KNOWLEDGE MANAGEMENT MODEL PROPOSAL BASED ON AN ECONOMIC OUTPUT INPUT FRAMEWORK.

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ABSTRACT.

In the current macroeconomic scenario making economic decisions in any public organization must be supported by adequate economic-intelligence. It is a priority to obtain models, techniques and tools to ensure adequate control in all its investments. In this paper we present a model of knowledge management based on the input-output framework that enables us to know the economic impact of the investments. This model is supported by an information system that will contribute to economic analysts in decision-making in the field of public investments. The model and the system have been applied in the area of Defense in order to assess the economic impact of a series of investment programs in the aeronautic sector.

Keywords: Input-Output Analysis; Economic Impact, Defense Economy, Knowledge Management.

1. INTRODUCTION

The study of the defense sector from an economic perspective has attracted increasing attention in recent years. Globally, defense spending accounted for 2.5% of world GDP (SIPRI, 2013) and in the last decade has grown by over 130% in nominal terms. In Spain, this sector contributes significantly to the national economy, as Fonfría and Correa-Burrows (2010) highlight and during the last twenty years, defense spending in Spain has represented on average 1.4% of Spanish GDP, according to the Stockholm International Peace Research Institute, SIPRI (1988-2012). Investments in the field of defense have an economic impact of great importance and are focused on key sectors of the economy.

The investments in the defense area are mentioned in the eighteenth century by Adam Smith (1776) although the modern concept "defense economy" was used in the nineties by Intriligator (1990), who mentioned the key criteria in it such as the analysis of defense spending and employment, Hartley and Sandler (1995), who include the resource allocation or distribution of income; Lee Jones (1990) who addresses the concept in terms of investment in security or McGuire (1995) in his analysis that considers a range of topics such as exports, contracting or procurement in defense.

In line with these proposals, the economic impact of defense spending on the national economy was one of the first issues to be resolved in our analysis. This was done, however, without neglecting other equally relevant ones, such as the impact on employment, value added or production, or how this impact is distributed in the areas of high technology and knowledge-intensive services, as key sectors of the national economy, or even how to make predictions that allow us to know how our scenario will vary in the future, for example by increasing certain investments and reducing others.

Following the recommendations of Reppy (1991), we used the theoretical advances in adapting the standard economic analysis of the special features to the world of defense and thus address the challenges of the analytical complexity of the issues to be considered. To resolve all these issues we built a model that allows us to improve our management of knowledge on economic matters. To construct this model we rely on the input-output framework and the most advanced studies for the establishment of knowledge management models and the development of knowledge-based systems. This model, although it has been used in a particular scenario in the field of defense, can be extrapolated to other economic scenarios.

First in this paper, we outline a brief historical context of an input-output framework and models of knowledge management, then we present our model of knowledge management in economic matters, including the development of an information system that supports this model. Subsequently we summarize the application of our model in a particular case study in the aviation sector within the area of defense. Finally, we present the main conclusions of our research projects.

2. HISTORICAL REVIEW

We have taken as reference for our model the input-output analysis, which has its roots in the works of Leontief (1936, 1941 and 1951) and the subsequent development of the input-output framework in Leontief (1986) and Leontief, Carter and Petri (1977). One of the first applications of this methodology is in the work of Herderson (1955) where the input-output method is used to analyse the Italian economy. Another very relevant work was done by Miller, R.E. and P.D. Blair (1985), covering social accounting matrices (SAMs), extended input–output models, their connection to input– output data, structural decomposition analysis (SDA), multiplier decompositions, and identifying important coefficients, and international input–output models.

In the area of some sectors such as shipping in the literature we highlight the studies by Hill (1975), which determined the impact of the Port of Baltimore (USA), or even in the area of leisure and sports competitions, with Barker, Pagey Meyer (2002); Crompton, Lee and Schuster (2001), and Kasimati (2003). The environmental sector contains many works such as Duchin (1992) about the implications of the input-output analysis for Industrial Ecology; Heijungs and Suh (2002) with the Computational Structure of Life Cycle Assessment, a tool for environmental decision-support in relation to products from the cradle to the grave; Lenzen et al. (2004) (2006) and the CO2 Multipliers in Multi-Region Input–Output Models; Cohen et al (2005) determining the total (direct plus indirect) energy requirements of a given set of Brazilian households based on IO analysis; Peters et al (2007) about China's growing CO2 Emissions; Wiedmann et al. (2007) and Wiedmann (2009) with Input–Output Models for the Assessment of Environmental Impacts, or the EU-funded project EXIOPOL, a Global Multi-Regional Environmentally Extended Input–Output

Database, Tucker et al. (2009); the Input–Output Analysis of CO_2 Emissions, Su et al. (2010) or the latest studies by Manfred Lenzen (2011) and Glen P. Peters et al (2011).

