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A framework for measuring logistics performance in the wine industry

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ABSTRACT

Nowadays, in order for wine companies to reach a world-class standard, it is necessary to implement the industry best practices and continuously adapt their logistics processes. Through benchmarking, these enterprises can find opportunities for improvement. So far, little research in benchmarking and performance measurement has been developed for the wine industry. In this paper a logistics benchmarking framework for the wine industry is proposed. A benchmarking study considering several wineries from Mendoza (Argentina) is presented as a case study, in order to demonstrate the validity of the developed framework.

1. Introduction

In a global economy and competitive and dynamic environment, Supply Chain Management (SCM) is a key strategic factor for increasing organizational effectiveness. Wine companies around the world are realizing the importance of supply chains and the impact of their performance on the business.

The importance of the wine industry worldwide can be measured by its business and operations volume. According to a study of the International Wine and Spirit Record (IWSR, 2010), in 2010 the wine world market reached 23.6 billion liters, representing 183.1 billion dollars, a growth of 4.5% from 2005. For 2014 an increase of 3.2% is expected.

Logistics activities in the wine industry are becoming more and more important. New markets are appearing as a consequence of the economic development of some emerging countries such as China, Russia and the Asia-Pacific region. Moreover, the IWSR (2010) report indicates that today 25% of wine bottles consumed are imported wines, and this proportion will be higher in the next years. Therefore, an increase of the logistics operations in the wine industry is expected.

Additionally, different segments of wines, from table to super premium, need particular logistics activities. For example Dollet and Diaz (2010), studied the premium and super-premium wines, a market driven by time-to-market and customization, and they proposed a multi-level network orchestration SCM model for this specific market. On the other hand, for commodity wines the fierce competition for existent and new markets leads to search for supply chain strategies in order to reduce transportation cost. Roy and Cordery (2010) proposed a collective procurement approach for growers and wine producers, and export in bulk rather in bottles. Furthermore, Wen et al. (2010) applied the Quality Function Deployment methodology to identify customer segments and infer wine taste but also scale operation and supply chain strategy for this growing market.

Supply Chain Management is important for wineries worldwide because they compete in an international marketplace where, even though the production is rather flat (Fig. 1), the "old world wine producers" tend to decrease their wine production and consumption while "new world wine producers" are becoming more aggressive, offering very high quality wines at more competitive prices. Moreover, due to the complexity of the different segments, the traditional dichotomy "old world"/"new world" does not have sense anymore (Banks and Overton, 2010), as each production country has different supply integration levels, winery sizes and production styles (traditional, modern, artisanal, closely tied to place and vintage, large-scale industrial production for a mass market). Therefore, wine producers have to be able to better meet their customers' demands at a more affordable cost and ensure few stock outs on store shelves. This evolution has resulted in a growing necessity to higher inventory turns, service level and improved customer satisfaction.

Therefore, improving supply chain's effectiveness and efficiency becomes a critical factor to remain competitive in a marketplace that is more and more global, and where competition is tougher and tougher. The Wine Supply Chain (WSC) is a very complex system due to several aspects: the nature of the product (which forces the use of a mixed push/pull schema), the

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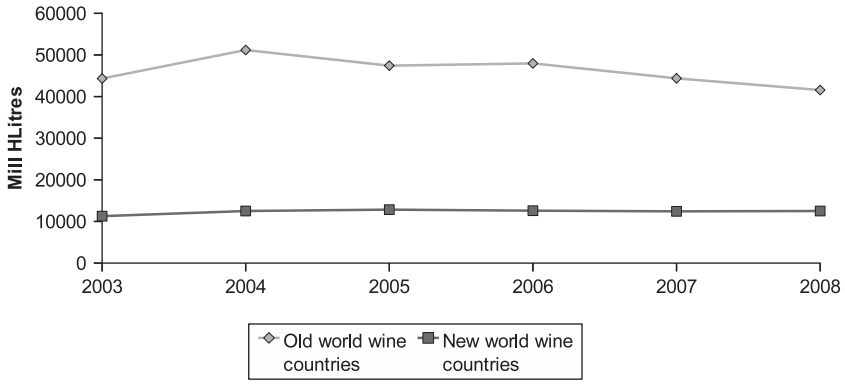

Fig. 1. New/Old World wine countries average production (Source: OIV – International Organization of Vine and Wine).

number of actors and relationships between them, the multi-tier systems in distribution cycle of some countries, the requirements of final customers, the continuous pressure of local and external competitors in the market and the legal constraints of distribution, among others. Some of these characteristics, like the mixed push/pull schemas, apply to other industries as well, particularly alcoholic beverage industries and agro-food industries.

For wine companies it is increasingly important to integrate logistics processes along the supply chain and to improve the performance of each process to reach a world-class standard. In order to improve the performance, it needs to be measured, so the definition of a consistent and world-class performance measurement framework, and the execution of benchmarking studies to acquire knowledge about the organization's performance related to its competitors and to the leaders of the industry, is an important tool for reaching world-class standards (Frazelle, 2002).

Many organizations have improved their logistics processes performance through the implementation of the industry best practices. However, little attention has been given so far to the performance evaluation, and hence, to the measures and metrics in the wine industry. Benchmarking is the search of those best practices that will lead to the superior performance of a company (Camp, 1989).

In this paper a description of the WSC is presented along with a hierarchical benchmarking framework for measuring the performance of logistics processes along the WSC. Additionally, a list of potential problems and the relation between these problems and the corresponding indicators of the hierarchy is presented. Finally, the results of a benchmarking study conducted on a sample of wineries from Mendoza (Argentina), is described.

2. Benchmarking background

During the past years, different works related to supply chain performance measurement have been developed following different approaches, e.g. different scopes (all logistics activities vs. individual logistics processes), different techniques (grouping indicators within dimensions, Data Envelopment Analysis, multi-criteria analysis, etc.). These works have different objectives (e.g. measuring internal performance, benchmarking, extracting knowledge in the form of dependency relationships between indicators, etc.). The proposed models and techniques have been applied in different industries and company sizes (e.g. manufacturing, hardware and software, textile and garment, etc.). In this section, a review of the recent literature is presented to illustrate the use of performance measurement in different industries, settings and with different objectives.

Bhagwat and Sharma (2007) developed a balance scorecard approach for supply chain management focused on small and medium sized enterprises. The availability of indicators that this kind of dashboards provides has made possible to obtain a quantitative perspective of the dynamics of distributed logistics chains. This has opened the possibility of implementing tools already developed for internal logistics chains, such us the implementation of information systems, costs management, optimization systems or multi-criteria decision support.

In recent years, the impact of information systems on logistics activities has grown. Performance of information systems activities has been measured following several perspectives (Martinsons et al., 1999), and the relation between IT implementation, Supply Chain Integration and Supply Chain Performance has also been researched (Li et al., 2009). Bayraktar et al. (2009) presented a study on which they have empirically tested a framework identifying the causal links among SCM and information systems practices.

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, such as manufacturing organizations (Lohman et al., 2004). Muchiri et al. (2010) presented a conceptual framework for guiding the definition of performance indicators for supporting the alignment of maintenance objectives with manufacturing and corporate objectives. Neely et al. (1996) identified different aspects that define a performance measurement system, and surveyed the use of structured processes for defining such systems, including more than 850 SMEs in the UK, which indicates that using structured approaches simplifies this task and improves the quality of the systems obtained.

Danese and Kalchschmidt (in press) investigated the impact of forecasting variables on companies' performance. Pinheiro de Lima et al. (2009) presented a process to integrate operations strategy to the design of operations performance measurement systems. Xu et al. (2009) studied the main uncertainty factors affecting the supply chain performance evaluation, and developed a performance evaluation model based on Rough Data Envelopment Analysis. Kulmala et al. (2009) propose to include leadership behavior in performance measurement in order to improve that area.

