A Computer Simulation Model of Knowledge Management in Small and Medium Agri-Food Enterprises

Moisés Martínez Soto, [1]*, Carlos Rodríguez Monroy, [2]**, Joaquín Fuentes-Pila, [2], Anne Morris Díaz [1] and M. Gil Araujo [1]
[1] University of Zulia, Joint Projects Coordination Unit, Venezuela
[2] Technical University of Madrid, Food Quality Engineering Research Group
* moisesenriquemartinezsoto@yahoo.es ;** crmonroy@etsii.upm.es

Abstract

System dynamics is an appropriate tool to build management models due to its ease of application in solving unstructured problems. In the twenty-first century the sustainability of organizations is influenced by the way it manages its knowledge. In this sense, knowledge management (KM) represents a strategy that contributes to improving the production supply chain (SC) of the agri-food industry (AFI). The objective of this research is to develop a computer model to simulate the effect of KM on the production of AFI. The methodology applied was that of the system dynamics by using the Vensim PLE ® v. 5.10 software, whose determining indicators were selected through an empirical study of KM in the SC of precooked corn flour industry in Venezuela. The study concluded that the balanced implementation of KM practices in the strategic dimension and in the functional dimension achieved an increase in production through the stabilization of the system. Further evaluation of the methodology developed in other agro-industrial environments is recommended.

Keywords: *Small and Medium Enterprises, System Dynamics, Supply Chain, Knowledge Management, Food Industry.*

1 Introduction

The agri-food industry (AFI) is of strategic importance for the vast majority of nations especially in regard to small and medium enterprises (SMEs). For example, in the European Union the food industry is one of the most important and dynamic industrial sectors with an annual turnover of 900 billion Euros, 310,000 businesses and over 4 million direct jobs. Agriculture, processing industry and food distribution combined represent more than 5% of GDP, 7% of employment and 17% of household expenditure (European Commission, 2011). In this sense, the agri-food SMEs make a significant contribution.

According to Massa and Testa (2009), SMEs in Europe dominate the AFI. Italy is an example of this situation, because 90% of total agri-food companies are SMEs and only 7% have more than 20 employees. However, the food sector in Italy is the second largest manufacturing industry behind the metalworking industry in terms of sales, with 14% of the volume (Federalimentare ISMEA, 2005).

Currently small and medium enterprises (SMEs) in supply chains (SC) of the agri-food industry (IAA) with its special characteristics, are challenged to increase their productivity, quality and innovation, at the a global and local level in order to meet the food and nutritional requirements of the population. But, simultaneously they are facing a growing demand for agricultural raw materials for industry in general and for the energy industry in particular, with greater requirements, regulations and regulatory constraints by consumers and governments, together with an degradation of the environment, which is the support base of its activity, with instability in financial markets and other multiple challenges, difficulties and expectations inherent in its multifunctional nature (Audicana, 2007).

The concepts set out above, on the challenges of the SC of the AFI are to be considered from the perspective of opportunities rather than of crises. In that sense, it is possible that the border strip between crisis and opportunity is located in this area in the ability of organizations which are part of the AFI supply chain to manage knowledge.

According to Drucker (2000), Davenport and Prusak (2000) and Nonaka and Takeuchi (1995), in the twenty-first century competitiveness and sustainability of productive organizations, such as AFIs, is based on knowledge assets and management. The management of intangible assets is key to creating value in organizations and a source of competitive advantage. In this regard, the GC is a tool to improve yields and the performance of supply chains of agri-food products (Sporleder, 2005).

The concept of KM has evolved since its emergence in the context of industrial management in the 90's. Riesco (2006) and Arboníes (2006) distinguish three major stages. During the first phase (1990-1995) the focus was on getting the right information to the person in need in a timely manner. A vision based on information management prevailed. For the second phase (1995-2001) there was a customer-oriented approach: data storage, conversion of tacit knowledge into explicit knowledge and exploration of the worldwide web. Information is differenciated from knowledge. In the third phase, from 2001 onwards, the trend focuses on knowledge as a process. We are dealing with a dynamic set of skills or know-how that change constantly.

Although many different definitions of KM, because it is an immature concept, from the perspective of this research, it is defined as an organizational strategy which, based on an innovative environment and the use of ICTs, develops skills to originate, store, transfer, apply and protect organizational knowledge, in order to increase the competitiveness and sustainability of SCs and the organizations or companies that conform them (Martínez Soto, 2011).

In this regard, according to Martinez Soto (2011) the concept of KM, is composed of three dimensions: strategic management of knowledge, innovative environment and functional management or cycle of knowledge, the latter dimension in turn composed of the following sub-dimensions.

- Source of knowledge: creation and acquisition of new knowledge.
- Storing knowledge: classification and categorization of knowledge for storage and retrieval.
- Transfer of knowledge: knowledge dissemination to users.
- Application of knowledge: using knowledge to achieve business goals.
- Protection of knowledge: preserving the competitive advantage.

Each of these dimensions and sub-dimensions are associated with a set of KM practices which in different industrial contexts have their own conditioning variables such as size and type of company, level of use of ICT and professionalization of human talent, among others.