There are also some relevant impact studies within the input-output framework in Spain, such as that of Alcaide (1996) who proposed a simplified accounting model at a regional level, Llano (2004), which analyses the impact on the Spanish economy at the interregional level; Goicolea, J. Herce and De Lucio (1998), studying the growth of the economy in Spain; Moreno, Lopez-Bazo, Go and Artis (1999) analyse the external effects in production; Fontela -Montes and Rueda-Cantuche (2005) provide an input-output model of global social accounting (including environmental issues), and the analysis conducted by Soza-Amigo and Ramos-Carvajal (2011) which offers interesting conclusions concerning the role reduction of an input- output table in multipliers and linkages of non-binding branches. With regard to its application in economic sectors, applied studies highlight the tourism sector in Spain (González, 2010; Doors- Medina, and Mari-Selva and Calafat-Marzal, 2012; Sánchez-Rivero, 2012) and the study of Marti et al. (2009) which includes application to the various ports of Valencia.

Considerable resources have been obtained by using existing global Input-Output analysis to perform a large number of country-specific studies such as the Asian International IOT (AIIOT), released every five years since 1985 and mainly focused on the Asia region with a variety of applications IDE (Ed.) (2006); the EU-funded project WIOD (World Input–Output Database), focused on productivity studies of a variety of environmental, social and economic aspects, Timmer, M. (2012) and the Australian-funded AISHA project (Automated Integration System for Harmonised Accounts, Lenzen et al. (2010).

Knowledge management is based on a process that enables you to locate, filter, organize and present information in order to enhance learning and understanding of a specific area of interest (Koontz and Weihrich, 1996, Laurence Prusak, 1996; Jozef Loermans, 2002); and performs a search through a synergistic combination of data and information, the use of information technology and the creativity and innovation capabilities of people (Malhotra, 1998). In the digital economy the assumptions from the old economy that most of us are comfortable with do not carry over to what is now the mainstream digital economy, Amrit Tiwana (2000). To develop a project about Knowledge Management, Davenport, De Long and Beers (1997) propose a variety of ways to generate value based on knowledge assets. These proposals do not necessarily mean technological solutions, but a combination of different types, which by means of their relationship form the structure of the final solution.

From the theory, according to Donald Hislop (2013), it is necessary to have a multidisciplinary perspective, encompassing issues of structure, strategy, systems, HR management, technologies, or culture management and leadership. From the application point of view, Kimiz Dalkir (2013) provides a comprehensive overview of the field with an emphasis on transferring theory into practice and using key concepts, tools, techniques, contents management and cybernetics. Thus, management and information science are changed into a three-level approach to understand Knowledge Management from the individual, the community, and all the organizational levels. From the latest in management knowledge and techniques proposed by the input-output framework in the references to processes already mentioned, our work has focused on developing a model of knowledge management

on the economic impact of the investments. This model is applied in the field of defense, on several aircraft programs of great economic scope.

3. ADVANCED KNOWLEDGE MANAGEMENT MODEL FOR THE ECONOMIC IMPACT (KMMEI)

To carry out our project, we built a model that includes three layers of knowledge management (perception of existing components in the organizational environment, the comprehension of their meaning and the projection of their status in the future). Our proposal is supported by a model we have called KMMEI (Knowledge Model for Economic Impact).

This model allows us to relate the layers of situational awareness of data fusion processes in terms of the economic impact of an investment program. In the figure below we show a simplified diagram of the model. The sensors shown in the figure are devices in the system to capture data sources and provide this information to a number of levels.

Examples of these sensors are the various reports of the offices of the investment programs; information from the National Statistical Institute provides national data input-output or international databases of input-output data. At zero level of our model the sensor data from different sources can be integrated through a process of data fusion, which can address the problems of adaptation (changes in currency, price updates, and accuracy of data) or differences in the presentation of output formats.

