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Network analysis: the supply chains of products of animal origin in Italy

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ABSTRACT

In the last years we have seen a growing complexity and an unusual dynamic in the markets for food commodities, now comparable to those of more sophisticated financial systems. Productions are strongly affected by these imbalances, and classical models of demand and supply are no longer able to describe evolutions and developments for these markets.

A food commodity is the result of a complex series of production and transformation processes, which determine price and availability. This study aims to a complete mapping of the major food commodities of animal origin, milk and meat chain. The main objectives of this presentation cover many of the issues that the governance and the players of food industry, from producers to processors, have to face without appropriate tools for qualitative and quantitative assessments.

Keywords: Food chain, complex network, strategic nodes, qualitative analysis, quantitative analysis, Italy

1. INTRODUCTION

The supply chains of products of animal origin are chains of production and transformation events connected by links of various kinds. Because of their complexity, these supply chains are comparable to networks with a dense grid, in which the nodes of the network represent the players in the process, while the net trace the relationships among the actors (Jackson, 2008). This reticular nature, combined with the abstraction from some contingent situations which would represent only some company specific features, allows the representation of the supply chains by use of graphics software. Nevertheless it is good to keep in mind that an abstract representation, however accurate, is in any case only a partial reproduction of reality, that therefore omits some details in order to be representative of the majority of cases.

However, this network has been designed to be enriched with new details if necessary, details that may in turn become the object of observation and study.

The aim is to provide a mapping of the productions of animal origin as complete as possible and representative of the relationships among players.

At the present this study provides a tool to evaluate the quality of the relationships along the supply chain. It is in progress the implementation of a database containing

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quantitative data from official or administrative sources whose goal is making the network a quantitative as well as qualitative evaluation tool (Bigras-Poulin et al., 2006)

1.1 Features of this representation

For this map, it was decided to represent the network of animal products overlapping in a single framework the milk and dairy products chain and meat supply chain (Natale, et al., 2009). Currently in the meat supply chain are shown only beef and pigmeat chains, but the model is suitable to the addition of meat chains of other animal species. In the milk chain is instead considered cow's milk, buffalo milk, goat's and sheep's milk.

In order to allow those who play a role in the supply chain to recognize themselves in the various nodes of the network, it was decided to represent the chain according to the players. In this way we exclude business structures and emphasis is put on production processes, processing, trade, and consumption (Sieczka, 2009). As a result, for example, a company that performs multiple processes in the chain, does not recognize itself in a single node of the network, but in the path along multiple nodes.

Often a chain is represented by the production to the trade in the product. In this network, it was decided to represent also the recipient of the product, the consumer.

1.2 Graphical tool: yEd Graph Editor

The device used for the design of the network is the software yEd Graph Editor. It is a graphic software that allows you to establish a accurate symbolism for each segment of the network and for each level of specificity of representation from the most general to the most specific by changing color and geometric shape.

This graphic software also allows the variation of the layout of the network, that arranging the nodes in the space in different ways, allows to highlight those who occupy strategic positions because linked by a multiplicity of direct relationships to other nodes. Together, they form the subnets.

2. THE NETWORK

The network of the supply chains of products of animal origin has been described "according to the players" and divided into four segments, the same for all chains, representing the first general issues and then on the detail. The segments represented are Producers, Processors, Traders, Consumers. It is a complex network, which counts 201 nodes and more than 460 relationships among them. Within the four segments, nodes belonging to each segment are specified with increasing level of detail. Moreover are also drawn relations with which each node is connected to the others, and the direction of each relationship.

In order to precisely define the segments of the chain, described according to players, or agents, meaning those who perform actions along the supply chain, it was necessary to establish precisely the beginning and the end of each segment and of what it is included in:

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- Producers: the agents of production. This segment of the chain goes from the time of production, whether it is milk or meat, up to the permanence of the product in the company. It is excluded from this segment the physical exit of the product from the breeding company.
- Transformers: agents of processing. This segment of the supply chain goes from when the product leaves the farm (including the exit by the farm) until the end of the path in the processing company (or in the transport vehicles). It is included any process or treatment, even the simple cooling.
- Retailers: agents of the trade in the product. This segment starts from the exit from the factory for processing (or from the transport vehicles) and regards the trade of processed product for sale.
- Consumers: agents of consumption. Consumers are the buyers of the product, the last players in the chain, as it is designed in this network.

