Almond market dynamics and strategic planning

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Abstract

This paper highlights the value chain of the almond oil industry. The research objectives are to understand and explain how value emerges as a result of agricultural industry dynamics, to investigate the effect of speculative dynamics and inventories in agricultural industries and make policy analysis and recommendations in order to maintain the economical sustainability of Almond Oil Industry. The elaboration was prepared using the software Vensim, education version. The result of the analysis could be applied in a context in order to predict and correct the possible scenarios in order to better the situation studied on alomond market.

Key words

almond oil market, production of almond, system dynamics

Introduction

While in recent years, consumer prices for almond oil have unexpectedly and dramatically increased despite the decreasing producer prices, competitive pressures are forcing farmers to produce even more effectively - based strategic way. System dynamics models use simulation to leverage uncertainty, linking the quantitative and qualitative worlds and can be used to quantify how a particular leadership behavior will affect organizational performance over time. It is increasingly recognized as an important tool for companies that seek better alignment between strategy and execution—provided that the model is built carefully and manages its uncertainty appropriately.

It is also interesed to make analysis why almonds, this dried fruit is currently one of the most interesting and profitable agricultural products in the Portuguese context [Doll, 2021]. In addition to these factors the production is extremely interesting and complex as it is a drop-by-drop irrigation system and when harvested it can be stored for a long time thus developing stock and thus creating negotiating power at the time of sale for producers.

In the literature review the model of crop production was developed in the last century [Baker, 1976]. In depth study shows that this part of models is still important, nowadays because of the war, food and crises after pandemic time. There will be a new challenge to find a global equilibrium on the food market. Almond market could be an example however the authors realise that it is not a key crop product.

1. Model – strategic questions

The first idea of system dynamics was introduced by L. Bertalanffy in 1937 at the University of Chicago, where many academics do not catch the main ideas [Bertalanffy, 1984]. The system dynamics approach was moved significantly forward by Jay Forrester where backgrounds were described in his book in 1961 [Forrester, 1961]. At the same time was developed also a system thinking [Meadows, 2020]. In Poland the system dynamics was popular in the 1970s [Kulikowski, 1977]. Academics from business started to use system dynamic models and structured the knowledge into practical cases in the end of 20th century. MIT was probably the first one, who used it on a large scale. J. Sterman published his elementary book about business dynamics in the new Millenium. His model consist of five steps [Sterman, 2016]:

1) Problem Articulation (Boundary Selection),
2) Formulation of Dynamic Hypothesis,

3) Formulation of a Simulation Model,
4) Testing,
5) Policy Design and Evaluation.

Practical approach to strategic modelling and business dynamics was also described by Morecroft, where the readers can learn about the tools and hot to use in business growth, oil as an industry dynamics and the public sector [Morecroft, 2007].

To conduct the case study, many of policy makers, farmers, could set up the following strategic questions [Paich, 2011]:

1. Will this system have a positive effect on production?
   The system focuses on optimizing the harvesting and transformation of almonds to its maximum potential, whether by better certain variables or less understanding harvesting failures that must be corrected in order to have the maximum harvesting possible at the lowest cost. Furthermore, our system will be easy to understand and easy to implement so that it is used by the maximum number of farmers.
2. Does this production (segmentation of agricultural activity) justify the creation of such a system?
   Given the current reality, we can see that in Portugal the production of such products is growing at impressive levels. In 2021, Portugal already had more than 39,640 hectares of this species and produced more than 33,550 tons of almonds, and the profitability per hectare exceeds 3,000 euros while the almond is still in its rawest state (in the shell). In addition to these factors, farmers have great international demand in their favor, which allows them to export their entire production at a very interesting price.
   (https://vozdocampo.pt/2019/08/05/potencial-e-rentabilidade-da-cultura-da-amendoa-no-ribatejo/)
3. Is it possible to create an internal demand for our product?
   Given the data presented above and considering that more and more consumers are opting for healthy alternatives and that, given the studies on almonds that are being published today, we can conclude that there is a demand for our product.
   (https://www.saberviver.pt/comida/nutricao/conheca-os-beneficios-da-amendoa/)
4. Why is almond oil so important?
   Almond oil contains vitamins E and B1 and essential fatty acids, making it a great moisturizer for both your hair and skin. It's also full of antioxidants

that can help prevent damage from free radicals - a major cause of aging, wrinkles, and acne wrinkles.
https://latourangelle.com/blogs/general/10-health-benefits-of-almond-oil

5. Can this system be used for other types of agricultural production?
The system is also designed to be implemented in other types of agricultural products, if they have the system parameters, such as, being a production that the product in question is taken from a tree, that we have production data (expected amount, costs, time taken to pick up, etc.).