FIGURE 1: GENERAL STRUCTURE OF KMMEI
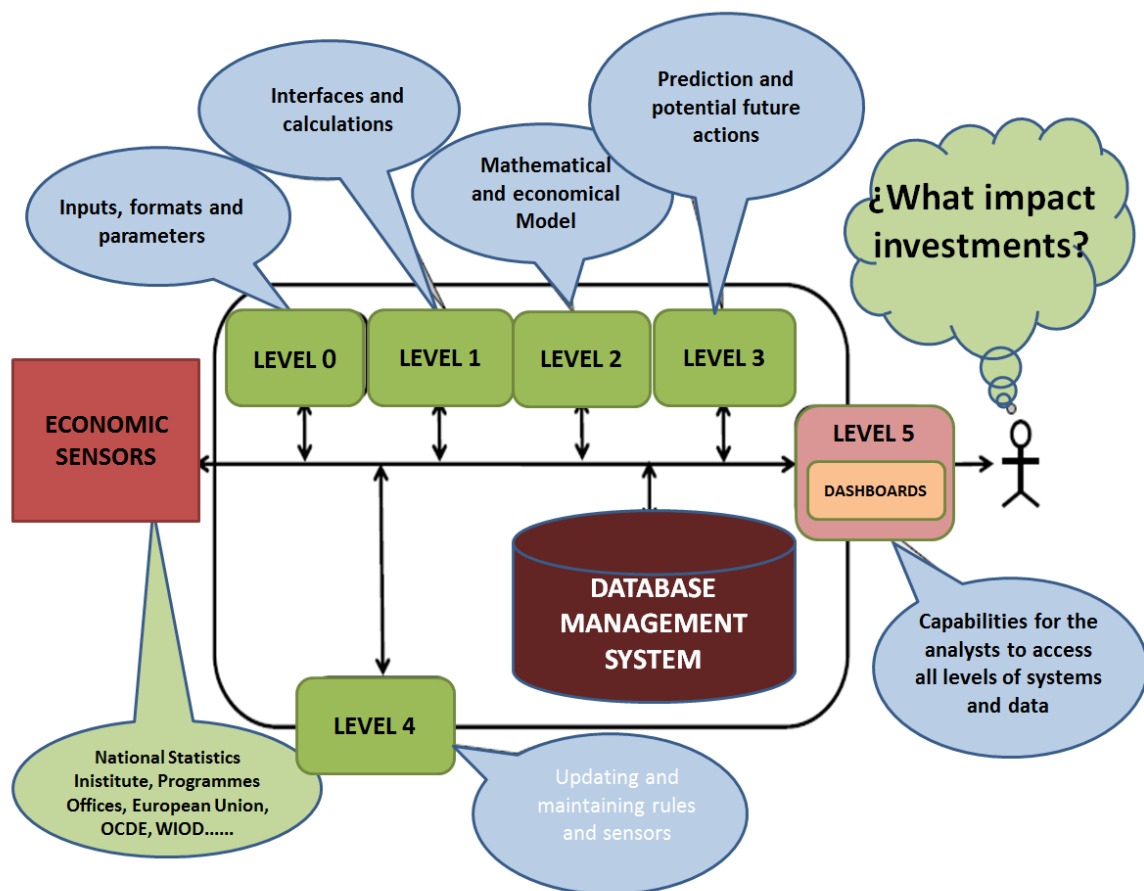
The level one model is supported by a process of information fusion that combines these data to perform various calculations and simulations, enabling standardized information that can be operated by a full mathematical model at level to be obtained. In this level (2), all variables are combined into a model for providing output current perspective of the state of our investments in terms of economic impact.

At level three, the process provides an ability to predict future states of our investment systems (for example, if we invest more in certain sectors, how could it vary our economic impact?, or how much would we have to invest in a certain sector to get more jobs in strategic sectors?, and what sectors will receive a greater impact if I change my investment scheme on certain projects?).

The level four KMMEI model addresses the system's ability to maintain rules and sensors; for example, updating input-output data at the national level would be an example of basic capability in level four. Finally, level five is the interface between the economic analyst and the data fusion system. The information visualization plays a very important role here.

In general, the display consists of a representation of information to graphically convey a concept clearly. It is an essential component in the transmission of situational awareness and enables faster decision making, since the presentation of data visually can leverage the processing power of the human brain and our natural ability to detect patterns, trends and changes in the images.

The full analysis of economic information will continue to require a large human component, despite all the efforts of automation. Here the display systems play an essential role. The data stream has to be analysed, both in real time and from its historical data. It is for this reason that it is necessary to have visualization systems to reduce analysis time without producing a lack of data summarized through having too much and thus it shortens the time needed for decision making. One of our objectives to achieve this goal was to develop an information system to support this process

3.1. INFORMATION SYSTEM TO SUPPORT KMMEI

Figure two represents the architecture of our knowledge management system, supporting the model KMMEI, consisting of a presentation layer, where the researchers can interact through a series of collaboration tools. This layer is integrated with a knowledge repository where all information resides. To manage this information we propose a process to identify, obtain, classify, process, and retrieve this residing information.

The data sources are part of the literature, experimental data and use of our case studies, calculations and models and finally the various databases searched, which for our case study are: sources of the National Statistical Institute of Spain (INE), the Ministry of Defense, the European Union and the Program Offices.