Despite the potential positive effect on firm performance KM, Wong and Aspinwall (2005) indicate that most SMEs have not implemented KM systems, but intuitively apply practices related to this organizational trend, including the following activities:

- Electronic capture of knowledge
- Use ICT to share and transfer knowledge
- Use of Intranet to publish and access information
- Development and maintenance of employees' skills and abilities
- Identification of internal and external best practices
- Creating an enabling environment for knowledge sharing
- Development of KM strategies
- Appointment of leaders and KM teams
- Rewarding employees who contribute and share knowledge
- Measurement of intellectual capital

In consideration of these statements it is estimated that widespread implementation of KM systems in the agri-food SMEs, has to go through the development of management models and methods that are reliable, practical and effective to facilitate its uptake by agro-industrial chains.

In this sense, system dynamics offers a set of possibilities due to its capacity to recognize and analyze unstructured and soft nature problems, such as those which relate to the design and simulation of KM in the supply chains of AFI.

As a result of the above, the objective of this research is to model with system dynamics the effect of knowledge management on the production of agri-food SMEs. For this purpose a case study has been performed, analyzing the production deficit of 310 tonnes per month of pre-cooked corn flour for human consumption in a local market of two million inhabitants, in a developing country which is a net importer of food.

2 System Dynamics,a tool that facilitates the implementation of KM in the agri-food SMEs.

According DEDALUS (2010), system dynamics is a methodology for building simulation models for complex systems, such as the one studied in this research. The research applies hard systems methods, basically the concepts of feedback and dynamic systems together with the theory of models in the space of states and numerical analysis procedures. It would therefore be one more methodology among those of hard systems. However, it aims at unstructured problems (soft systems) and those occurring in production systems. This approach raises two types of difficulties: the first one related to the quantification of the concepts and elements involved and the second one related to the validation of the results obtained.

In system dynamics, before quantifying the results of the causal model, the variables of interest and the relationships among them need to be identified. It is then essential to quantify these relationships, which sometimes poses insurmountable difficulties.

Also, once the model has been built, it is reasonable to test it against reality. This question may only be solved if the model is capable of generating the characteristic behaviors of the real system, denominated reference modes. In such case, some confidence in the validity of the model is gained. These reference modes are varied. Among them we can find the following: the comparison with historical and future data of the real system; the comparison with data from other similar systems; qualitative comparisons of numerical results and trends of the model through consultation with experts, among others.

In system dynamics simulation allows for paths to the variables included in any model by applying numerical integration techniques. However, these paths should not be interpreted as predictions, but rather as projections or trends. The basic objective of system dynamics is to understand the structural causes that provoke the behavior of a system, through the knowledge of each of its components and the interactions that arise among them, an approach that is far from the traditional methods of analysis (Forrester, 2003).

This understanding of the elements and their relationships should normally produce a favorable environment to determine actions that can improve system performance or solve the identified problems. Some of the factors that represent an advantage in applying system dynamics for analysis and testing policies for solving production problems in the AFI, are reliability, versatility, low relative costs and time.

In this context, it follows that system dynamics helps to resolve complex situations, identifying the most appropriate leverage points. To do this, it is necessary to focus on the whole issue, rather than on its parts. It is obvious that the whole is much more complex than any particular individuality. However, it is useful to know that there are two types of complexities, one concerning the details and another related to dynamics. The latter is present in situations where cause and effect are subtle, and where the effect of the intervention over time is not obvious, for example, the effect of KM in the SC of the AFI.

3 Materials and methods

To model the effect of KM on agri-food SMEs, the system dynamics methodology of, with the support of the management software Vensim ® PLE v. 5.10 has been used. This is a graphical simulation modeling tool enabling to conceptualize, document, simulate, analyze and optimize system dynamics models (Vensim, 2010).

In this research, careful analysis of the KM system elements in the agri-food SMEs and the design of the model were based on the results of an empirical study of KM construct in the four stages of the supply chain industry of precooked corn flour, which are: corn producers, processors, distributors and suppliers of goods or services in a developing country which is a net importer of food (Venezuela).

This empirical study enabled the selection of the determining indicators of the KM practices, because of its validity, reliability and consistency. The selection was made from two hundred thirteen variables, through the main components factorial analysis with varimax rotation. Determinant indicators and the dimensions and sub-dimensions of the KM with whom they associate, are presented in Table 1.

Table 1. Dimensions, sub-dimensions and determinant indicators of KM in agri-food SMEs

Dimension	Sub-dimension	Indicators (KM practices)
Strategic management	Strategy of KM	▪ Use of ICT ▪ Strategic organization of knowledge
	Objectives of KM	▪ Productivity ▪ Quality ▪ Innovation
Innovative environment	Innovative Leadership	▪ Innovative leadership
	Autonomy to innovate	▪ Workers with autonomy to innovate
Functional management or Knowledge cycle	Source of new knowledge	▪ Relations with the economic environment ▪ Knowledge acquisition
	Stored knowledge	▪ Storage of organizational knowledge for physical and digital means
	Transferred knowledge	▪ Consulting of manuals
	Applied knowledge	▪ Development of work routines
	Protected knowledge	▪ Reputation for quality ▪ Difficult to imitate processes

Source: Authors

Having identified the key elements through the empirical study referred to above, we proceeded to develop the KM model through the following sequence of activities: characterization of the system elements; assigning values to the parameters; creating a first version of the model and its stability; identification of key elements; simulation and model validation.

