De quienes se reciben pedidos en los países a los que se exportan?<br>a- De Importadores? (si / no)<br>b- De consumidores finales (si / no)<br>c- De otras bodegas (si / no)<br>d- De freight forwarder? (si / no) | |
| 3.8 Manejan la exportación por medio de freight forwarder? (si / no) | |
| 3.9 Que puerto de salida utilizan?<br>a- Valparaíso (si / no)<br>b- Buenos Aires (si / no)<br>c- San Antonio (si / no) | |
| 3.10 Hasta llegar al puerto que modalidad de transporte utilizan?<br>a- Terrestre (si / no)<br>b- Aéreo (si / no) | |
| 3.11 Bajo que condiciones exportan? (FOB, CIF, EXW, etc.) | |
| **Si trabajan en mercado local** | |
| 3.12 Los envíos llegan al consumidor final a través de<br>a- Sólo Distribuidor (si / no)<br>b- Distribuidor y Mayorista (si / no)<br>c- Distribuidor y Minorista (si / no)<br>d- Mayorista y Minorista (si / no)<br>e- Envío directo al consumidor final (si / no) | |
| 3.13 Para la distribución se utiliza<br>a- Flota propia (si / no)<br>b- Servicio de distribución contratado (si / no) | |
| 3.14 De quienes se reciben pedidos en el mercado local?<br>a- De Distribuidores finales? (si / no)<br>b- De Mayoristas (si / no)<br>c- De Minoristas (si / no)<br>d- De otras bodegas (si / no)<br>e- Del consumidor final? (si / no) | |

## Questionnaire for the winery of the case study

The second questionnaire was made for the winery of the case of study, in order to apply the framework proposed and to validate the model of the winery. The purpose of the questionnaire was to identify the information needed to apply two of the most important indicators of the hierarchy: *Total Logistic Cycle Time* and *Resource Utilization Percentage*.

| **Cuestionario para bodega del caso de estudio** | | | |
|---|---|---|---|
| | | | |
| 1. Los siguientes insumos se compran a proveedores nacionales, internacionales o ambos? Indicar si es posible el lead-time promedio de entrega de cada insumo. | | | |
| | | Origen | Lead-time promedio |
| | Botellas | | |
| | Corchos | | |
| | Cápsulas | | |

| | Etiquetas | | | |
|---|---|---|---|---|
| 2. Que cantidad de proveedores tienen aproximadamente? | | | | |
| 3. Que cantidad de clientes tienen aproximadamente? | | | | |
| 4. De que país son los clientes más importantes? | | | | |
| 5. Tienen warehouse propio para insumos? | | | | |
| 6. Cual es el tiempo promedio de las siguientes tareas de fraccionamiento (indicar la unidad de medida utilizada) | | | | |
| a. Desde la confirmación de la orden hasta la programación en el sistema (Schedule) de esa orden | | | | |
| b. Desde que esa orden es programada hasta que la orden comienza a embotellarse (o etiquetarse según corresponda) | | | | |
| c. Desde que comienza el llenado hasta que termina | | | | |
| d. Desde que comienza el tapado (corcho y capsula) hasta que termina | | | | |
| e. Desde que comienza el etiquetado hasta que termina | | | | |
| f. Desde que comienza el empaquetado hasta que termina | | | | |
| g. Ciclo del Embotellado completo | | | | |
| 7. Cual es el tiempo promedio de las siguientes tareas de distribución si se conocen (indicar la unidad de medida utilizada) | | | | |
| a. Desde que la orden está lista en el warehouse hasta que llega al puerto origen | | | | |
| b. Desde que la orden sale del puerto origen hasta que llega a puerto destino | | | | |
| c. Desde que la orden sale del puerto destino hasta que llega al warehouse del Importador | | | | |
| d. Tiempo promedio de carga del container | | | | |
| 8. Tienen una línea de llenado? Cuál es la capacidad máxima de la línea de llenado? X bot/hr | | | | |
| 9. Cuál es número de botellas promedio que se llenan en la línea de llenado? X bot /hr | | | | |
| 10. Tienen línea de etiquetado? cuál es la capacidad máxima de la línea de etiquetado? X bot/hr | | | | |
| 11. Cual es la cantidad promedio de botellas que etiqueta la línea de etiquetado? X bot /hr | | | | |
| 12. Tienen warehouse propio para producto terminado? Que capacidad máxima de posiciones pueden almacenarse? | | | | |
| 13. En promedio, cuantas posiciones del warehouse están ocupadas por mes? | | | | |
| 14. Que capacidad máxima tiene la bodega para estiba? | | | | |
| 15. Cuanta capacidad en promedio está ocupada por mes? | | | | |