2. Model – development

Questions such as these help you to create a solid understanding of the overall market and identify what is necessary to grow your business. Decision making is all about understanding the nature of the problems we face, evaluating alternative solutions, and choosing the right one. Effective models are those that help make better decisions. Understanding the structure of an indication marketplace allows decision makers to formulate a better, more effective set of strategies for operating within it (Szydło et al., 2022; Szpilko et al., 2021).

How can we improve our sales forecasting? Which elements of the company's marketing mix will have the biggest impact on our top-line revenue? Which channels are best suited to support our innovation? If we want to increase customer satisfaction and loyalty, how do we develop tailored pricing strategies across different customer segments? In response, system dynamics provides a unique approach to understanding feedback loops. This enables one to predict which actions will lead to desired results and allows one to experiment with different paths forward until they achieve their goals.

Answering questions such as these depends on a clear understanding of marketplace dynamics and the structure/behavior paradigm. To address these types of questions, we have developed a basic but expandable framework that combines aspects of almond tree quantity, almond tree harvest, and production process and tools.

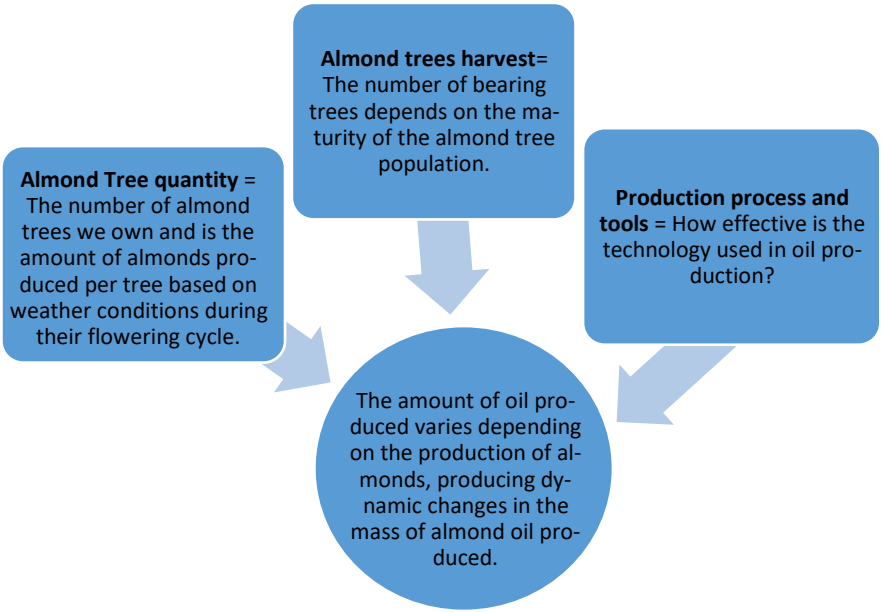

Fig. 1. Three components for almond markets

Source: author's elaboration inspirited Paich et al 2011.

These components are populated with data over the years to ensure a robust representation of actual market dynamics. Merging these three structural pieces into a simulation model determines the amount of olive produced, quality of production and the flow of the physical material from one process to another.

The simulation environment allows for the testing and implementation of strategic initiatives through a wide range of possible outcomes, including performance improvements, cost savings, and valuation jumps.

3. Vensim model for almond markets

In-depth review of almond business allowed to create a submodels through the Vensim Education software program, however at this stage without equatations. The authours, based on three main components of almond markets, prepare a general relation for submodels.