4 Results and discussion. Case study

The problem under study was the assessment of the effect of KM on agri-food SMEs. This evaluation was conducted through a simulation model of the effect of the independent variable *Knowledge management* on the dependent variable: *Difference in production*. We selected the variable production which reached the rank of reliable and valid in the empirical study, as a quantitative, tangible and continuous variable, which has been measured in *metric tons (t)*. As for the KM variable, the measurement was performed using the magnitude *hours (hr)*, in accordance with the requirements of the simulation tool used.

The statement of the case or problem under study is as follows: In a local population of approximately two million inhabitants in a developing country which is a net food importer, there is a monthly demand of 6,400 t of precooked corn flour. The most important supply chain in the market has a share of 50%, but produces only 2,890 t/month. Therefore, it has decided on a plan based on a knowledge management model to reduce the gap between demand and supply, within a period of 25 months and if possible, to generate a surplus of production.

First, an estimate of working hours per month devoted to activities related to KM practices (including information management), by staff employed in SMEs in the supply chain of the industry under study, at the supervision, technical and operational levels has been made. This figured reached a value of 28,896 hr/month. To integrate the output variable and the KM variable, the concept of knowledge productivity, which is measured in t/hr, has been developed.

4.1 Definition of first, second, third and fourth order influences

Having identified the problem under study, which is the gap between demand or production target and current production, which is hereinafter designated as the level variable, *Production difference*, we began to identify the first, second, third and fourth order influences. In this regard, first-order influences are considered to be those that directly modify the behavior of the problem under study. The influences of second order are those that modify the first order influences and so on in the case of the of third and fourth order influences. The influences in their respective order and their associated variables are the following:

- First order influences: *target production*, *current production* and *production from knowledge management*. The latter can reduce the output gap.
- Second order influences: *knowledge management, productivity of organizational knowledge, market share* and *estimated demand.*
- Third order influences: *current organizational knowledge, innovative environment, development of ICT, demand for new knowledge, new knowledge source, knowledge storage, knowledge transfer, applied knowledge* and *protected knowledge.*
- Fourth order Influences: they are represented by the indicators of KM practices in the functional dimension of knowledge management which are: *knowledge acquisition, alliances and relationships, physical file, digital file, consulting manuals, sequences and routines, quality reputation* and *hard to imitate management.* All these concepts represent the determinant indicators of the KM construct selected in the empirical study. That is, were included in the computer model for reliability, validity and consistency.

4.2 Definition of the casual relationships

At this stage, causal relationships are outlined in the system under study (Figure 1). The arrows represent the influences that exist between elements of the system. The arrows which are assigned a positive sign (+), represent direct relationships and arrows to which are assigned a negative sign (-) represent inverse relationships.

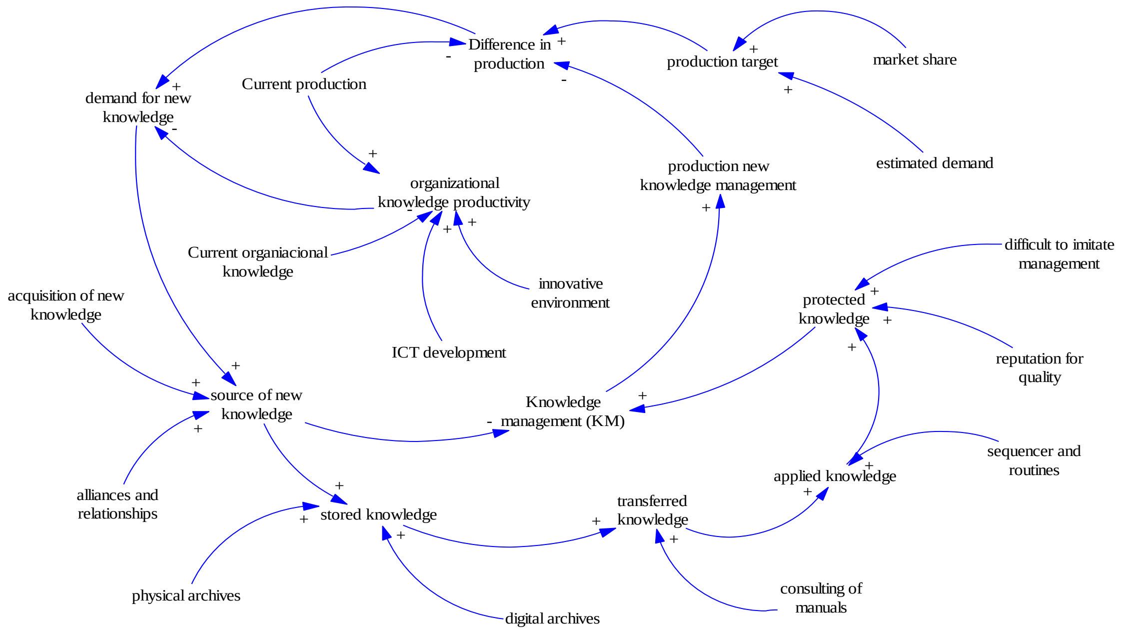

Figure 1. Model diagram of the causal effect of KM on SMEs food production
Source: Authors

After developing the causal diagram and identifying the critical system variables: *Difference in production* and *Knowledge managed*, an analysis was performed on them, through the tools tree of causes and tree of consequences.