2.1 The Direction of the Relationships

Relations along the supply chain (the relationships linking the nodes of the network) are drawn with arrows that start from one node to reach another one. The choice of using arrows rather than simple union paths to represent the links between two nodes is due to the will of specify the direction along the supply chain that it is not only the flow of raw materials, but also temporal sequence of production processes, processing processes and trade.

The direction is not always the same along the chain, even if for many nodes you locate a linear path which starts from the Transformers segment and passing by the Producers segment and after by the Traders, ends in the Consumers segment. In some cases, such as the import of foreign products, it takes place before the transition from the Traders segment, who import the product from abroad. Then you go in the Transformers segment, to return after to the Traders segment when the product is ready to be sold on the national market. Other cases of atypical route are those that represent the "short chain", where the layout of the relationships bypasses the segment of traders, passing directly from the segment of the Transformers in the Consumer one because of the direct sales of the product.

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2.2 Key to symbols of the network: Colors and Geometric shapes

In order to a transcription of the chain of animal products into a network graph it has been necessary to adopt a specific symbology that could encode without the use of words the characteristics of each single node of the network. Different colors have therefore been adopted to indicate the membership of each node to a segment of the chain, and also different geometrical shapes for the different levels within each segment, having to start from a more general level in the description to get to the more specific ones.

For the identification of each segment have been used the following colors:

- a) Pink / Red: Segment "Producers"
- b) Turquoise / Blue: Segment "Transformers"
- c) Green: Segment "Traders"
- d) Blue: Segment "Consumers"

For the representation of the levels within segments of the supply chain the following geometric shapes have been used :

- a) Rectangle: Level 1
- b) Parallelogram: 2nd level
- c) Hexagonal: 3rd level
- d) Octagon: 4th level
- e) Ellipse: 5th level

2.3 Interpretation of the network of products of animal origin

The network of animal products defined in this study was obtained by mapping the milk and dairy products chain and the beef and pig meat chain at first individually and then overlapping them in a single network. (Figure 1.) This was made possible thanks to the preliminary identification of the four constituent segments of both the milk chain and those of the meat chain, Segment Producers, S. Transformers, S. Traders and S. Consumers, the four rectangles that contain all other nodes. The mapping provided by the network prescind from the dimensional characteristics and organization, production or processing characteristics of companies. Having chosen to represent the actors, or agents, that is to say those who act, the network returns a concatenated sequence of processes represented by the arrows, which often converge on some nodes, while maintaining their individual path. These nodes are "strategic" because they are situated on the production path of several products. The thing is made more evident by making a change in the layout that rearranges the nodes in the space while leaving unchanged the mutual relations. After doing this in fact you can appreciate subnets, which are characterized by the centrality of a node linked by the relationship "one to many" to other nodes.

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2.3.1 An example: Parmigiano Reggiano

To observe the Parmigiano Reggiano (Figure 3.) it is necessary to start as with all products, by Segment Producers in which is included the node Producers of milk for Parmigiano R. From this node an arrow leads to the Segm. Transformers in the node-group Cheese Factories which includes another node-group, the DOP cheeses, in which is contained the node Dairy Farm Parmigiano R. For the Parmigiano it is possible the "short chain" and direct selling. For this reason, a link leads to the next node, that of Maturing in the cheese factory - Packaging and direct selling, while another link leads to the node Maturers, and from there to the node Transformation in processed products, but also to the node Packaging for sale through traditional channels. By both nodes you switch to the different nodes of the segment Traders, while by the node Transformation in processed products a link also leads to the node representing the Wasting of the Segm. Transformers. From nodes in the Segm. Traders start the links to the Segm. Consumers that will go on the node of Parmigiano R. Consumers from which an outbound link will direct you to the node Wasting of Segm. Consumers. It represents the end point of the reading of the network, as the last node of the terminal segment.