FIGURE 2: SCHEMA OF THE INFORMATION SYSTEM TO SUPPORT KMMEI
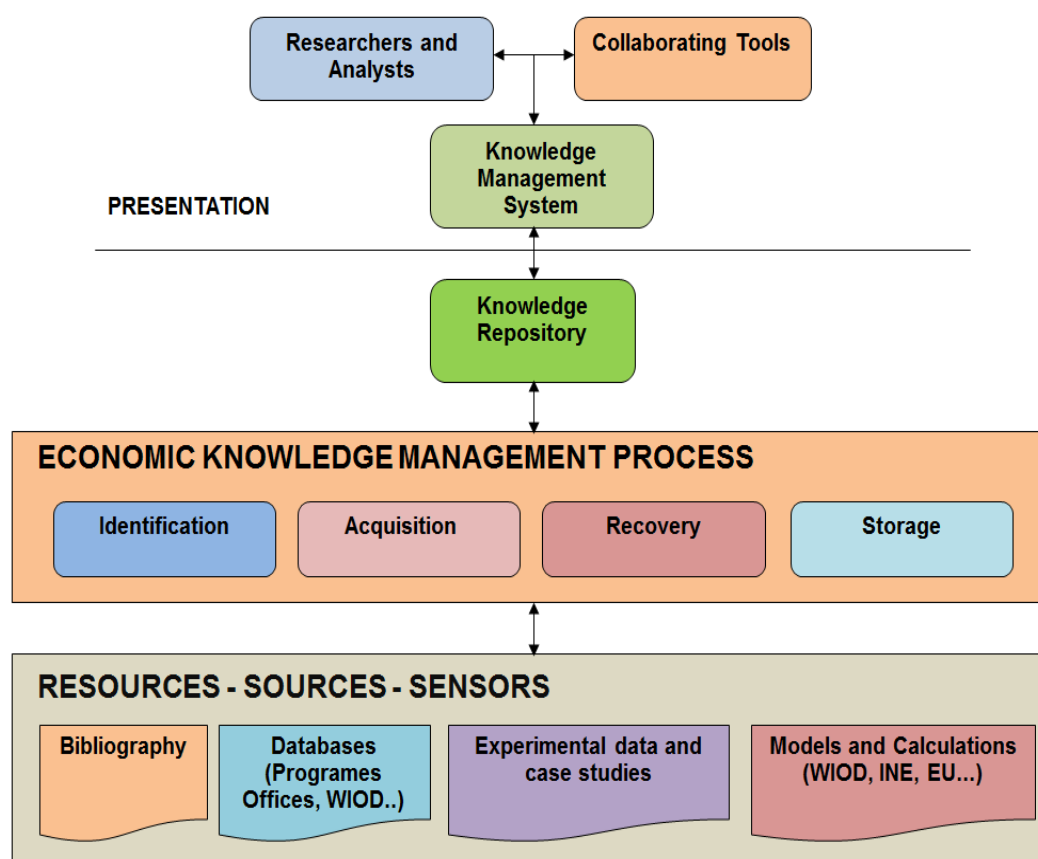
We propose that the model of knowledge management should be applied in a decision-making scenario, as it is presented in Figure 3. The decisions and actions that are carried out, and are ex post measures vary depending on the state, which is analysed through different levels as can be seen in the figure:

- Perception (level 1),
- Compression (level 2) and
- Projection (level 3).

Depending on the skills, training and experience of the roles involved in the decision flow, they feed a loop that is supported by a system with a variety of interfaces, a degree of automation and complexity. The main entrances of the model are the expectations, goals and objectives of assigned missions.

Some organizations could make use of the term "*sense-making*", which is the process by which an investment analyst could, from situational awareness, make sense of the information collected on investments, and from that level provide information flow to the layers of decision making, if necessary, with an appropriate level of detail. To achieve this purpose, most of the advanced organizations could make use of models that allow the linking of all levels of situational awareness information in terms of economic impact.
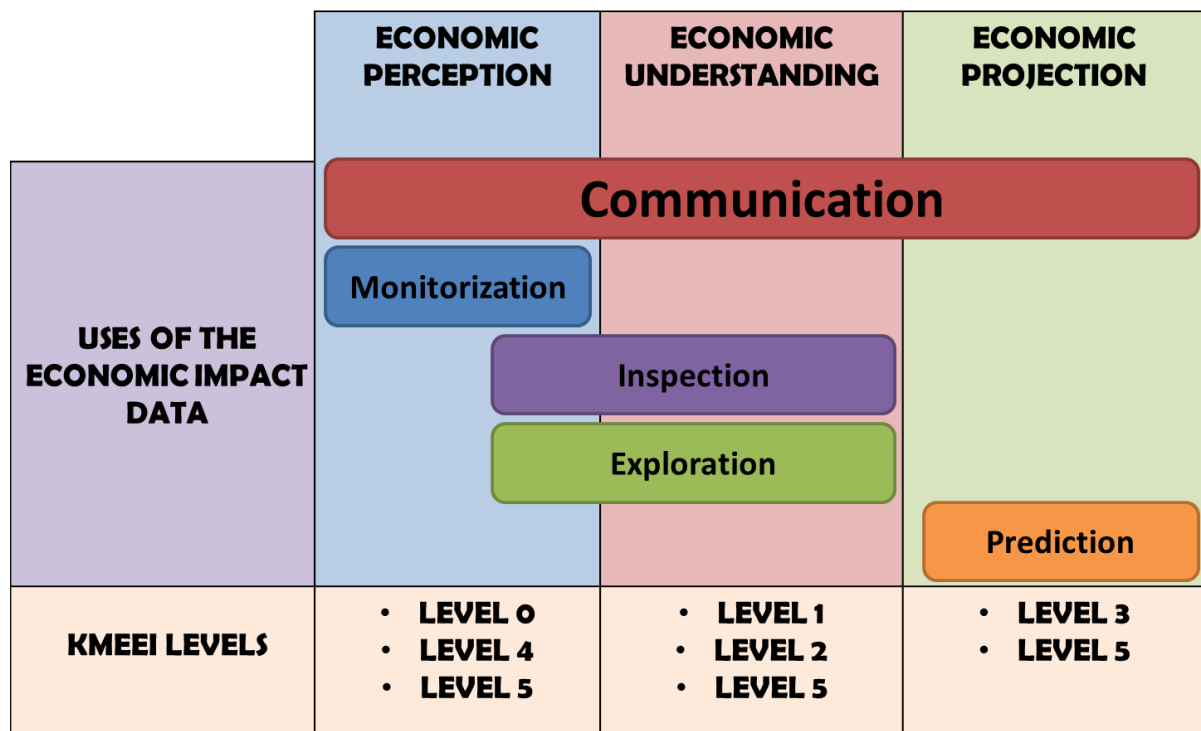
FIGURE 3: TAKING DECISIONS ON KMMEI
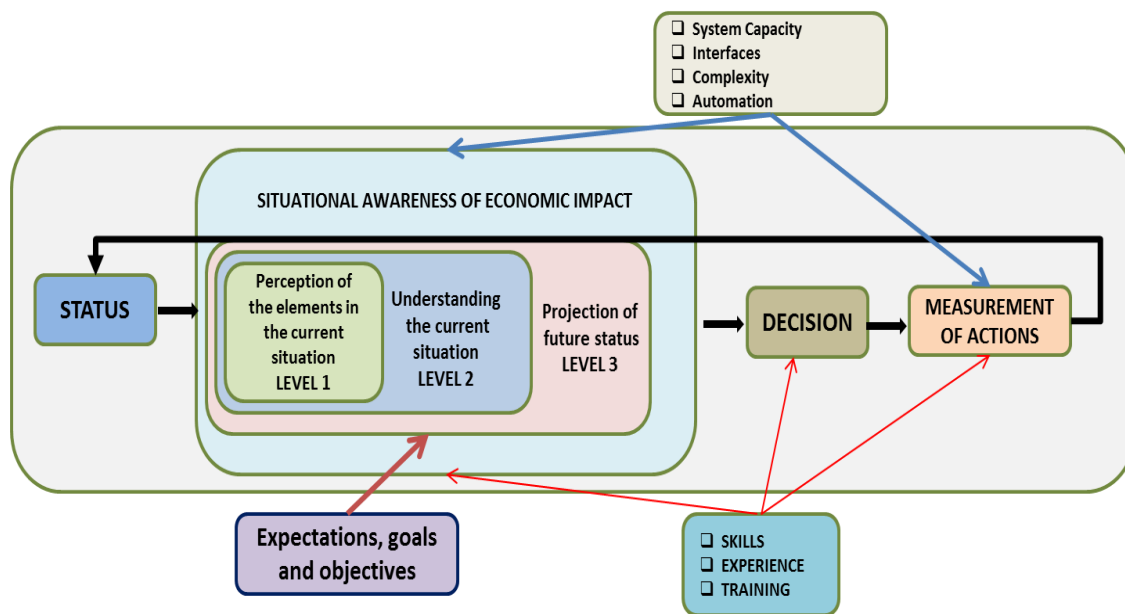
Graphical representations of the data in our case are performed using colour, shape, position, size or other proprietary graphics that can encode information. The idea is, based on some data from a high-level abstraction, to get an interactive way to move data from a lower level if necessary to understand what we are shown.