| |
|---|
| 16. De la siguiente lista de potenciales problemas detectados en la cadena de abastecimiento del vino clasificar de 0 a 5 la importancia de cada uno de ellos para la bodega y el impacto que tienen en la performance (ya sean incremento de costos, baja productividad, etc.) |
| |
| "0" especifica ausencia del problema |
| "1" el problema se presenta pocas veces, no es grave, no implica impactos graves |
| "2" el problema se presenta esporádicamente pero no implica impactos graves |
| "3" el problema se presenta seguido, es medianamente grave e implica algunos impactos |
| "4" el problema se presenta varias veces en la bodega y tiene altos impactos |
| "5" el problema es grave tienen grandes impactos y ocurre muy seguido en la bodega. |
| |

| Descripción del Problema | Calificación |
|---|---|
| 1. Se cosecha la uva sin haber alcanzado el punto óptimo de madurez en la uva | |
| 2. Durante la cosecha se detecta falta de capacitación en el personal. | |
| 3. Cosecha de la uva fuera de periodo correcto. | |
| 4. Largas esperas de las uvas en la entrada de la bodega exponiendo las uvas a condiciones desfavorables | |
| 5. Insumos entregados en malas condiciones | |
| 6. Producto final entregado en malas condiciones | |
| 7. Fluctuaciones de temperatura a lo largo del canal de distribución del producto terminado | |
| 8. Demoras en la entrega de los insumos críticos (botellas y etiquetas) | |
| 9. Demoras en la entrega de los corchos y cápsulas | |
| 10. Los proveedores de botellas o etiquetas no son lo suficientemente flexibles para adaptarse a nuevos requerimientos de productos (ej. nuevo diseño de etiquetas) | |
| 11. Los procesos de pruebas de calidad durante la elaboración y embotellado demoran el proceso | |
| 12. Largas demoras debidos a setups de las máquinas durante el embotellado | |
| 13. Mal manejo de programación de actividades en la elaboración y/o embotellado | |
| 14. Se observan ineficiencias en la distribución del vino para comercio exterior (demoras, congestiones, papeleo innecesario por inspecciones, certificaciones, mala coordinación de containers, etc.) | |
| 15. El sistema de distribución de algunos países impide la visibilidad de la bodega hacia adelante en la cadena de abastecimiento, no se conoce al cliente (impacta en efecto "bullwhip", mala precisión en predicciones, etc.) | |
| 16. Falta de sistemas de información integrales a lo largo de la cadena | |
| 17. No se comparte información con proveedores y clientes | |
| 18. Bajo uso de sistemas de ayuda a la toma de decisiones (OLAP, Datawarehouse, cuadros de mando integrales, etc.) | |
| 19. No se tiene en cuenta la capacidad de recepción de las bodegas, al momento de la recepción de la uva. (falta de planificación de recepción de los camiones) | |
| 20. Capacidad desperdiciada de los camiones y containers al transportar uva y producto terminado | |
| 21. Capacidad oseosa de las máquinas de embotellado | |
| 22. Re empaquetado de botellas para ajustar a requerimientos de clientes | |
| 23. Re paletizado de producto terminado | |
| 24. Otros problemas que considere importantes y no han sido expuestos | |

# Appendix B

## Statistic tables

In this section all tables which contain the data for the curves presented in chapter 1 are presented.