Outsourcing of logistics activities has become a common practice applied by companies to focus on their core competencies, what has yielded the need to measure performance of service providers. Krakovics et al. (2008) discussed the definition and design of a quantitative system to measure logistics performance when logistics activities are outsourced to 3PL (Third-Party-Logistics). Wong and Karia (2009) identified strategic logistics resources acquired and bundled by logistics service providers to achieve competitive advantage. Bustinza et al. (2010) presented a model to study the impact of outsourcing on the firm's competitive capabilities. Hsiao et al. (2010) presented a research framework to assess the effect of the outsourcing decision at 4 levels

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(transportation, packing, transportation management and distribution network management). Awasthi et al. (2010) proposed a fuzzy multi-criteria approach for evaluating environmental performance of suppliers.

Many benchmarking studies have been carried out in the past years in the integrated supply chain (Andersen et al., 1999) in several industries like manufacturing (Stewart, 1995; Voss et al., 1995; Collins et al., 1996; Voss et al., 1997; Hines, 1998; Geary and Zonnenberg, 2000; Choy, 2002; Cooper and Edgett, 2003), software and hardware (Cohen et al., 1997; Beitz and Wieczorek, 2000; Hamilton, 2006), transport (BizSys, 2006), port (Bichou, 2007) and textile and garment (Jolly-Desodt et al., 2006), among others. Lai et al. (2004) conducted a benchmarking study of companies in the transport logistics industry of Hong Kong, considering efficiency (economic use of resources) and effectiveness (fulfillment of customer requirements) measures, using a framework based on the SCOR model.

Pestana and Peypoch (2009) applied a two step Data Envelopment Analysis (DEA) procedure to evaluate the operational performance of a sample of the Association of European Airlines. Schmidberger et al. (2009) developed a holistic performance measurement system (PMS) for airport ramp service providers with a process-based perspective, and conducted a benchmarking study in several European hub airports. The authors followed the action research approach for defining the PMS, which associates weights to the measures in an Analytical Hierarchical Process, and groups measures into the perspectives of the Balanced Scorecard (BSC).

Benchmarking studies developed follow a wide range of approaches, including definition of measurement indicators for specific domains, defining best practices for improving efficiency in a specific industry, modeling different processes to measure its performance and the use of a tool to benchmark a specific domain. In the particular case of the wine industry there are some benchmarking studies focusing on particular aspects, such as the financial and economic performance of the enterprises (Deloitte and Winemakers' Federation of Australia, 2004; Deloitte and New Zealand Winegrowers, 2008), the energy efficiency opportunities (Galitsky et al., 2005), and the changes that have happened in the wine industry and their impact in old world and new world wine countries, from the demand, innovation, supply chain structure and institutional framework perspectives (Cusmano et al., 2010).

Although there are works related to logistics benchmarking in others industries such as in warehousing and distribution operations (Hackman et al., 2001) and in manufacturing industry (IAC, 2000), there are few works on logistics benchmarking in the wine industry. On the other hand, aspects other than logistics have been researched within the wine industry in previous works: supply cycle, production and distribution cycle, analysis of the situation of different countries, sustainability, etc. (Duraj et al., 2000; Adamo, 2004; Sheu et al., 2005; Colman and Päster, 2007; Musee et al., 2007; Alturria et al., 2008; Dunstall et al., 2008; Ferrer et al., 2008; Gabzdylova et al., 2009).

Therefore, there are no integrated supply-chain-wide frameworks to measure logistics performance in the wine industry. Only separated measures have been presented (Bailey, 2003), but no integrated framework covering the whole supply chain has been found in the literature. The definition of an integrated and consistent framework for measuring the logistics performance in the wine industry, and its evaluation in a case study, is the focus of this article.

3. Wine supply chain

Considering the complexities of the WSC detailed in Section 1, it is difficult for managers to make appropriate decisions and to measure and improve logistics performance without a model of the supply chain including its actors and relationships (Lambert et al., 2008). Therefore, it is necessary to count with a formal and generic model of the WSC, which represents all the possible instances.

Every SC consists of several nodes which can be called "actors" (Gigler et al., 2002). Each actor is a character, a link of the chain, a part played by a performer. Fig. 2 shows the actors of a generic 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 representation of the WSC is presented, which means that it contains the more general SC, and it can be instantiated into many particular cases. This representative model has been defined following the supply chain modeling approach described by Lambert et al. (2008), and considering: (a) literature review and analysis, (b) through extensive observation of real wineries and other actors in the WSC, and (c) using information gathered by means of questionnaires and interviews made to people of different wineries and other WSC actors in Mendoza, Argentina (Garcia, 2009).

Grape Grower: The Grape Grower is responsible for the production and harvest of the grapes (GS1, 2005). This node

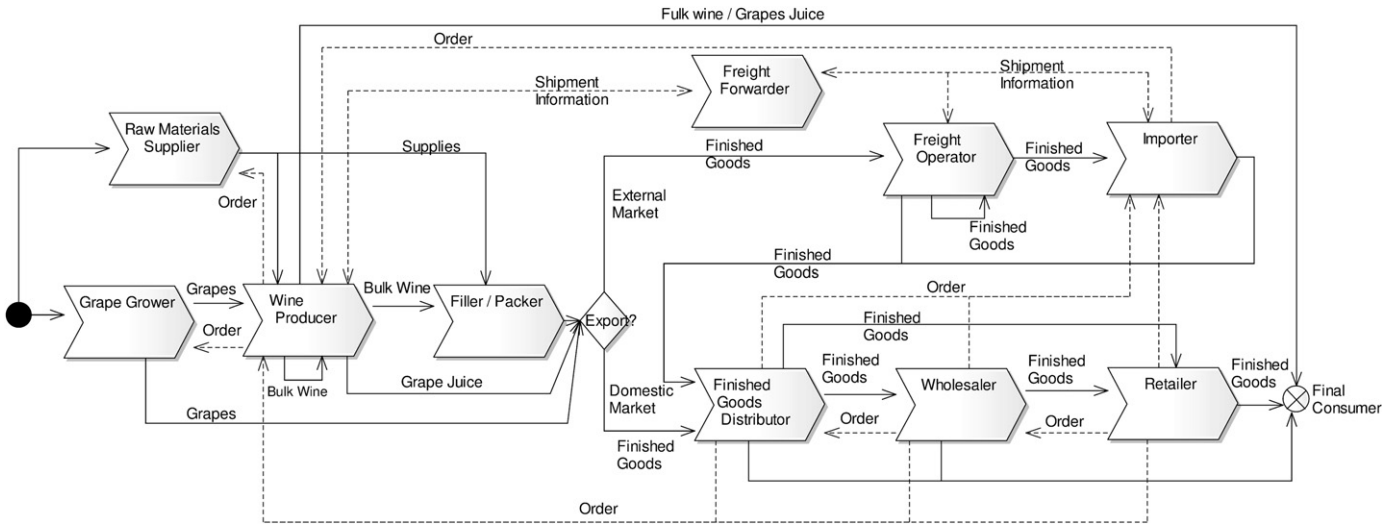

Fig. 2. Wine supply chain.

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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 (Adamo, 2004). The main activities of grape growers are: planting the grapes, cultivating and pruning the vines, eliminating the inadequate vineyards, fertilizing the vineyards, controlling plagues, harvesting grapes, etc.

Raw Materials Supplier: This actor provides Wine Producers and Fillers/Packers with all the supplies needed for wine-making or filling and packing. 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, etc.

Wine Producer: Wine producers are responsible for receiving grapes, the elaboration, manufacture and/or blending of wine products. Depending on the type of wine that is going to be elaborated, the process is different (Llera and 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 decanting, addition of yeast, fermentation, refrigeration, clarification and stabilization, temperature control, storage in stainless steels tanks or oak barrels, filtration, preparation for bottling, maturation in bottle, etc. Several aspects of the WSC will be different depending on the segment of wine produced, such as the number and quality of vineyards used, the number and the quality of supplies, the packing and labels of the wine, etc. (Adamo, 2004).