The visualization techniques are designed or selected to align with one or more of the stages or levels of situation awareness: perception, comprehension and projection. These phases refer, respectively, to being aware of the latest data, having a necessary understanding to draw conclusions about the situation in which we find ourselves concerning these data and, finally, trying to predict the future situation in which we will find ourselves based on that information.

There are five major standardized visualization applications in our model, as are shown in the following figure:

- *Monitoring,* which is an ongoing phenomenon in which the data may be in constant flux, as may be the case for the values of exchange rates for currency notes.
- *Inspection,* in which the analyst seeks specific details request clarification and finds data that allow him/her to test hypotheses.
- *Exploration,* where a thorough, free study of the data is performed, is investigated without previous tracking and the data are combined in a novel way and experienced interactively with views of the data, finding regions of interest for analysis and new hypotheses are generated.
- *Prediction,* in which, we either try to find the most likely future state assuming the current progression will continue if there is no intervention, or determine a particular future state based on potential action plans and
- *Communication,* in which all data are presented to third parties, the reports are made, or activities are presented.

FIGURE 4: VISUALIZATION CONCEPTS ON KMMEI

USES OF THE ECONOMIC IMPACT DATA	ECONOMIC PERCEPTION	ECONOMIC UNDERSTANDING	ECONOMIC PROJECTION
	Communication		
	Monitorization		
		Inspection	
		Exploration	
			Prediction
KMEEI LEVELS	• LEVEL 0 • LEVEL 4 • LEVEL 5	• LEVEL 1 • LEVEL 2 • LEVEL 5	• LEVEL 3 • LEVEL 5

4. CASE STUDY IN THE AERONAUTICAL SECTOR AND THE DEFENSE AREA

The Defense Industry is of strategic importance to the state. Defense and its associate activities represent 1.9% of total employment in the Spanish economy and more than half of Defense demand is directed toward high-technology and knowledge-intensive industries. Defense Programs, in particular the Special Weapons Programs (called PEAs) have accounted for a very important investment in questions of the economy, employment and innovation in research and development in recent years, and it has acted as a domestic tractor industry in a multitude of sectors.

Our case study allows us to analyse the impact of a number of Defense programs on the national economy: the impact on production and employment in strategic sectors of the economy. Using KMMEI it can give us the support for the economic intelligence in the Ministry of Defense, enabling improved decision making. Our case study includes several maintenance programs of the F-18 Aircraft.