In the case of variable *Difference in production* the following causes were identified: *the production target, the current production* and *the new production* derived from *Knowledge management*. In this sense, the increased *production target* is directly proportional to the *Difference in production*, and the increase of *current production* and *new production derived from KM* are inversely proportional to the *Difference in production* (Figure 1).

Simultaneously, by the tree of consequences method, the direct proportional relationship between the *Difference of production* and *demand for new knowledge* was identified, that is, for a higher difference in production the demand for new knowledge will increase.

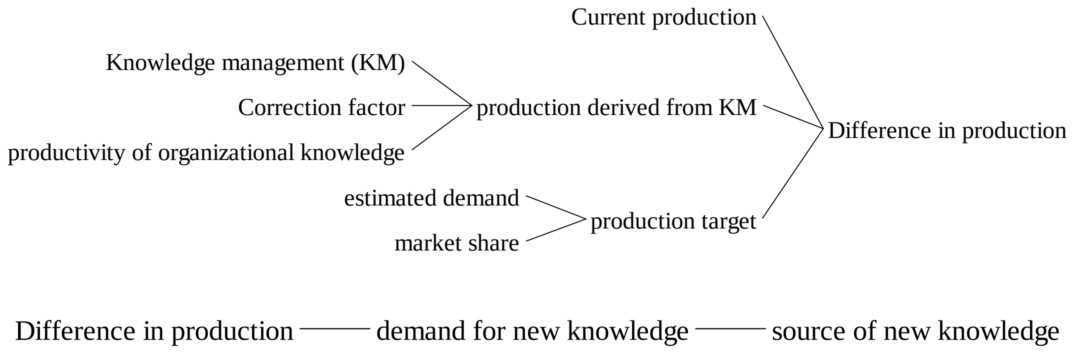

Figure 2. Tree of causes and tree of consequences of the variable *Difference in production* of the KM model causal diagram in the agri-food SMEs
Source: Authors

In the case of knowledge managed the following causes were identified: protected knowledge and new knowledge. In this sense, managed knowledge is directly proportional to the protected knowledge and inversely proportional to the new knowledge that has not been managed within the SC (Figure 3).

Similarly, in the tree of consequences, the directly proportional relationship between the knowledge managed and the new knowledge production derived from KM, which ultimately affects in inverse sense the difference in production, was identified.

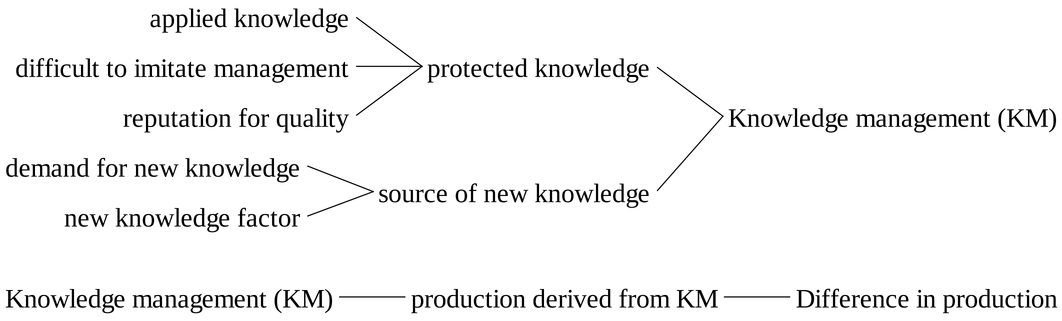

Figure 3. Tree of causes and consequences of the variable *Knowledge management (KM)* of the KM model causal diagram in the agri- food SMEs
Source: Authors

4.3 Identification of the feedback loops

The loops are signs on the possible behaviour of the system, and also on possible measures to enhance or mitigate their effects. For this purpose, both the existing loops, as well as the signs of these loops have been identified. Positive loops are identified with the drivers for change and negative loops with the causes for the stability of the system.

The causal diagram has two loops which are presented below:

```
Loop Number 1 of length 4
  Difference in production
     - demand for new knowledge
     - source of new knowledge
     - Knowledge management (KM)
     - production derived from KM
Loop Number 2 of length 8
  Difference in production
     - demand for new knowledge
     - source of new knowledge
     - stored knowledge
     - transferred knowledge
     - applied knowledge
     - protected knowledge
     - Knowledge management (KM)
     - production derived from KM
```

```
Loop Number 1 of length 4
  Knowledge management (KM)
     - production derived from KM
     - Difference in production
     - demand for new knowledge
     - source of new knowledge
Loop Number 2 of length 8
  Knowledge management (KM)
     - production derived from KM
     - Difference in production
     - demand for new knowledge
     - source of new knowledge
     - stored knowledge
     - transferred knowledge
     - applied knowledge
     - protected knowledge
```

Loop number one is positive and is linked to the dynamics of *Difference in production* and to the effects that *Managed knowledge* has on it. Loop number two is negative and is more related to the way the managed knowledge is produced through the cycle of knowledge, whose different stages are: *source of new knowledge, stored knowledge, knowledge transferred, applied knowledge* and *protected knowledge*.