Filler/Packer: Fillers/Packers are responsible for the reception, analysis, filling, packing and dispatch of finished goods (GS1, 2005). The Filler/Packer receives containers of bulk wine from the Wine Producer, 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 packing into consumer units into cartons and pallets or other logistic units.

Freight Forwarder: This actor organizes the shipment planning, which is the process of choosing shipment frequencies and deciding for each shipment which orders should be assigned. It also includes 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. 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.

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 used in the country.

Finished Goods Distributor: This actor is responsible for the reception, storage, inventory management and dispatch of finished goods, as well as re-packing and re-labeling as per specific customer requirements required (GS1, 2005).

Wholesaler: The Wholesaler receives pallets and cartons from the Finished Goods Distributor and picks and dispatches goods to the retails stores. They put new orders to the Finished Goods Distributor, to the Importer and 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 stores, drugs stores, specialist store, hotels, restaurants, catering, clubs, etc.

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).

4. Proposed framework

The term benchmarking implies the measurement through a collection of metrics to adequately quantify the performance of processes. These quantitative analyses may be complemented with qualitative ones in order to support decision making processes, for example by exploring good or bad practices to implement or improve once the values of the metrics have been obtained and contrasted against target values.

These metrics should be selected and maintained as a system. For an organization to arrive to a world-class standard it is necessary to implement a set of world-class logistics performance indicators (Frazelle, 2002). Through the measurement of logistics performance along the WSC it is possible to understand the industry's best practices through which it is easier for a winery to fulfill the customers' requirements, to better understand the WSC dynamics, which helps to find bottlenecks all along the chain, and finally to have a diagnosis of the wineries with respect to their competitors and the industry leaders, which helps to develop new strategies to become more competitive.

In order to define a set of key logistics performance indicators for a winery, it is important to specify classification dimensions for these indicators. The SCOR model (Supply Chain Council, 2010) defines a single classification dimension for metrics: the performance attributes. In this work, following the approach described by Frazelle (2002), we propose two classification dimensions, namely the ***performance attributes*** and the ***logistics processes***. Both attributes and processes are guides to apply the relevant framework indicators for a particular situation, since they group performance metrics.

4.1. Performance attributes

The SCOR model (Supply Chain Council, 2010) defines 5 performance attributes (reliability, responsiveness, agility, costs and assets). Some of these performance attributes are also considered in the approach proposed by Frazelle (2002), who states that from the logistics point of view every business competes on the basis of financial performance, productivity performance, quality performance, and cycle time performance. Garcia et al. (2009) adapted these categories for defining the following 4 performance attributes related to logistics processes in the WSC, which we adopt in this work: ***Quality***, ***Timeliness***, ***Logistics Cost***, ***Productivity and Capacity***. *Quality* is related to both process and product quality along the WSC. Measuring the quality performance of logistics processes and products is the way to improve these processes and at the same time insure the customer's satisfaction level. *Timeliness* is related to the response time of the supply chain to

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satisfy the customer's requirements; *Logistics Cost* is related to logistics financial performance; and *Productivity & Capacity* is related to the efficiency of the resources usage.

4.2. Logistics processes

Logistics performance is measured along Logistics Processes. Based on the logistics activities identified by Frazelle (2002), we defined the following 6 logistics processes: ***Supply***, ***Production and Bottling***, ***Inventory Management***, ***Warehousing***, ***Transportation and Distribution*** and ***Customer Response***. Supply includes all activities related to the purchase of supplies, management of suppliers, products income, etc. Production and Bottling includes all the activities related to the wine elaboration process, bottling (including bottles, bag-in-box, etc.) and packing. Inventory Management, includes all the activities of planning, inventory administration, inventory moving, etc. Warehousing involves all warehouse management from product reception and picking to container loading. Transportation and Distribution includes all the activities of distribution and transportation of the wine orders to arrive to the customer location. Finally, Customer Response includes all the activities related to customer services, order entry, order processing, follow up, etc. Fig. 3 shows the relation between these two classification dimensions.

The figure shows how a performance attribute can be measured through all the logistics process. For example, considering the response time, it represents the lead time of suppliers in the supply process, the elaboration and bottling time in the production process, the transportation time in the distribution process, etc.

4.3. Key performance indicators hierarchy

Within this work, we consider the winery point of view, i.e. we consider the winery as the focal company (Lambert et al., 2008). In order to make the performance measurement framework manageable, considering the complexity of the WSC, the number of actors and its dynamics, the generic catalog of indicators is structured in a hierarchy of three levels. Although the classification dimensions are not the same, nor the specific metrics defined on each level, the idea of including several aggregation levels was inspired in the SCOR model (Supply Chain Council, 2010).

The *first level* contains indicators that reflect the global performance of the winery as well as the whole WSC. These first level indicators will show the result of the efficiency of several activities performed along the WSC by different actors, and they represent high level aggregated results. The combined use of these indicators will help to further understand the overall logistics performance of the enterprise taking into account quality, logistics costs, time, and productivity.

As we go down through the hierarchy, the number of indicators at each level grows, thus providing more detailed measures for each combination of performance attribute and logistics process. The *second level* contains indicators to measure performance of the enterprise in the same performance attributes and logistics processes previously described, but the information is shown in more detail than it is in the first level.

The *third level* measures the performance of the operations of the organization. This level is related to the everyday operations of the enterprise, with the purpose of improving its performance. As the previous level, the lower level indicators complement the high levels of the hierarchy with further details.

This generic catalog is composed of a great number of indicators (the second and third levels of the hierarchy are shown in the appendices). 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 structure of its supply chain, that is, depending on the place the company occupies within the supply chain.

Some KPI (Key Performance Indicators) of the framework have been adapted from different authors' frameworks (Frazelle, 2002; Choy, 2002; Lo et al., 2005) and others have been defined specifically for measuring the integrated WSC performance. The selection and adaptation of indicators from the other frameworks, as well as the definition of the new indicators not included in previous works were done through questionnaires, observation and interviews to people of different actors of the WSC in Argentina. The adaptation of metrics included in the other frameworks, as well as the new indicators added convey much of the particularities of the wine industry that might be generalized to other alcoholic beverage or agri-food industries.

Fig. 4 shows the KPI hierarchy, including the three aggregation levels, the four performance attributes defined, and the six logistics processes performed within the winery where each indicator must be measured.

This figure also shows the indicators' relation from one level to the other. For example, for measuring the time consumed in the warehousing process, there is one key performance indicator in the first level which 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; the lower level indicators give more details of high level indicators, but they do not define them directly), and the same applies to the second and third levels of the hierarchy. Table 1 shows all the first level indicators, a description and the formula.

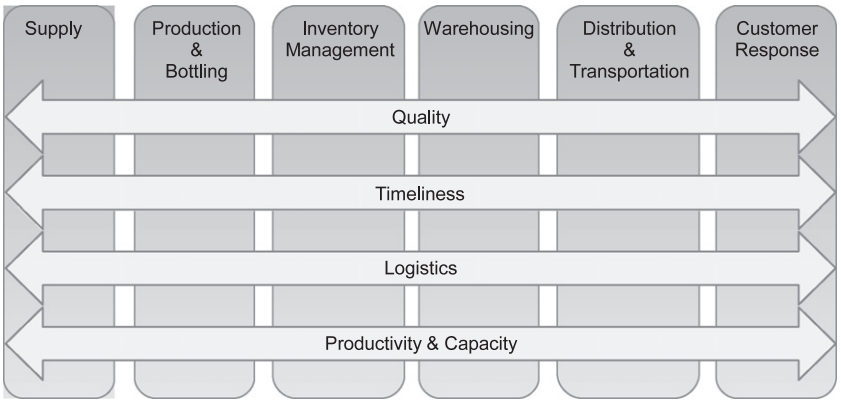

Fig. 3. Logistics processes and performance attributes (*Source*: elaborated by authors).