The acquisition and maintenance of the F-18 Aircraft has been a reference for both the Ministry of Defense and the Industry Sector since May 1983, when the Council of Ministers decided to acquire the aircraft from the U.S. government. This milestone marks the beginning of an exemplary industrial policy from Defense leading to the current policy of Industrial Cooperation in matters of Defense.

The F18 maintenance programs have had a major economic impact on the Defense Industry in Spain, including the development in the field of simulation, automatic test beds, avionics subsystems, the development of structural aircraft components, the creation of the Logistics Center of Armament and Experimentation (CLAEX), electrical cogeneration power plants, etc.

For our case study we have taken the information from various programs of the F18 aircraft between 2005 and 2010, including acquisition programs´ electronic warfare equipment, installation of aircraft communications, updating the average life or major maintenance programs of the weapon system and others.

The set of programs under study involves great complexity, because it is encompassing procurement technical assistance, consulting, production systems, logistics support, training, construction materials, development of computer and communications systems, electronic equipment development, financial management and many others. In order to be able to use analysis tools provided by the input-output framework incorporated in our model, we have reconstructed the Input- Output Tables for the Spanish economy at KMEEI level zero (corresponding to the inputs, sources and sensors slightly modified) to incorporate and tailor individually the investment program under study.

The decoupling is done at level one of the general government sector, as in our case this field of defense is not individualized in the original tables (from the sources obtained at level zero, corresponding to information from the National Institute of Statistics). The ultimate goal at level five (which corresponds to the final output interfaces for the analysts) is to convert the case under study into an industry in itself, allowing us to carry out a rigorous analysis to measure the program's relationship with other sectors of the economy and the dependence of these on the program.

Our model allows us, from this level, not only to measure the weight of the defense program on the economy, but also to show their relationships with other sectors through trade with them. The input-output table is modified at level 1 (corresponding to the interfaces of our system, matrix calculations and simulations). From level 2, we will be able to show, first, which sectors this program is sold to, and what quantity is sold. That is, who your customers are and how important each one is. And, conversely, what sectors do you buy from and what amounts, or who your suppliers are and how important.

This detailed information would allow us to calculate the effects of the program, both directly and indirectly on other sectors of the economy. The symmetric input-output table of 2005 of the Spanish economy is used as the initial data source. In this table, Defense appears on the aggregate service sector in Public Administration. Therefore, to include a program as another sector of the economy, this breakdown will be required at level 1. Allocation of the program sales will not be necessary as, being a public service sector, they do not exist as such and thus this layer in our case is not used. In the case of inputs or intermediate consumption data program purchases of goods and services will be used.

From the knowledge of the production processes of each sector and their relations (the input-output table modified at level 1), the analysis carried out with the model consists of calculating the whole chain of effects that the activity has on a sector or company. Thus, you can transform the economic activity of a company (or sector of the economy) into a greater supply and increased demand for various sectors. These, in turn, demand more goods and services from everyone else, while recipients of supply increase production, carrying out a succession of cross effects which can be measured by combining the information with input-output matrix algebra, which is implemented in detail at level 2. From this level, our system enables us to reach an expression that calculates the total effect and also can be decomposed into the direct, indirect and induced effects described below.

The direct effect involves the injection of resources which the Defense programs we are studying contribute to the national economy. This amount is used to calculate the so-called cross effects (the sum of the indirect effect and the induced effect), which are also carried out at level 2. The indirect effect is composed of various amounts arising from the relationship among the productive sectors. On the one hand, the effect of the program´s activity on the sectors of the Spanish economy with which it has a direct relationship is quantified, in what is called indirect dependent effect. One of the objectives is to measure the production in other sectors and it is intended to meet the demand for goods and services of the program under study. On the other hand, the sectors directly benefiting from the activity (purchases and sales) that the program generates, in turn, have a number of indirect effects. In terms of suppliers, to produce what they require they buy more from their own suppliers who, in turn, also generate new demand in the economy. And on the side of the customers; increased supply of goods and services benefit all sectors who buy these customers and so on.

One of our first goals was to obtain from our model both the direct effect and the indirect effect to make it visible on level five of the KMMEI. The direct effect will be to the output generated by the program in the Spanish economy. The indirect effect will be produced by the expenditure necessary to carry out the activities of the sectors directly affected, and the necessary expenses of other economic sectors generated by all the chain reactions caused by the program. These reactions come from the economic interrelationships between the originally affected sectors and other economic sectors. In addition to these effects, there is one more: the induced effect, which is that caused by the increased consumption generated by growth in employment.

Using the model proposed we find at level five, for the case study, that the highest impact on production is produced in the years 2005 and 2006, where large investments mainly in the program group update half-life were performed, reaching numbers over hundred million euros, as can be seen in Figure 1. Overall, including the impact on production of all the years considered in our case study and all programs, the total impact on production has been 627.56 million Euros.