4.4 Creation of the flowchart

It is conformed basically with the same elements as the causal diagram, although some auxiliary elements have been added.

4.4.1 Characterization of the elements of the model

In the model under study, the levels or accumulation variables are represented by the variables *Difference in production*, measured in metric tons (t) and *Knowledge managed*, measured in hours (hr). The variations of the levels are the flows, which have the same units as the levels plus a temporal component (t/month and hr/month). In the KM model in the SC of the AFI, the flows are represented by the variables: *target production* and *current production*, as well as by the variables source of *new knowledge* and *protected knowledge* respectively.

Auxiliary variables and constants allow a better view of the factors affecting the flow behavior. In this model, they are represented by the determining indicators of KM practice selected from the empirical study.

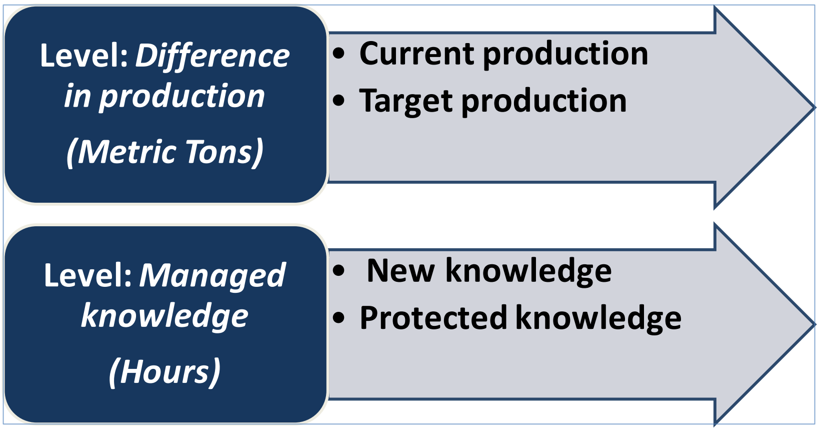

Figure 4. Characterization of system elements

4.4.2 Assigning values to the parameters

Model elements have been assigned initial values based on problem data or case study. These data are reasonable approximations, referring to the reality of a local market of the precooked corn flour industry in Venezuela. Accuracy does not usually provide significant advantages to this type of model, because even if the exact value in the past of a constant is known exactly, it is certainly more useful to know if this value is to be maintained in the future or not (Martín-García, 2007).

The equations and the values assigned to the various parameters at the baseline or time zero of the model are the following:

(01) acquisition of knowledge= 1 Units: 1/Month [?,?,0.1]

(02) alliances and relationships=1 Units: 1/Month [?,?,0.1]

(03) applied knowledge= transferred knowledge*(sequences and routines/5) Units: Hr/Month

(04) consulting of manuals=1 Units: Dmnl [?,?,0.1]

(05) Correction factor=1 Units: 1/Month

(06) current organizational knowledge=28896 Units: Hr/Month

(07) Current production= 2890 Units: t/Month

(08) demand for new knowledge= Difference in production/productivity of organizational knowledge Units: Hr

(09) Difference in production= INTEG (production target-Current production-production derived from KM,310) Units: t

(10) difficult to imitate management= 1 Units: Dmnl [?,?,0.1]

(11) digital archive=1 Units: Dmnl [?,?,0.1]

(12) estimated demand=6400 Units: t/Month

(13) FINAL TIME = 25 Units: Month The final time for the simulation.

(14) ICT development=1 Units: Dmnl [?,?,0.1]

(15) INITIAL TIME = 0 Units: Month The initial time for the simulation.

(16) innovative environment=1 Units: Dmnl [?,?,0.1]

(17) "Knowledge management (KM)"= INTEG ((source of new knowledge-(source of new knowledge-protected knowledge)),3100) Units: Hr

(18) market share=0.5 Units: Dmnl

(19) new knowledge factor=(acquisition of knowledge+alliances and relationships)/10 Units: 1/Month

(20) physical archive=1 Units: Dmnl [?,?,0.1]

(21) production derived from KM="Knowledge management (KM)"*productivity of organizational knowledge*Correction factor Units: t/Month

(22) production target= estimated demand*market share Units: t/Month

(23) productivity of organizational knowledge= (Current production/current organizational knowledge)*(innovative environment+ICT development)/10 Units: t/Hr

(24) protected knowledge= applied knowledge*((difficult to imitate management+reputation for quality)/10)Units: Hr/Month

(25) reputation for quality=1 Units: Dmnl [?,?,0.1]

(26) SAVEPER = TIME STEP Units: Month [0,?] The frequency with which output is stored.

(27) sequences and routines=1 Units: Dmnl [?,?,0.1]

(28) source of new knowledge=demand for new knowledge*new knowledge factor Units: Hr/Month

(29) stored knowledge= source of new knowledge*((physical archive+digital archive)/10) Units: Hr/Month

(30) TIME STEP = 1 Units: Month [0,?] The time step for the simulation.

(31) transferred knowledge= stored knowledge*(consulting of manuals/5) Units: Hr/Month

4.4.3 Flowchart of KM in SC in the AFI

The following flowchart (Figure 5) shows the level variables, the flow and the auxiliary variables and the influences they exert on each other. All the elements of the model has been described and analyzed in the previous sections. Therefore, we have moved to simulate the management model based on four scenarios.