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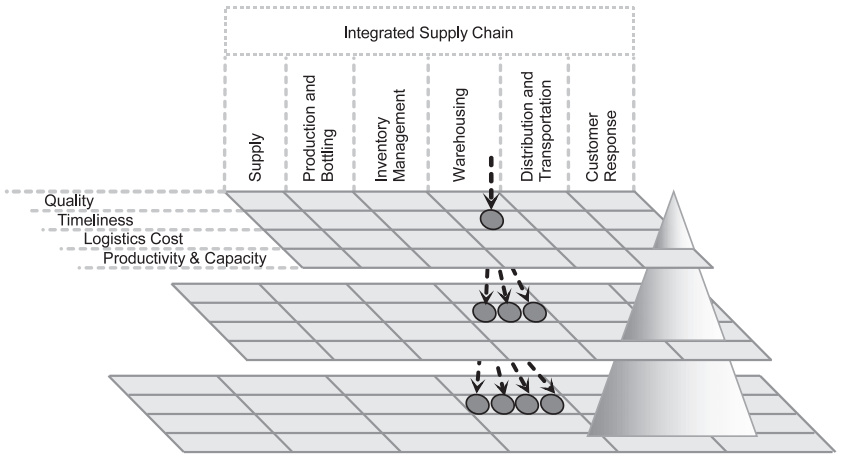

Fig. 4. Key performance indicators hierarchy.

Table 1
Key performance indicators—1st level of indicators.

Performance attribute	Indicator name	Description	Formula
Quality	Supplier performance index	It measures the supplier's performance (including the average of claims made by the winery to the supplier in a specific period of time)	∑Number of perfect purchase orders/number of placed purchase orders (1)
	Right quality grapes percentage	It is a rate of the quantity of grapes obtained with the right quality during harvest (in a specific period of time)	∑Quantity of grapes of right quality obtained/total quantity of grapes obtained (2)
	Production performance index	It is a rate of perfectly produced units in a specific period of time	∑Orders produced as planned without failures and rejections/total orders from customer (3)
	Inventory performance index	It shows the global performance of all activities of inventory in a specific period of time	∑Lower level indicators performance/total number of lower level indicators (4)
	Warehousing performance index	It is related to the performance of all activities of warehousing processes performed in a specific period of time	∑Numbers of items received or put away or picked or shipped correctly and without damages/number of items manipulated (5)
	Customer satisfaction index	It measures the customer's satisfaction during a specific period of time	$\sum[\sum$Quantity of perfect customer$_i$/total orders entered for customer$_i]$/number of customers (6)
	Perfect order percentage	Is the rate of orders that were perfectly produced, bottled, without damages, with perfect documentation, and with no claims from the customer received in a specific period of time	∑Quantity order without any problems/total orders (7)
Timeliness	New demand response time	It is the average time the supplier takes to respond to demand of new supplies	∑[Reception date–new demand confirmation date]/total number of new demands (8)
	Total production cycle time	It is the average time needed for elaborating and aging the product, including quality tasting and bottling time	∑Quality tasting cycle time+elaboration cycle time+aging cycle time+bottling cycle time/total number of order produced (9)
	Delivery cycle time	It is the average freight transport time. From the moment the order is ready in the warehouse to the reception by the customer.	∑[Reception date by customer–order ready date in the Warehouse]/total number of delivered orders (10)
	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	∑[Reception date − transaction confirmation date]/ total number of orders (11)
Logistics costs	Total logistics cost	It is the aggregated cost of all logistics activities considered in a specific period of time	Supply log. cost+production log. cost+inventory log. cost+warehouse log. cost+transportation log. cost+log. cost of returns from customers+customer response logistics cost (12)
	Total logistics cost contribution	It is the contribution of the Total Logistics Cost to the enterprise's total operational costs considered in a specific period of time	Total logistics cost/total operational cost (19)
Productivity and capacity	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	∑Utilization % of resource *i*/number of resources (20)

All the formulas have to be used considering a specific period of time, defined at the moment of the implementation of the framework, (e.g. annually, monthly, daily, etc).

Tables 2 and 3 present the details of the second level indicators related to the *Total Logistics Cycle Time* and *Resources Utilization Percentage* first level indicators, which are used in the case study.

Fig. 5 graphically shows all the periods measured within the Total Logistic Cycle Time.

4.4. Different uses of the framework

Considering the wine supply chain described earlier, several instantiations are possible depending on the wine segment

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Table 2
Second level indicators related to the total logistics cycle Time.

1st level indicator	2nd Level indicator	Description	Formula
Total logistic cycle Time	Order processing CT	Is the period elapsed from the moment the order is entered in the winery until the moment the order is released to the warehouse	∑[Order prepared at warehouse date − confirmation transaction date]/total orders requested (21)
	Purchase order CT	If the supplies are not available from stock and a purchase is needed it measures the average time of the procurement process	∑[Purchase orders reception date − purchase order confirmation date]/total purchase orders (22)
	Bottling CT	It measures the average time needed for bottling the wine. It includes the scheduling, filling, covering, labeling and packing of the order.	∑[Finished bottling date/time − start bottling date/time]/total orders produced (23)
	Warehouse CT	It measures the average time required to prepare the order in the warehouse, including picking, packing and shipping	*MTS (Make-to-Stock)* ∑[Order prepared at the warehouse date − order transaction confirmed date]/total orders prepared *MTO (Make-to-Order)* ∑[Order prepared at the warehouse date − finished bottling date]/total orders prepared (24)
	Delivery CT	It includes waiting for loading, travel time and unloading time in the customer's site.	∑[Received date in customer location − order prepared in the warehouse date]/total orders delivered (25)

Table 3
Second level indicators related to the resources utilization percentage.

1st level indicator	2nd level indicator	Description	Formula
Resources utilization percentage	Capacity utilization bottling machines	Used capacity of bottling machines compared with their full capacity	[Quantity bottles/product bottled]/ bottling machines full capacity (bottle/ product per hour) (26)
	Warehouse utilization percentage	Storage location that are occupied compared with full capacity	Location occupied/Total number of location in warehouse (27)
	Cellar utilization capacity	Storage for wine aging that are occupied in comparison with cellar full capacity	Used capacity/cellar full capacity(28)

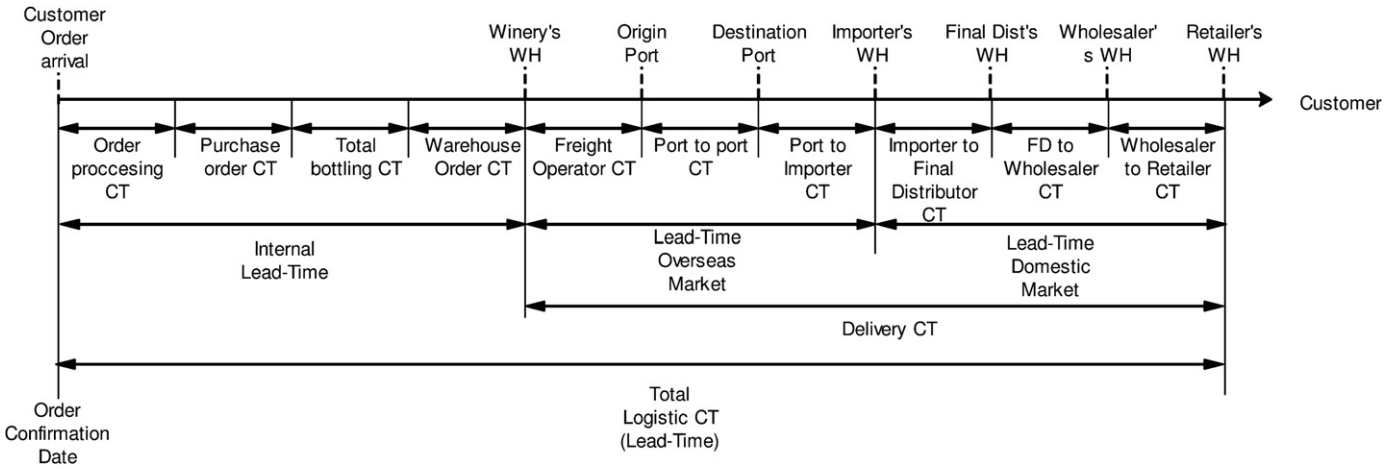

Fig. 5. Total logistics CT.

produced, the market, the actor in the supply chain, etc. For example, a winery that delivers in the overseas market under a FOB (Free-On-Board) schema has a particular supply chain, as shown in Fig. 6.