GRAPHIC 1: PRODUCTION IMPACT OF THE STUDY
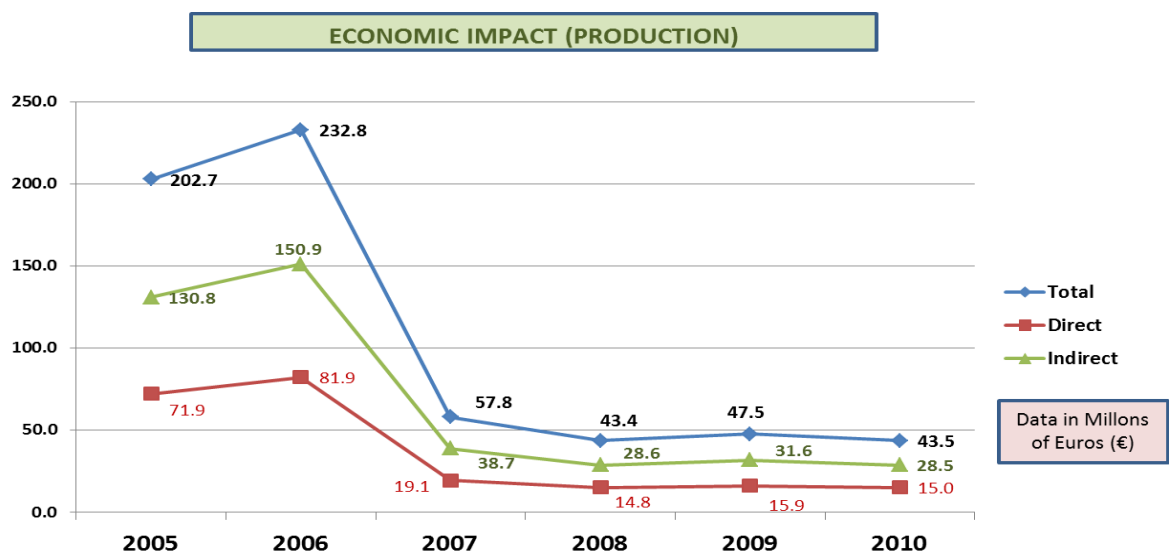
Source: obtained from the KMEEI level 5.

In addition, the second objective of the application of our model to the case study was to obtain from level two of the corresponding data obtained on employment, both directly and indirectly. Level five allows us to obtain the corresponding graphs, as shown in Figure 2.

As can be seen from the data obtained at level five, in global terms, including the impact on employment of all the years considered in our case study and all programs, the overall impact has been of 3,887 jobs, 1,167 corresponding 2,720 direct and indirect impact to impact.

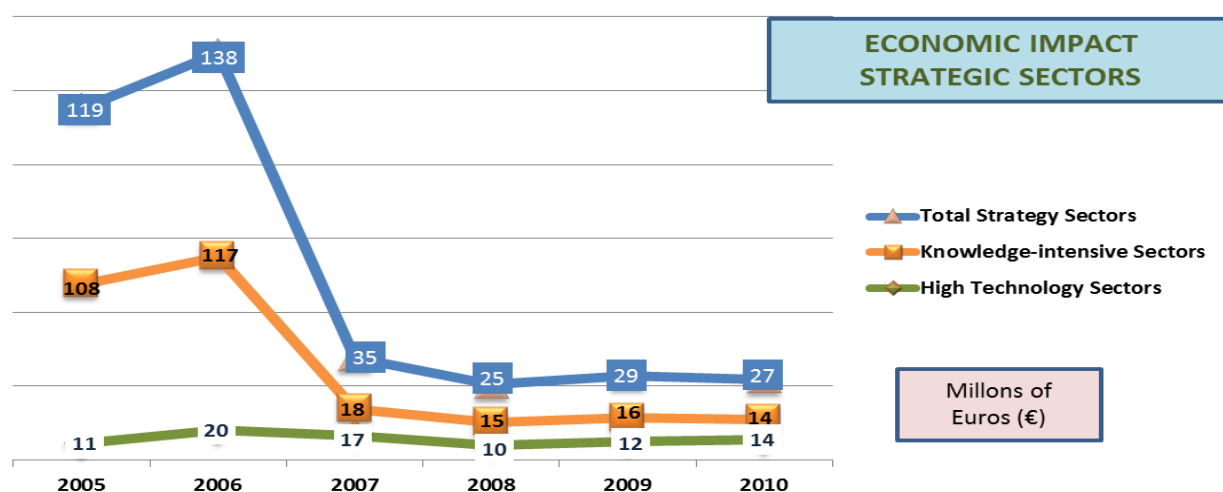GRAPHIC 2: EMPLOYMENT IMPACT OF THE STUDY
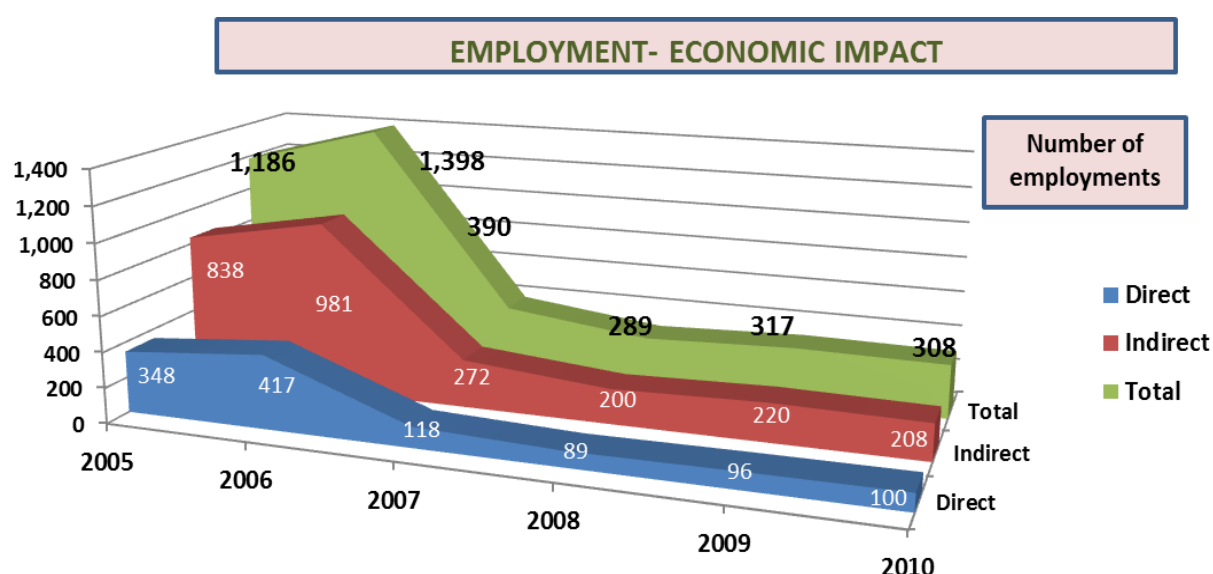
Source: obtained from the KMEEI level 5.