3.1. Flow of almond tree quantity

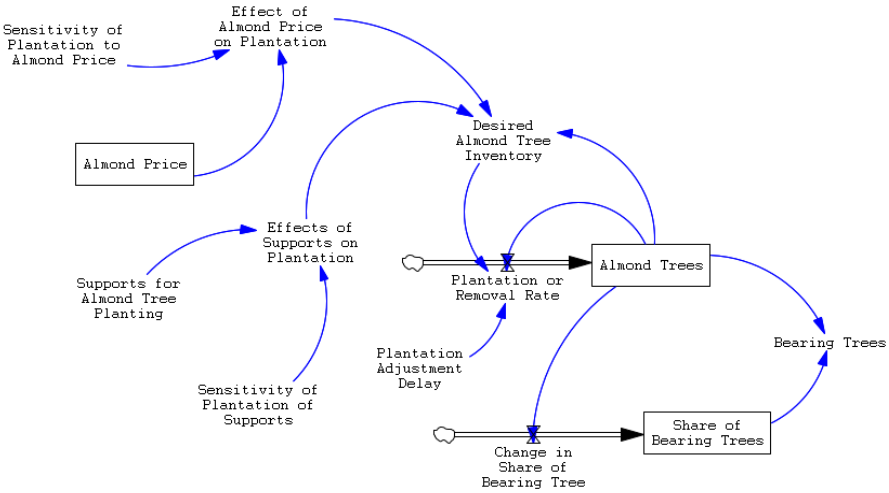

Fig. 2. Model: flow of almond tree quantity

Source: author's elaboration.

Once planted, it takes three to four years for an almond tree to begin producing nuts. The almond tree has an average life span of 20 to 25 years. Once established, trees typically begin blooming mid-February through March. Almond trees are alternate bearing, meaning that a large crop will be followed by a lighter crop the following year. Computing the Desired Almond Tree Inventory level is a predictive task. To predict the length of time between successive years, we need to compute it as a function parameter of expected almond price and financial support for planting, which are the indicators of profitability of almond farming business. Plantation or Removal Rate adjusts the Almond Trees level with respect to Desired Almond Tree Inventory. Depending on the perceived profitability of almond farming business and hence Desired Almond Tree Inventory, Plantation and Removal Rate may take positive or negative values.

3.2. Flow of harvesting

Almonds are harvested between mid-August and October, about two weeks after the last irrigation. The effect of almond harvest on price can be estimated by calculating the relative magnitude of the realized almond fruit for oil with respect to

expected almond fruit for oil. The larger share of almonds harvested is used for almond oil production, while the remaining part is used to sell almonds as nuts. Data is accumulated in Bulk Almond Oil Inventory.

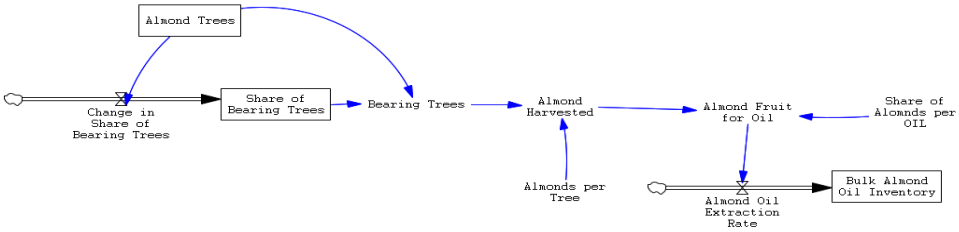

Fig. 3. Model: flow of harvesting

Source: author's elaboration.

The harvesting flow, such a system developed in Vensim, is presented below and has the following variables.

In this flow we can observe the almond harvesting process in all its extension, from the variation that each tree produces of the fruit to the percentage of it will be used for the process of creating the oil. In addition, we can also observe the period of harvesting the almonds and the volume we expect to obtain from the oil through the processing of the dried fruit.

3.3. Flow almond oil production

Different extraction methods can be used for almond oil extraction, although, as with other seeds, solvent extraction will provide the highest industrial yield [Roncero, 2016]. The evaluated three main influence parameters: extraction temperature, size of almond particle and solid/ solvent proportion regarding yield.