According to the definition appeared in the INCOTERMS,[1] FOB means that the winery sells, delivers and is responsible for the finished goods up to the boarding port, from where the goods will be transported to the destination country.

Fig. 7 shows another example, the supply chain of the Wholesaler, on which the visibility is restricted up to the Importer (the wholesaler usually has not access to information and material flows between wineries, freight operators, etc.)

These figures show 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 of the importer is measured considering the wholesaler's supply chain, it will include the *Importer to Final Distributor* cycle time and *Finished Goods*

[1] The Incoterms are formulated and updated by the International Chamber of Commerce which regulates the norms, obligations and rights on international commerce trades.

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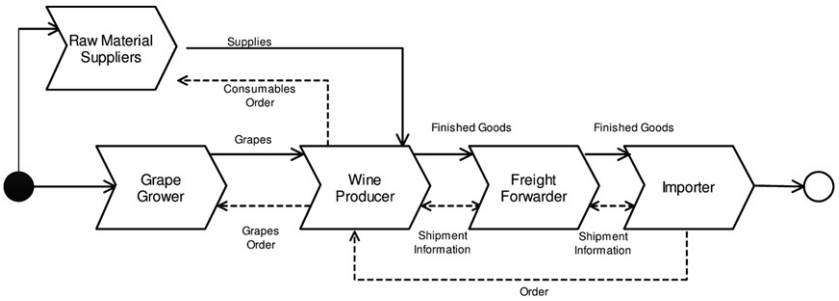

Fig. 6. Winery's supply chain.

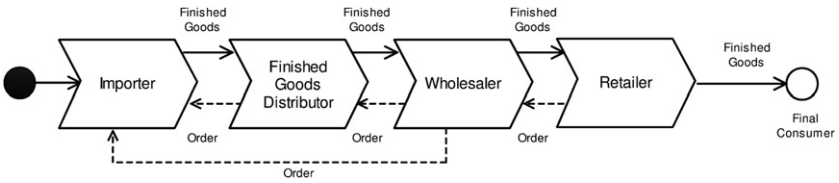

Fig. 7. Wholesaler's supply chain.

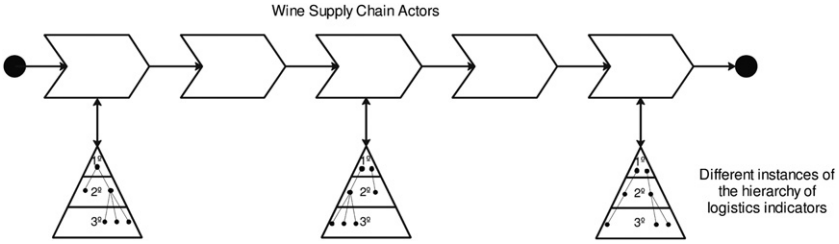

Fig. 8. Framework instantiation for different actors along the WSC.

Distributor to Wholesaler cycle time in order to arrive to the wholesaler's warehouse. Therefore, it covers the time elapsed from the moment the order is prepared in the importer's warehouse until the order is delivered in the wholesaler's location. Considering the winery's supply chain, the Lead-time covers the Internal Lead-time of the winery, the *Freight Operator* cycle time, the *Port-to-Port* cycle time, and the *Port-to-Importer* cycle time in order to deliver the product to the importer (which is the customer for the company because it follows a FOB sales strategy). This lead-time covers the time elapsed from the moment the order is prepared in the winery's warehouse until the order arrives to the importer's location.

Fig. 8 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 for 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" (i.e. be meaningful) on each case. In some cases the majority of these indicators are used together following the relations that exist between them in order to facilitate the decision making process and to have a better understanding of the processes as a whole.

4.5. Applying the framework

A concrete example of instantiation (i.e. selection of relevant indicators) is shown in order to illustrate the application of the framework. Consider the *Lead-time* (*Total Logistic Cycle Time*) indicator in the context of the winery's and the wholesaler's supply chains previously described.

For the Winery's supply chain the lead-time includes: the *Production Cycle Time* (including order processing, procurement and bottling), and the *Freight Forwarder Cycle Time,* including the *Freight Operator Cycle Time* (order picking in the winery, transportation, freight consolidation, etc. up to the origin port); the *Port-to-Port Cycle Time;* and the *Port-to-Importer Cycle Time* (up to the importer's warehouse). In the overseas market, the Importer is usually the winery's customer. Therefore, in some cases the winery's lead-time is considered only up to the origin port since under FOB, it is usually the importer who takes care of the transportation operations carried out from that point on.

For the Wholesaler's supply chain the lead-time includes: *Final Distributor to Wholesaler Cycle Time*, which is the elapsed time between the moment the Wholesaler puts an order to the Distributor and the moment on which finished goods arrive to wholesaler's facility; the *Wholesaler to Retailer Cycle Time* (time between order entering and arrival of finished goods to retailer's facility).

This example aimed at highlighting the differences in the application of the framework depending on the actor in the WSC who uses the framework.

5. Case study

A comparison of the logistics performance of 6 wineries from Mendoza (Argentina) is presented as a case study. There are more

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than 1000 wineries at Mendoza, with different sizes and markets, and only some of the KPI defined in the framework (Section 4) were measured and evaluated. Therefore, this study was conducted as an initial validation of the proposed framework and it is not a complete benchmarking study of the wine industry in Argentina, neither considering the wineries compared, nor from the point of view of the indicators measured.

These wineries belong to different segments considering the production volume and size of the organization. However, we selected them because an important part of their production goes to the overseas market and because they produce wines of similar quality and price segments, which make their logistics operations comparable. Additionally, the aspects measured were normalized and compared in order to obtain performance gaps from their logistics performance. Tables with the main results are shown in the appendices.

The required data was collected by means of questionnaires. These questionnaires were prepared and tested with people of the participant wineries, in order to make relevant questions and to get the appropriate information.

5.1. Wineries background information

The percentage of the production volume of the wineries of the study for overseas markets ranges from 45% to 98%. The wine segment delivered to these markets is of high quality wines. Some super premium wines are only available for overseas markets. The main markets are USA, Brazil, Mexico, China, Holland, United Kingdom and Canada.

Different production strategies are followed by wineries when an order arrives: *bottle to order, label to order, packing to order* or *make to stock* (deliver to order) (Garcia, 2009). Winery 1, winery 2, and winery 4 follow a *label to order* strategy. They use the previously bottled wine and they label the order when the confirmation from the customer arrives. This strategy is followed because of several reasons. Premium wines need extra aging process in bottle, which helps to increase wine quality. Additionally, this strategy helps wineries to save time in order to have a faster response to demand. Another reason for using this strategy is that when exporting, labels need to be customized because they must contain importers' information, and some specific data depending on the destination country (language, regulations, dates, etc). Therefore, labels (sometimes just second labels) need to be printed as late as possible (once all these parameters are known). After this process, the preparation and transportation processes begin.

Winery 5 follows a *make to stock* strategy, because it can forecast the demand and plan its production and bottling processes for the most important customers.

Winery 3 and Winery 6 follow a *bottle to order* strategy when the order arrives. Although this strategy implies an extra time for bottling process and for the procurement of supplies, it reduces the risks related to obsolescence of the labels.