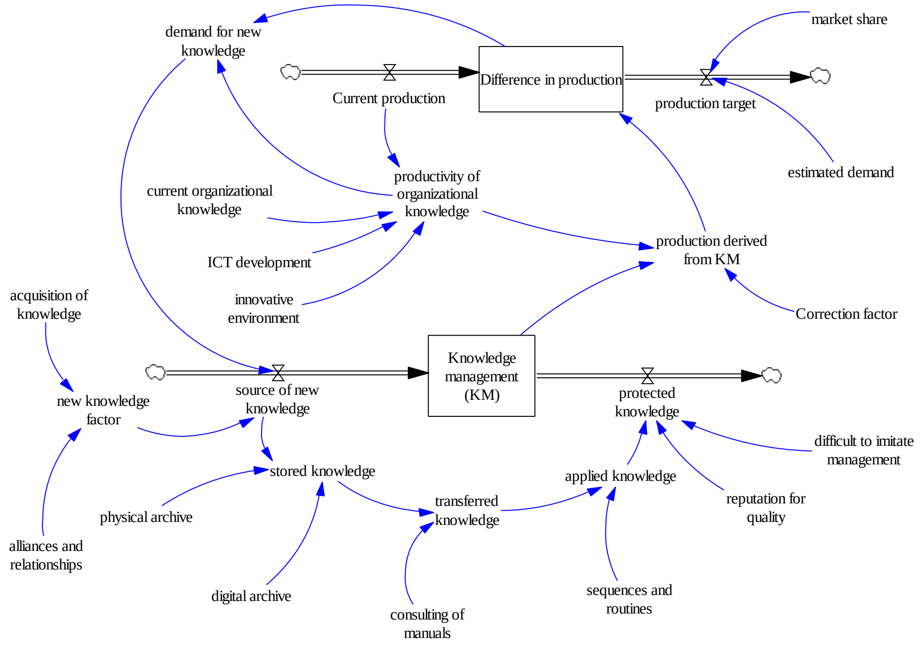

Figure 5. Flowchart of KM in SMEs in the AFI
Source: Authors

4.4.4 Simulation and validation of the KM Model in the AFI supply chain

The method consists in introducing changes to the model that can later be implemented in order to select the option that provides better results. For the computer simulation of this model, we analyzed four scenarios:

Scenario 1: Without KM practices

In this scenario, in the initial time the variable difference in production was 310 t and at the end of the period, the figure increased with a very steep slope to reach 6,300 t. Simultaneously, the variable knowledge managed, had an initial value of 3,100 hr. and at the end of the period it reached a value of 4,395 hr. In this regard, it is inferred that this scenario is not one that enables to solve the production deficit problem raised, since it is out of balance. In this scenario, KM practices are not developed neither in the strategic dimension, nor in the functional dimension, so the differences in production are increased uncontrollably (Figure 6).

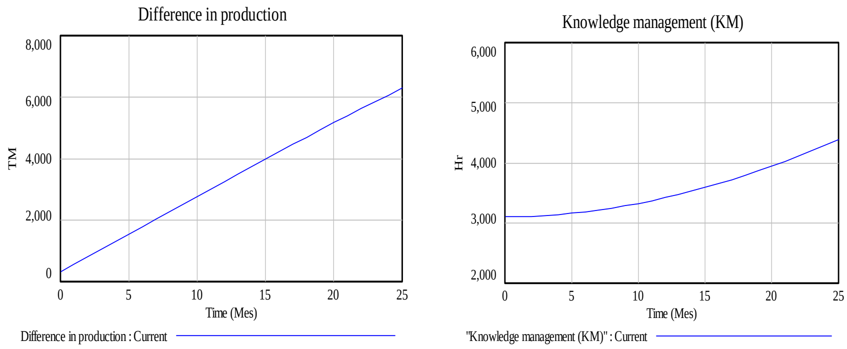

Figure 6. First simulation of the initial design stage of KM in agri-food SMEs
Source: Authors

Scenario 2: Only strategic KM practices

In this scenario, the initial variable, *Difference of production*, was 310 t and at the end of the period, the figure rises with a moderate slope to 1,785 t. Simultaneously, the variable *Managed Knowledge*, presents an initial figure of 3,100 hr and end at the end of the period 3,203 hr. In this regard, it is concluded that the Scenario 2, does not solve the problem. Like the previous one it is also unbalanced. The production shortfall grows moderately compared with scenario 1, but ultimately it is still increasing. KM practices are geared only to the strategic aspect, such as the use of ICT and organizational changes (innovative environment). But they do not consider the functional dimension of knowledge cycle, so it does not reach the expected results. It is truly a stage with too much emphasis on technology and organizational superstructure that does not solve the existing problem (Figure 7).