In this third part of submodel, we observe how the production, distribution and sale of almond oil would be carried out.

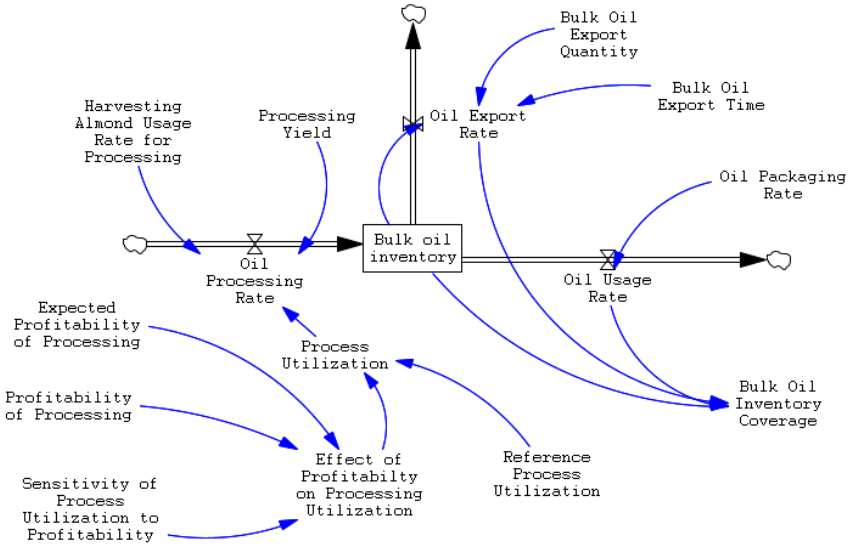

Fig. 4. Model: flow of almond oil production

Source: author's elaboration.

In this flow we can observe the processing of almonds in oil, then their distribution and respective sale. In the model we can observe all this process and its respective variables. From which we can highlight the production ratios, distribution and production times, and the respective inventories of almond oil production.

Almond oil selling inventory can be seen as the retailing inventory which is available for selling to end consumers. Processed Packaged Almond Oil Inventory can be seen as the finished goods inventory which is available for distribution to wholesalers and retailers. In a similar way, Almond Oil Selling Inventory can be seen as the retailing inventory which is available for selling to end consumers.

Almond Oil Inventory is a commodity which is stored in bulk at an Almond Oil Warehouse. The inventory level, volume and type of storage media determine the quantity of inventory available to the market (consumption, import or export). The available quantity is affected by several economic factors including agricultural production (almond harvest) and seasonality as well as marketing factors including buyer demand, price, and rebate schemes.

4. Integration of planting, harvesting and almond oil production

Determining attractiveness

A number of factors can impact the aggregate utility evaluation for treatment options in a given indication, such as:

- efficancy,
- threat of new competitors,
- market size,
- technology development,
- seasonality and profitability.

Assigning importance to almond oil production will establish what percentage each factor plays in the weighted average calculation of aggregate evaluation of utility, as shown in Tab. 1. This is done by weighting the different factors with specific values that reflect their relative importance, and then summing them up (multiplication) to determine a weighted value.

Tab. 1. Attractiveness calculation for almond

Almond market attribute	Weighting	Rating	Calculations
Efficancy	25%	70	17.5
Threat of new competitors	15%	50	7.5
Market size	20%	35	7
Technology development	30%	75	22.5
Seasonality and profitability	10%	60	6
Total	100%		60.5

Source: author's elaboration.

Considering the factors presented and through the articles researched, we can consider that of the 5 factors presented above, there are variables which have more weight than others in terms of determining attractiveness, with technology development being the most important with 30% and seasonality and profitability with the lowest weight with a value of 10%.

5. System Dynamic Almond Oil

System Dynamics are an important part of Production Management because it allows us to better understand why some problems are caused and how they affect the final product.

Simulation interprets the vision of the system through numerical values to system variables and functions. This allows to create an initial idea of the behavior of the system.

This Vensim model includes three basic elements of almond oil production: almond tree quantity, the flow of harvesting, and almond oil production focused on production technology. It shows the dynamics of the system through the interaction of variables, where each variable has an important role in the production of the final output.