3. CONCLUSIONS AND REMARKS

At present, this study allows a qualitative assessment. By matching a network database, which is currently being implemented, which contains numeric data, it will be possible to match to each node its weight in quantity and price (Figure 2.). This will give a "weight" to each node that derives not only from the qualitative assessment, depending on the number of relationships, but also by the quantitative evaluation (Vignes, 2011). This "weight" may vary the design of the network in relation to the distances between nodes, approaching those linked by very strong relationships. This does not mean, however, that the qualitative evaluation has minor importance, since a node linked to many others, regardless of its actual weight, is still crucial in all relationships with the nodes it is connected to. Therefore, if it came into crisis, it would be a problem for all the processes to which it is connected.

This aspect, but also the "weighted" definition of the strategic importance of the network nodes make it the basis for a tool for prediction of the critical issues and study of the choices by the governance about decisions on actions to support the sector. Furthermore, the actors in the chain can recognize their own activities in the paths traced by the network of relationships, whatever the type and size of their company. The ability to map along the network activities and relationships of a business enterprise makes this complex network the starting point for a possible tool to optimize management.

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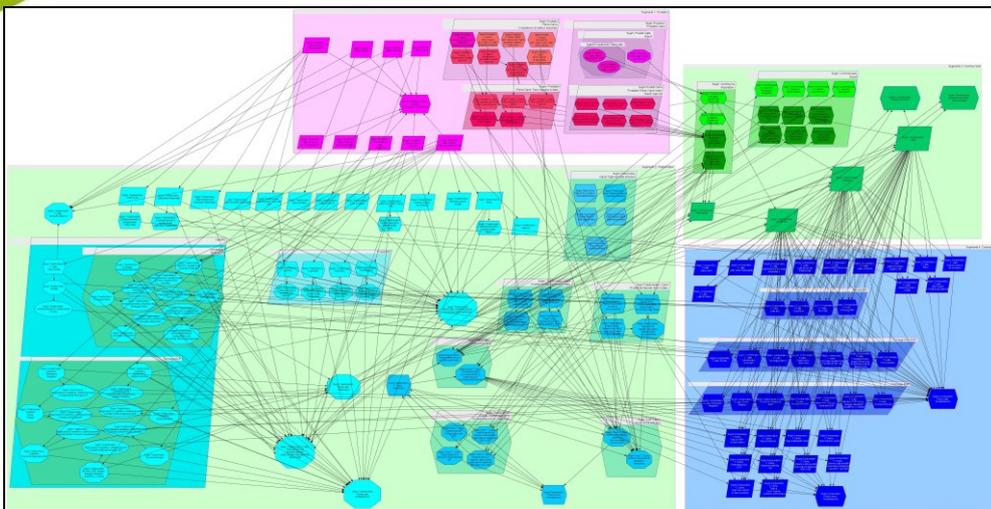