5.2. Performance comparison

5.2.1. KPI

As exposed in Section 4.4, not every actor in the WSC uses all the indicators for measuring the performance or doing a benchmark study. The indicators selected (i.e. the framework instantiation) may depend on the segment of the wines produced, the market, etc. Therefore, only some indicators of the framework were evaluated in this case study, which were selected according to the feedback received from the wineries that participated in the study. These wineries indicated that the impact of logistics in their business was mainly related to the timeliness and resources utilization performance attributes.

The first and second level KPI measured and benchmarked in the study are:

1. Total Logistics Cycle Time
   - 3.1 Order Processing Cycle Time
   - 3.2 Purchase Order Cycle Time
   - 3.3 Bottling Cycle Time
   - 3.4 Delivery Cycle Time (partially)
2. Resources Utilization Percentage
   - 5.1 Capacity Utilization Bottling Machines
   - 5.2 Warehouse Utilization Percentage
   - 5.3 Cellar Utilization Capacity

Regarding the Delivery Cycle Time indicator, the transportation time beyond the origin port was not included in the evaluation since, according to the wineries that participated in the study, they did not have control over the subsequent stages, and their visibility was restricted.

In the following sections, the values measured for these KPI, along with an analysis of the gaps found between the wineries is presented.

5.2.2. Timeliness

Fig. 9a shows the average lead-time of all wineries. As said before, the transportation time from the origin port to the reception of the order in the importer's warehouse was not considered. The lead-time shown in Fig. 9a includes the values of the first 4 indicators of the previous section, namely: **Total Logistics Cycle Time** (**Order Processing Cycle Time, Purchase Order Cycle Time, Bottling Cycle Time** and **Delivery Cycle Time** until the origin port).

Fig. 9b shows how each cycle influences the total lead-time of each winery. Winery 4 has the shorter lead-time, with 11 days to prepare and put the order in the ship. Some good practices for having this result are: work with a *make to stock* strategy for highly rotating products, and work with a *label to order* strategy for the other products, but only putting second labels when the order arrives. Bottling and labeling processes are scheduled following sales forecasting, and considering delivery dates for confirmed orders.

The average lead time is 28 days. The BIC (Best-in-Class) is 11 days and the WIC (Worst-in-Class) is 40 days.

Fig. 10 shows the average delay of local suppliers for each type of key supply. This is an alternative view of the purchase order cycle time, in which the purchase time has been split across different supplies averaging each winery's average. As can be seen, labels are the most critical supply, and they have the longest delay. This is an aspect that affects wineries which follow a JIT (Just in Time) strategy, because they have to buy supplies when the order is confirmed. In order to reduce the lead-time, it is better to have a security stock of some supplies. However, maintaining a stock of labels conveys a risk of obsolescence because the specific information related to regulations of the destination countries may change. Similarly, bottles are very fragile which may cause losses due to breakage.

Wineries which have long lead-times are mainly influenced by the suppliers' lead-times. For those wineries who buy supplies JIT this becomes a problem and a different strategy must be implemented in order to reduce delivery times, such as collaborative forecasting.

Fig. 11 shows the number of clients of each winery from overseas market. It is important to mention that Winery 4, the one who has the shortest lead-time, has a small number of customers in the overseas market. Winery 6, whose 98% of production is devoted to overseas market, has also a small number of clients.

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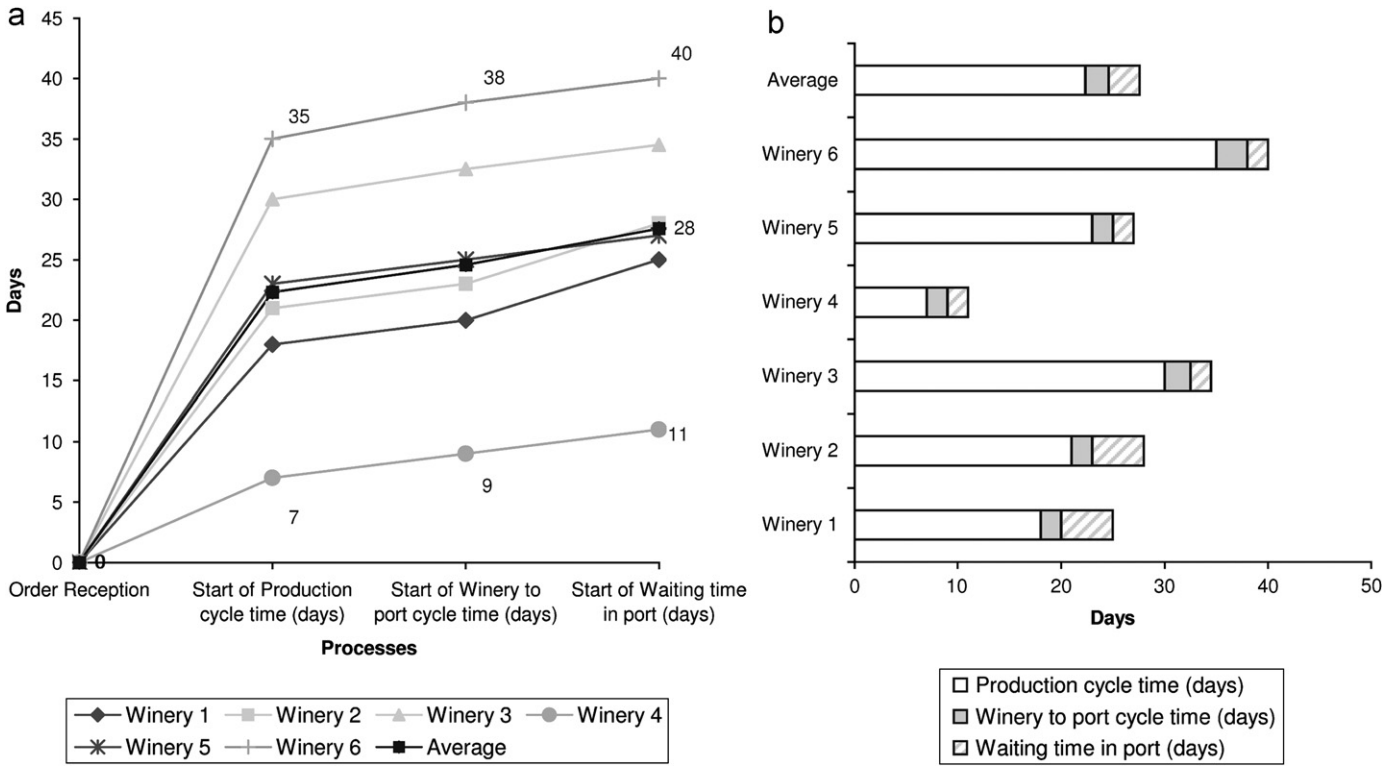

Fig. 9. (a) Average internal lead-time and (b) internal lead-time composition.

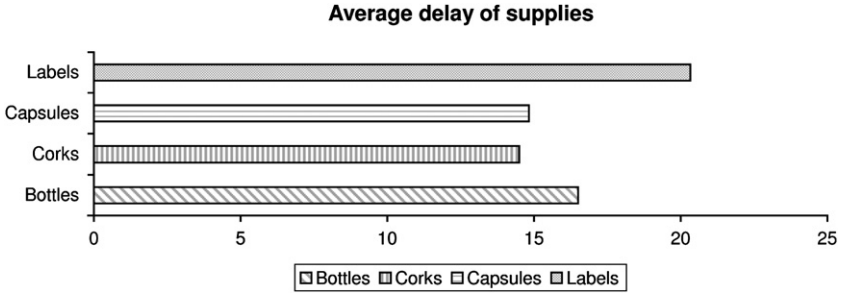

Fig. 10. Suppliers' delays.