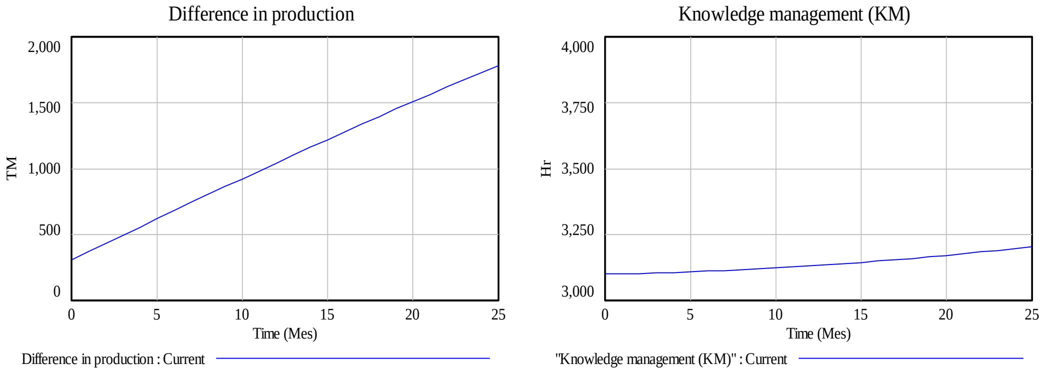

Figure 7. Second simulation of the initial design stage of KM in agri-food SMEs
Source: Authors

Scenario 3: Only functional KM practices

In this scenario (Figure 8), the initial variable *Difference in production* was 310 t and at the end of the period, the deficit figure fell to 22 t. In its evolution there was an increase in *Difference in Production*, probably due to resistance to change in the system, causing stress, which then was gradually moderated until the system got into balance, at the point of zero slope. Then the variable *Difference in Production* began to decrease, so it could be inferred that the problem is resolved. However, simultaneously, the variable *Knowledge Management*, which presented an initial value of 3,100 Hr., increased exponentially to 30,483 hr. This figure represents an increase of almost 10 times which is excessive and impractical to implement since it is equivalent to the ***current organizational knowledge***. In this respect, it is apparent that although the production deficit is reduced, the low productivity of organizational knowledge (0.02 t/hr), leads to a rejection of this scenario due to the excessive use of hours for KM.

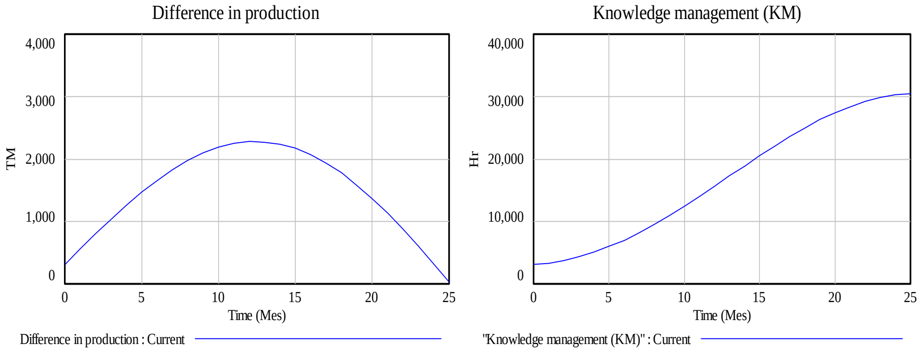

Figure 8. Third simulation of Functional KM in the agri-food SMEs

Source: Authors

Scenario 4: Strategic and functional KM practices

In this scenario (Figure 9), initially the variable *Difference in production* was 310 MT and at the end of the period, the figure went from deficit production to surplus production that reached an absolute value of 680 t. As in the previous scenario, there was an evolution, in which at first there are increases in *Difference in production*, but only to approximately 525 t, probably due to the system's resistance to change. Then this difference was moderated until the system got into balance, at the point of zero slope, beginning then to reduce the gap *Difference in production* until month 16 when the difference is zero (0 TM) and starting to experience negative values in *Difference in production*, which shows that the production target was exceeded and there is an absolute surplus production.

Simultaneously, the variable *Knowledge Management*, presented an initial figure of 3,100 hr. that increased to 5,100 hr in the 16th month to finally reach an estimated 3,805 hr. at the end of the period, well below the value attained in Scenario 3. This behavior is due to increased productivity of knowledge (0.08 t/hr). In that sense, it may be concluded, based on the simulation process that this scenario solves the problem on reasonable terms, because it goes from a deficit of 10.22% of production to a surplus of 23.52% of production taking as a reference the 2,890 t/month, which occurred at the initial time of the simulation.

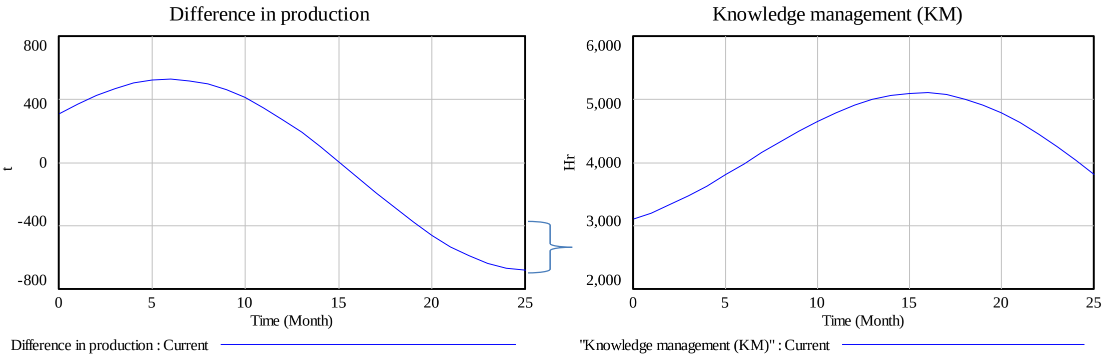

Figure 9. Fourth scenario in combining KM practices both in the strategic dimension and in the functional dimension (optimal)