It was built based on the authors ability to explain the model logic which could be used to improve the quantity and quality of production and this is something we are looking into. The Vensim model would also be useful for helping stakeholders to increase production efficiency.

As we can see in picture Fig.5 Almond Oil Extraction Rate it's directly connected with Almond Fruit per Oil. Almond Fruit per Oil represents the total amount of almonds harvested from Bearing Trees that will go for oil production. As there are some external factors in almond production such as climate and temperature that affect the production directly, we are focused on internal factors such as Desired Almond Tree Inventory and Share of Bearing Trees.

During the analysis the oil production process, it is worth to notice that Bulk Oil Inventory is a result of the Almond Oil Extraction Rate and Oil Processing Rate. This clearly shows the importance of each link of the chain and exposes how problems that occur at one point are followed by problems in all production steps.

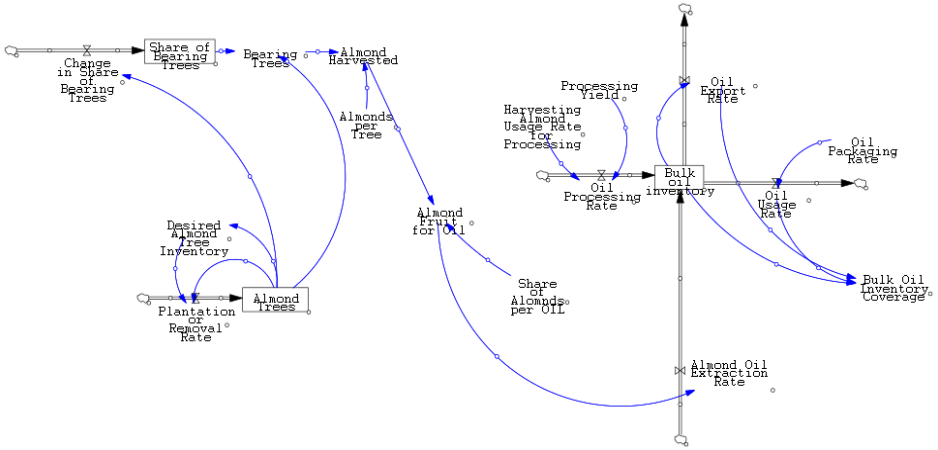

Fig. 5. Model

Source: author's elaboration.

Each varaibles were described in the program Vensim, where the final list is given at Tab. 1. For the simplicy evaluation reason and testing the genral relationships were used only main units for selected varaibles.

Tab. 1. Equations of the simulation

No.	Name	Unit
1	Almond Fruit for Oil = Almond Harvested*Share of Almonds per OIL	
2	Almond Harvested = Almonds per Tree*Bearing Trees	
3	Almond Oil Extraction Rate = Almond Fruit for Oil*1	
4	Almond Trees= INTEG (Almond Trees+Plantation or Removal Rate, 10000)	
5	Almonds per Tree = 150	kilograms
6	Bearing Trees = Almond Trees*Share of Bearing Trees	
7	Bulk oil inventory= INTEG (Bulk oil inventory+(Oil Processing Rate-Oil Usage Rate-Oil Export Rate+Almond Oil Extraction Rate)+7000, 7000)	kilograms
8	Bulk Oil Inventory Coverage = Bulk oil inventory/(Oil Export Rate+Oil Usage Rate)	
9	Change in Share of Bearing Trees = Almond Trees	
10	Desired Almond Tree Inventory = Almond Trees	
11	FINAL TIME = 100 The final time for the simulation.	Month
12	Harvesting Almond Usage Rate for Processing= 0.8	

No.	Name	Unit
13	INITIAL TIME = 0 The initial time for the simulation.	Month
14	Oil Export Rate = Bulk oil inventory*0.4	
15	Oil Packaging Rate = 700	kilograms/Month
16	Oil Processing Rate = Harvesting Almond Usage Rate for Processing*Processing Yield	
17	Oil Usage Rate = Oil Packaging Rate	
18	Plantation or Removal Rate = (Almond Trees+Desired Almond Tree Inventory)	Month
19	Processing Yield = 0.2	
20	SAVEPER = TIME STEP The frequency with which output is stored.	Month [0,?]
21	Share of Almonds per OIL= 0.8	Dmnl
22	Share of Bearing Trees=Change in Share of Bearing Trees	
23	TIME STEP = 1 The time step for the simulation.	Month [0,?]