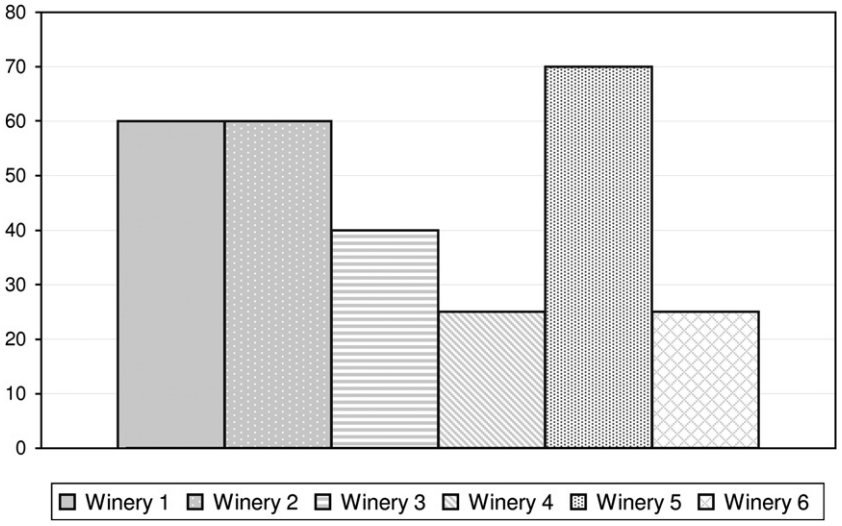

Fig. 11. Number of clients from overseas market.

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5.2.3. Productivity and capacity

All wineries, except Winery 4 have their own bottling and labeling lines. Winery 4 rents an external line for bottling and labeling for the first label. Second labels are put manually.

Fig. 12 shows used and wasted capacity of filling lines. Winery 5 has six filling and labeling integrated lines and 4 extra labeling lines. Although each winery has different bottling capacities, a large percentage of wasted capacity can be observed.

All wineries have warehouses for supplies and finished goods. The utilization percentage of finished goods warehouses is shown in Fig. 13.

Some wineries use finished goods warehouses to age the bottled wine. Others have specific spaces devoted to age the wine. Fig. 14 shows aging capacity in bottle (i.e. Cellar Utilization Capacity the indicator).

If we consider the first level KPI "Resources Utilization Percentage" for each winery (Table 4), it is possible to summarize the level of utilization of the described resources (filling lines, warehouses, aging capacity and vat capacity), as shown in table and Fig. 15.

From this information it can be observed that winery 2 is getting more than 80% of utilization of its resources in average. Wineries 1, 3 and 5 are near it, with more than 70%. Wineries 4 and 6, on the other hand, should implement and consider different strategies in order to improve their resources' utilization (which is below 60%).

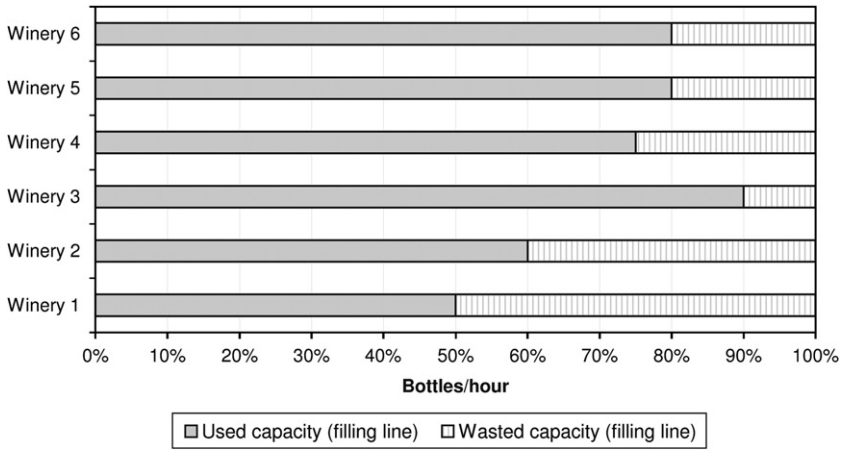

Fig. 12. Filling lines used and wasted capacity.

Fig. 13. Finished goods warehouse used and wasted capacity.

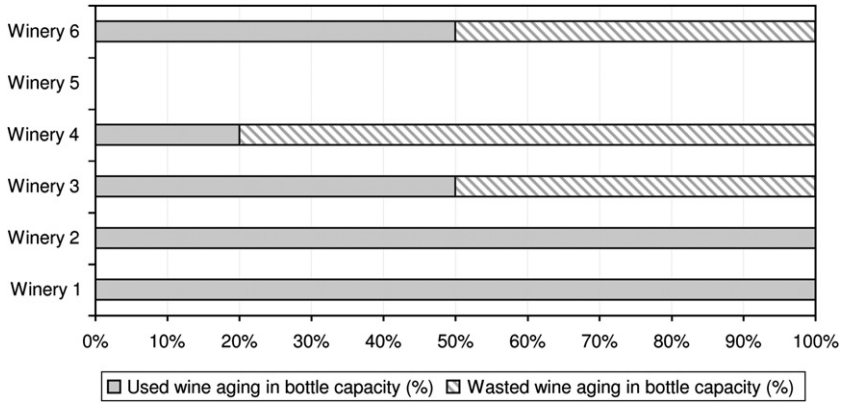

Fig. 14. Used and wasted capacity of aging in bottle.

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Table 4
Computation of the resources utilization percentage.

	Winery 1	Winery 2	Winery 3	Winery 4	Winery 5	Winery 6
Filling and labeling line utilization	50	60	90	75	80	80
Wine aging in bottle capacity	100	100	50	50		50
Warehouse utilization	80	90	90	25	70	50
Resources utilization (%)	**77**	**83**	**77**	**50**	**75**	**60**

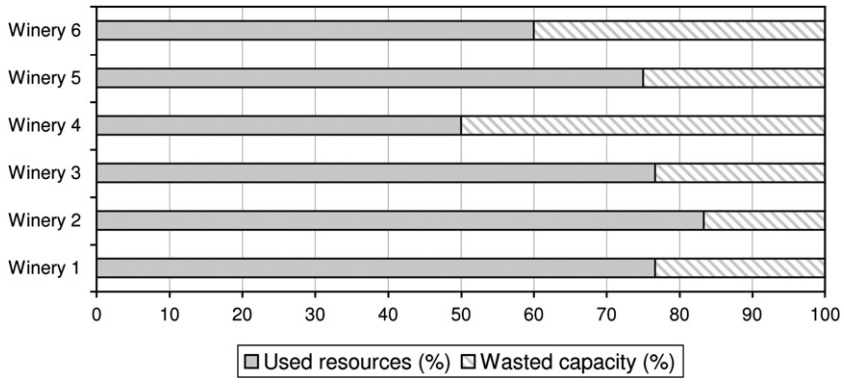

Fig. 15. Resource utilization percentage.

5.3. Analysis of the performance gaps

In order to illustrate how this analysis may be useful for an organization, consider the Winery 4. It has the shortest lead-time of all the wineries analyzed, so it is the BIC of this study regarding that indicator. In order to achieve this, it implements different strategies for fulfilling customers' orders. However, the resources utilization percentage is 50%. Therefore, this is a potential improvement area for the winery.

Through the study conducted, some good practices were discovered. In order to get a good average performance, it is convenient to define different strategies for each product, customer, destination country, rotation level, etc. This allows the winery to give the most suitable treatment to products, customers and markets with similar conditions, such as stability of the demand, seasonality and buying volumes. Another strategy is to maintain security stocks of those key supplies which have long lead times and that have no obsolescence problems.

Standardization of data of first labels allows the winery to avoid modifying them for each kind of customer. This makes it possible to keep stock of first labels and to reduce the impact of forecasting deviations regarding this supply. Additionally, second labels (which contain customizable data) may also contain some fixed (common) data, and be reprinted with the customized data as needed. Making collaborative forecasting with customers and suppliers is another desirable practice, although it is almost not applied.