Source: Authors

5 Conclusions and Recommendations

1. The combined application of KM practices in the strategic and operational dimensions stabilizes the system and manages to eliminate the agri-food production deficit and even achieve a surplus

2. The standardization of the methodology developed through its application in agri-food industries and in other circuits in different production environments is recommended

3. The development of computer KM model for the AFI SC is a powerful tool for simulating policies to overcome the shortfall in production and achieve a surplus in local food markets.

4. The scope of production surplus, exceeding previously the initial deficit was only possible in rational terms when combined and balanced KM policies were implemented, taking into account both the strategic dimension and the functional dimension.

5. The combined and balanced implementation of policies for both strategic and functional management of knowledge, facilitates the increased productivity of knowledge, an indicator that streamlines the relationship between knowledge and production in the case study.

6. The requirements of new knowledge gradually lessen as the production goals of the model are achieved, as it becomes managed knowledge which increases the intangible assets.

7. It is recommended to develop new computational models of KM in the agro-SC, where market share is energized by the variable quality prestige, as well as incorporating into the model the magnitude of costs and benefits. That is, the model should approximate the production reality of the AFI.

8. The standardization of the methodology through its application in different AFIs and other production environments is recommended.

References

Arboníes A., (2006). *Conocimiento para innovar: cómo evitar la miopía en la gestión del conocimiento*. 2ª edición. Madrid: Ediciones Díaz de Santos, S.A., 336 p. ISBN: 9788479787554

Audicana J., (2011). Los grandes retos de la industria agroalimentaria. http://www.santelmo.org/notas/Abril.%20Entrevista%20Julio%20Audicana.%20ALIMENATEC.pdf. 2007. Último acceso 05/02/2011

Davenport T.H, Prusak L., (2000). *Working knowledge: How organizations manage what they know.* 2nd edition. Boston: Harvard Business School Press. 2000. 240 p. ISBN-13: 978-1578513017

DEDALUS. (2010). Qué es la dinámica de sistemas? *http://www.daedalus.es/blog-y-recursos/sobre-inteligencia-de-negocio/dinamica-de-sistemas.html*. 2010. -Último acceso 06-12-2010

Drucker P., (2000). *El Management del Siglo XXI*. 1ª edición. Editorial Edhasa. 280 p. 2000. ISBN**:** 8435014525, 9788435014526

European Commission, (2011). Enterprise and Industry: Raising the bar for Europe's food industry Visible en http://ec.europa.eu/enterprise/sectors/food/-index_en.htm. Consultado el 22/01/2011)

Federalimentare ISMEA, (2005). 3 Report scenari 2015 della filiera agroalimentare (3rd Report: 2015 scenarios of agro-food industry). http://www.federalimentare.it.

Forrester J., (2003). "Dynamic Models of Economic Systems and Industrial Organizations". *System Dynamics Review.* 2003. Vol. **19**-4: 331–345.

Martínez-Soto, M., (2011). *Desarrollo de Un Modelo de Gestión del Conocimiento en la Cadena de Suministro de la Industria Agroalimentaria.* Tesis Doctoral en Administración de Empresas. Departamento de ingeniería organizacional, administración de empresas y estadística de la Escuela Técnica Superior de Ingenieros Industriales de la Universidad Politécnica de Madrid. (En prensa). 291 p.

Martín-García J., (2007). *Sysware*. 1ª edición. Barcelona: Editor l'autor. 2007. 315 p. ISBN**:** 8460924629, 9788460924623

Massa, S., Testa, S., (2009). A knowledge management approach to organizational competitive advantage: Evidence from the food sector. *European Management Journal* **27**:129– 141.

Nonaka I, Takeuchi H., (1995). *The knowledge-creating company: how Japanese companies create the dynamics of innovation.* Oxford University Press, 1995. 284 p. ISBN: 0195092694, 9780195092691

Riesco-González M., (2006). *El Negocio es el Conocimiento.* Madrid: Díaz de Santos. 2006. 312 p. ISBN: 8479787481, 9788479787486

Sporleder T., (2006). *Strategic alliances and networks in supply chains. Knowledge management, learning and performance measurement.* Wageningen UR Frontis Series**.** C.J.M. Ondersteijn, J.H.M. Wijnands, R.B.M. Huirne and O. van Kooten (Edist.). *Quantifying the agri-food supply chain*. Printed in the Netherlands. p. 159-169. ISBN: 1-4020-4693-6

Vensim Guía sobre Dinámica de Sistemas. http://www.dinamica-de-sistemas.com/vensim/guia_vensim.htm. (2010). Último acceso 05/02/2011

Wong, K.Y.; Aspinwall, E., (2005). An empirical study of the important factors for knowledge-management adoption in the SME sector. *Journal of Knowledge Management*, Vol. **9**, No. 3:64-82.