Source: author's elaboration.

6. Testing of the model

In the simulation that was created, we can visually expose the various points studied/discussed in the previous part of the article.

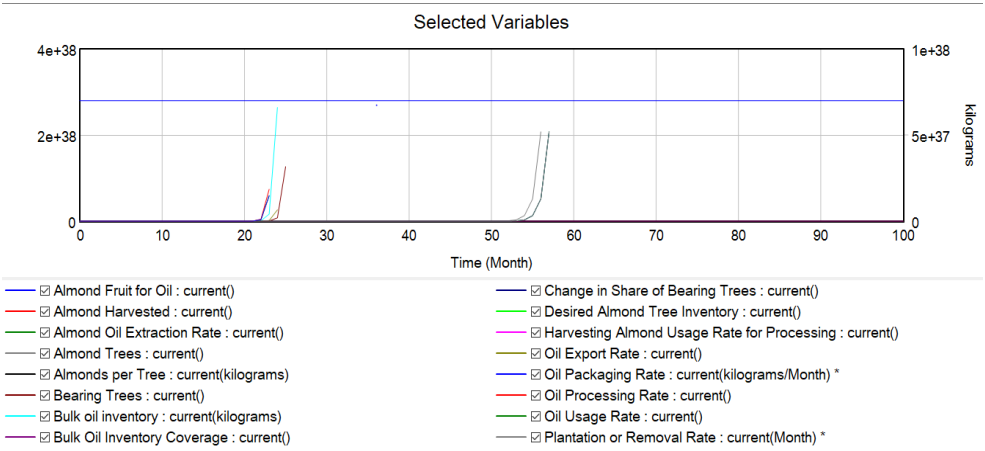

Fig. 6. Simulation the model of almond markets

Source: author's elaboration.

The system is closely intertwined with the cyclicity that the almond tree produces its fruits. Such evidence is possible to observe in the graph with the existence of time periods in which the production is null and others in which the production produces an exponential curve in the graph.

The graph is composed of two units of measurement (Months and Kilograms), due to the fact that this is a production of a product whose creation takes a long period of time, and because the production of the final product is more interesting from the perspective of the final buyer.

Conclusions

The almond oil industry has experienced rapid growth in recent years. This has helped to develop integrated system dynamics models based on the basic but expandable system dynamics framework. However, the basic principles between planting, harvesting and production are the same. By understanding the link between the structure of the almond oil industry, marketplaces and their customers, marketing teams are developing more cost-effective strategic plans.

The aim of this study, focusing on the almond oil industry in Portugal, is to understand and explain how the value of products (almonds and almond oil) emerges at the market because of agricultural industry dynamics. The Almond Oil Model was created using a system dynamics modeling tool (Vensim).

According to the growth of uncertainty and instability on the markets, the future updated research should be done. Understanding the relations of food markets and natural resources is crucial for society, not only academics. Much better is to make some simulation then meet the problem without preparation.

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Dynamika rynku migdałów i planowanie strategiczne

Streszczenie

W niniejszym artykule zwrócono uwagę na łańcuch wartości przemysłu oleju migdałowego. Celem badań jest zrozumienie i wyjaśnienie, w jaki sposób powstaje wartość w wyniku dynamiki przemysłu rolnego, zbadanie wpływu dynamiki spekulacyjnej i zapasów w przemyśle rolniczym oraz dokonanie analizy polityki i zaleceń w celu utrzymania ekonomicznej stabilności przemysłu oleju migdałowego. Opracowanie wykonano z wykorzystaniem programu Vensim w wersji edukacyjnej. Wynik analizy można zastosować w celu przewidywania i korygowania możliwych scenariuszy poprawy badanej sytuacji rynkowej na rynku migdałów.

Słowa kluczowe

rynek oleju migdałowego, produkcja migdałów, dynamika systemu