In each case, it is necessary to determine the logistics cost (e.g. supplies warehousing costs) in order to identify the optimum strategy. The same analysis may be extended to the other indicators in the framework, and more good practices may be identified in a similar way.

6. Conclusions and future work

In this paper a framework for performance measurement and benchmarking in the wine industry was presented. A descriptive model of the WSC was proposed including a representation of all actors who work to bring the product to the final consumer. For each actor in the supply chain, a description of the main activities was presented. Material flows and information flows were identified along the WSC. A framework composed of KPI for measuring logistics performance was presented. Additionally, formulae, description and different scenarios for implementing the framework were explained. A case study was presented for a set of wineries from Mendoza (Argentina), in order to illustrate the framework application and to compare logistics performance. Results of the comparison were exposed and explained along with a description of wineries' good practices found during the study.

The contributions of this research include the definition and representation of a model for the WSC, and a framework of KPI for measuring logistics performance along the wine supply chain. Additionally, a set of guidelines were described as part of the case study in order to illustrate the instantiation of the framework, and a benchmarking study conducted over a sample of 6 wineries from Mendoza (Argentina) was presented for illustrating the application of the framework.

With this model and the proposed framework, companies in the wine industry can have a better understanding of the relations and the complex dynamics present in the WSC. This could help them to focus on processes to improve, on new strategies or goals, on supply chain and resources optimization to increment final consumer's satisfaction level, and to lower costs and delivery times.

Future work will be carried out along three main directions. First, a more comprehensive benchmarking study will be performed in the Argentine wine industry using this model and the framework defined, in order to identify a wider scope of industry's best practices. Additionally, a deeper verification will be done and a comparison of the WSC of different countries will be carried out, to show the variety of instances and diversity of operations.

Second, additional aspects of the descriptive model of the WSC presented in this work, which includes actors, relations and flows, will be formalized. Simulation and formal mathematical models

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of different logistics aspects will be developed based on this descriptive model, as tools for wineries to evaluate different scenarios and make better decisions. Different aspects will be included in these models, such as timing, inventory, capacity and costs. Therefore, the descriptive model presented in this work will be a guide for creating and integrating such mathematical and simulation models.

Moreover, from the data collected in the study, different production strategies were observed (bottle to order, label to order, packing to order and make to stock). A correlation study of metrics performance, context situation (target market, wine segment, etc.) and production strategy will give more information on how each strategy is and should be determined. Advanced multi-criteria techniques will be used such as Choquet integral or AHP (Analytic Hierarchy Process), thus enabling the wineries to setup optimization models for each case.

Finally, the third line for future work will include generalization of the model (both the descriptive supply chain model and the performance measurement framework) to other industries, especially other alcoholic beverage and agro-food industries (e.g. olive oil).

Acknowledgments

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Appendix A

See Tables A1–A6.

Table A1
First and second level indicators—quality.

First level indicators	Second level indicators
Quality	
Supplier satisfaction index	Claims due to quality fails
	Claims due to out of time deliveries
	Claims due to costs
Right quality grapes percentage	Bad quality due to transport of grapes
	Bad quality due to storage of grapes
	Bad quality due to harvest
	Bad quality due to climate
Production performance index	Product unit perfectly produced
Inventory performance index	Forecast accuracy
	Inventory obsolescence
	Out of stock occurrences
	Inventory accuracy
Warehousing performance index	Receiving performance index
	Shipping performance Index
	Warehouse damage percentage
Customer satisfaction index	Claims due to quality fails
	Claims due to out of time deliveries
	Claims due to costs
Perfect order percentage	Perfect purchase order percentage
	Product unit perfectly bottled percentage
	Order perfectly fillable percentage—fill rate
	Order perfectly picked and packed
	Orders perfectly delivered percentage
	Orders perfectly received

Table A2
First and second level indicators—timeliness.

First level indicators	Second level indicators
Timeliness	
Total logistic cycle time	Order processing cycle time
	Return processing cycle time
	Backorder duration
	Purchase order cycle time
	Total bottling cycle time
	Warehouse order cycle time
	Deliver cycle time
Total production cycle time	Quality tasting cycle time
	Manufacturing and aging cycle time
	Total bottling and label cycle time
Deliver cycle time	Lead time for overseas market
	Lead time for domestic market
	Vehicle load/unload time
	Delayed in traffic time
New demand response time	

Table A3
First and second level indicators—logistics cost.

First level indicators	Second level indicators
Logistic costs	
Total logistic cost	Supplier total logistic cost
	Production total logistics cost
	Inventory cost
	Total cost of warehouse
	Transportation total logistics cost
	Cost to return from customers
	Total customer response cost
Total logistic cost contribution	Supply cost as contribution to supply chain total logistics cost
	Production cost contribution as to supply chain total logistics cost
	Inventory cost as contribution to supply chain total logistics cost
	Warehouse cost as contribution to supply chain total logistics cost
	Transportation cost as contribution to supply chain total logistics cost
	Urgencies cost as contribution to supply chain total logistics cost
	Return cost as contribution to supply chain total logistics cost
	Customer response cost as contribution to supply chain total logistics cost

Table A4
First and second level indicators—production and capacity.

First level indicators	Second level indicators
Production and capacity	
Resources utilization percentage	Winery reception capacity
	Purchase Order launched per person-hour
	Number of suppliers managed
	Capacity utilization filling/labeling machines
	Inventory turnover
	Inventory turnover of supply
	Storage density
	Warehouse utilization percentage
	Cellar utilization capacity
	Material handling equipment utilization
	Percentage of full-load trailer/container capacity utilized per shipment
	Transport/vehicle productivity
	Customer Orders processed per vendor—hour
	Requirements fill percentage
	Repalletizing of cartons percentage
	Re-pack bottles percentage

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Table A5
Benchmarking results. General information and lead-times.

	Winery 1	Winery 2	Winery 3	Winery 4	Winery 5	Winery 6
Annual production capacity (l)	1,000,000	12,000,000	3,750,000	1,300,000	–	2,700,000
Real annual production (l)	1,000,000	12,000,000	3,750,000	840,000	6,000,000	1,000,000
Percentage of production for Exportation (%)	60	45	60	90	60	98
Main Production Strategy	Label to order	Label to order	Bottle to order	Make to stock and label to order (second label)	Make to stock (bottle+label+ packing)	Bottle to order
Average size of orders (l)	9000	9900	9000	4000	3750	9900
Percentage of wasted space in containers (%)	9.09	0	9.09	59.60	62.12	0
Lead-time						
Internal lead-time (days)	18	21	30	7	23	35
Winery to port cycle time (days)	2	2	3	2	2	3
Waiting time in port (days)	5	5	2	2	2	2
Supplies transport cycle time	National suppliers					
Bottles	7	30	2	15	15	30
Corks		30	3		15	10
Capsules	7	30	5	15	15	17
Labels	20	20	19	25	15	23
Number of customers (international)	60	60	40	25	70	25
Most important destination country	Mexico, Brazil, USA, China	USA, Holland, Canada	Brazil	USA	UK, Canada, USA, Mexico,	USA, Brazil

Table A6
Benchmarking results. Resources utilization.

	Winery 1	Winery 2	Winery 3	Winery 4	Winery 5	Winery 6
Filling line capacity (bottles/hour)	2000	12,000	4500	2500	30,000	2500
Percentage of work-time (filling)	50	60	90	75	80	80
Percentage of idle time (filling)	10	40	10	17	12	12
Labeling line capacity					1000	
Percentage of work-time (labeling)					90	
Percentage of idle time (labeling)					25	
Finished products' warehouse capacity (bottles)	72,000	1,200,000	660,000	600,000	–	92,400
Percentage of finished goods warehouse used capacity	80	90	90	25	70	50
Wine aging in bottle capacity used (bottles)	300,000	60,000	352,500	600,000	–	40,000
Vat capacity	1,600.000	10,800,000	2,000,000	1,690,000	242,000,000	3,000,000

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