Figure 1. The network of animal products

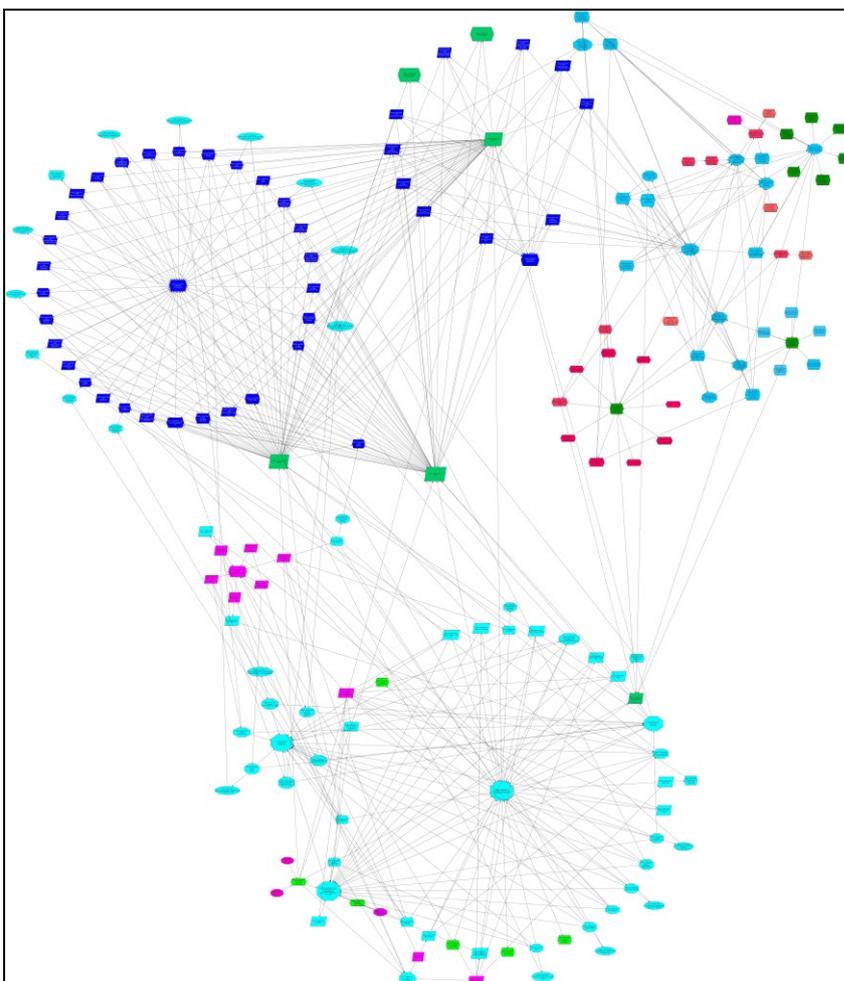


Figure 2. Qualitative evaluation of the network

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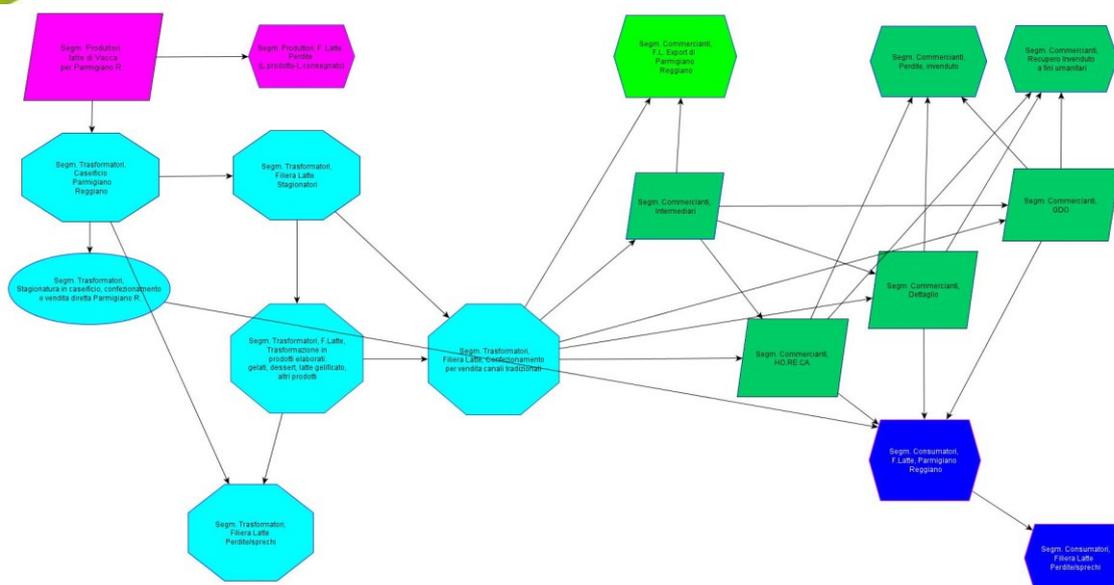


Figure 3. The Parmigiano Reggiano network.

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