**Table B.1:** World wine production

| Country | 86-90 | 91-95 | 96-00 | 01-05 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|
| Italy | 65715 | 60768 | 54386 | 49409 | 44848 | 53181 | 54021 | 53.462 | 47.981 | 48633 |
| France | 64641 | 52886 | 56271 | 51919 | 46360 | 57386 | 52105 | 52.276 | 48.400 | 41429 |
| Spain | 33519 | 26438 | 34162 | 36993 | 41843 | 42988 | 36158 | 38.173 | 36.781 | 34630 |
| USA | 18167 | 17619 | 20386 | 20399 | 19500 | 20109 | 22888 | 19.621 | 20.034 | 19200 |
| Argentina | 19914 | 15588 | 13456 | 14488 | 13225 | 15464 | 15222 | 15396 | 15045 | 14.676 |
| Australia | 4285 | 4810 | 7380 | 12543 | 10835 | 14679 | 14301 | 14.298 | 11.620 | 12365 |
| China | 2734 | 5140 | 9581 | 11460 | 11600 | 11700 | 12000 | 12.000 | 12.000 | 12000 |
| Germany | 10012 | 10391 | 9989 | 9225 | 8191 | 10007 | 9153 | 8.916 | 10.261 | 10400 |
| South Africa | 7742 | 8228 | 7837 | 8040 | 8853 | 9279 | 8406 | 9.407 | 9.840 | 10261 |
| Chile | 4135 | 3326 | 5066 | 6389 | 6682 | 6301 | 7886 | 8.449 | 8.227 | 8683 |

**Table B.2:** World Wine Exportations

| Country | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|
| Italy | 15.856 | 15.794 | 13.283 | 14.123 | 15.721 | 18.001 | 18.800 | 17200 |
| Spain | 9.946 | 9.594 | 12.359 | 14.042 | 14.439 | 14.340 | 15.283 | 16500 |
| France | 15.126 | 15.541 | 15.148 | 14.210 | 14.077 | 14.720 | 15.151 | 13600 |
| Australia | 3.750 | 4.715 | 5.365 | 6.426 | 7.019 | 7.595 | 7.850 | 7090 |
| Chile | 3.089 | 3.553 | 4.029 | 4.740 | 4.209 | 4.740 | 3.923 | 4017 |
| USA | 2.844 | 2.662 | 3.293 | 3.874 | 3.459 | 3.761 | 4.231 | 4549 |
| Argentina | 882 | 1.234 | 1.852 | 1.553 | 2.148 | 2.934 | 3.598 | 4141 |
| Portugal | 1.673 | 2.141 | 3.162 | 3.229 | 2.620 | 2.926 | 3.486 | 3100 |
| Germany | 2.372 | 2.375 | 2.773 | 2.709 | 2.970 | 3.197 | 3.445 | 3600 |
| South Africa | 1.773 | 2.174 | 2.385 | 2.677 | 2.811 | 2.717 | 3.132 | 4100 |
| Moldavia rep. | 1.368 | 1.537 | 2.022 | 2.280 | 2.425 | 1.020 | 1.500 | 1000 |
| Bulgaria | 791 | 788 | 768 | 905 | 1.142 | 1.127 | 1.150 | 1900 |

**Table B.3:** Destination of Exportations in thousands of Dollars and HL

| Country | 2006 | 2007 | 2008 |
|---|---|---|---|
| **Dollars** | | | |
| USA | 86610,66 | 115545,09 | 161696,03 |
| Canada | 29605,01 | 40576,01 | 57143,52 |
| United Kingdoms | 34523,49 | 41961,46 | 43503,7 |
| Brazil | 31352,67 | 38292,58 | 41266,59 |
| Russia | 23324,34 | 30678,28 | 38566,91 |
| Netherlands | 19668,44 | 26671,38 | 34981,38 |
| Paraguay | 14786,19 | 19017,1 | 21454,32 |
| Denmark | 18885,42 | 18625,02 | 21332,28 |
| Japan | 6214,58 | 6919,57 | 10543,66 |
| Chile | 3493,81 | 3765,76 | 3212,18 |

| Country | 2006 | 2007 | 2008 |
|---|---|---|---|
| | | HL | |
| Russia | 75872 | 930974,55 | 998714,04 |
| USA | 419213,36 | 684313,45 | 786744,27 |
| Paraguay | 258880,19 | 274156,17 | 284101,86 |
| Canada | 197582,7 | 223305,18 | 274539,18 |
| United Kingdom | 201244,56 | 226123,33 | 207186,69 |
| Brazil | 132534,02 | 163996,04 | 151035,28 |
| Netherlands | 99205,58 | 114996,04 | 132416,15 |
| Denmark | 92204,1 | 84904,28 | 88649,93 |
| Japan | 65371,76 | 66225,09 | 71973,26 |
| Chile | 59538,14 | 59974,96 | 33830,7 |

**Table B.4:** Surface Planted with vineyards in Argentina

| Surface Planted with vineyards | |
|---|---|
| Year | Surface [Ha] |
| 1991 | 209268 |
| 1992 | 208752 |
| 1993 | 208863 |
| 1994 | 209838 |
| 1995 | 210391 |
| 1996 | 210635 |
| 1997 | 209042 |
| 1998 | 210448 |
| 1999 | 208137 |
| 2000 | 201113 |
| 2001 | 204132 |
| 2002 | 207986 |
| 2003 | 210530 |
| 2004 | 212659 |
| 2005 | 218590 |
| 2006 | 223034 |
| 2007 | 225845 |

**Table B.5:** Number of Vineyards planted in Argentina

| Number of vineyards | |
|---|---|
| Years | Number of vineyards |
| 1991 | 35933 |
| 1992 | 35796 |
| 1993 | 34310 |
| 1994 | 34988 |
| 1995 | 34845 |
| 1996 | 34692 |
| 1997 | 33642 |
| 1998 | 33459 |
| 1999 | 31552 |
| 2000 | 25180 |
| 2001 | 25698 |
| 2002 | 26011 |
| 2003 | 26093 |
| 2004 | 25793 |
| 2005 | 25882 |
| 2006 | 26133 |
| 2007 | 26194 |

**Table B.6:** Argentine Exportations 1990-2008

| Year | Total |
|---|---|
| 1990 | 445,536 |
| 1991 | 282,097 |
| 1992 | 227,384 |
| 1993 | 250,799 |
| 1994 | 226,31 |
| 1995 | 1970,36 |
| 1996 | 1119,866 |
| 1997 | 1204,683 |
| 1998 | 1089,042 |
| 1999 | 880,461 |

| | |
|---|---|
| 2000 | 843,02335 |
| 2001 | 881,61843 |
| 2002 | 1234,409 |
| 2003 | 1852,25964 |
| 2004 | 1553,39034 |
| 2005 | 2147,759 |
| 2006 | 2934,248 |
| 2007 | 3597,70195 |
| 2008 | 4140 |

**Table B.7:** Argentine Exportations, comparison 2008-2009

| | Hectoliters | | Thousands dollars | |
|---|---|---|---|---|
| **Detail** | **2008** | **2009** | **2008** | **2009** |
| Total 2 month | 665135 | 456746 | 86137 | 85265 |
| Average | 332568 | 228373 | 43068 | 42632 |
| | | | | |
| January | 355780 | 232696 | 43919 | 42869 |
| February | 309355 | 224050 | 42218 | 42396 |
| March | 281973 | | 39117 | |
| April | 338572 | | 54398 | |
| May | 392167 | | 52533 | |
| June | 266437 | | 40282 | |
| July | 417488 | | 57331 | |
| August | 363051 | | 56722 | |
| September | 445548 | | 66351 | |
| October | 446282 | | 72786 | |
| November | 273604 | | 49803 | |
| December | 250291 | | 46530 | |
| Total | 4140548 | 456745,84 | 621991 | |

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