Another aspect analysed in our model has been to address the importance of both high-tech industries and intensive sectors in the use of guided directed demand, as defined by the Organization for Economic Cooperation and Development (OECD). From this information, we make our partnership level one of the sectors in our input output table and on level two perform the calculations necessary for this impact by making use of the mathematical model implemented in level two.

Level five of our model allows us to obtain the appropriate data that can be viewed by the analysts. Thus, the impact on production in these strategic sectors can be visualized in Figure 3, which is obtained from the information system supporting the KMMEI model. You can also check from the same interface that the impact has been in terms of employment in these sectors, shown in detail in Figure 4.

As can be seen, for our case study, the overall impact on these strategic sectors, which are high-tech and knowledge-intensive has been 372,89 million euro and 1,553 jobs. This indicates the strategic importance of such programs.

GRAPHIC 3: PRODUCTION IMPACT OF THE STUDY IN STRATEGIC SECTORS

Source: obtained from the KMEEI level 5.

GRAPHIC 4: EMPLOYMENT IMPACT OF THE STUDY IN STRATEGIC SECTORS
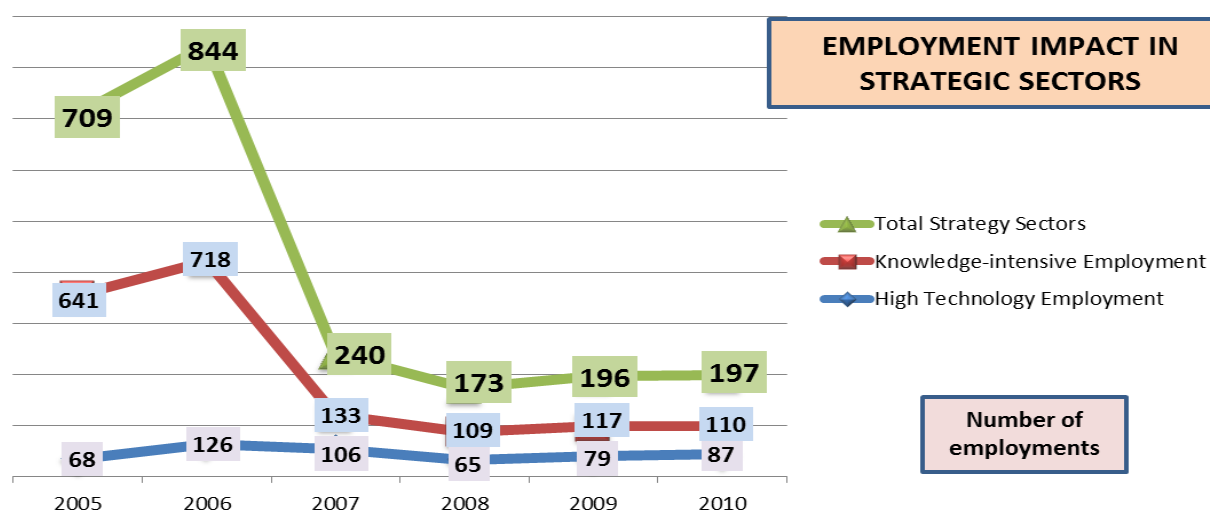
Source: obtained from the KMEEI level 5.

To make use of our model we match various hypotheses that have allowed a basic development at levels 3 and 4 of the model (predictive models and mechanisms for updating and maintaining the sensors) because although the scope of the study includes data corresponding to various annual payments, we only used as comparative use the input-output tables of 2005. All calculations are based on the year 2005 which was the year for our case study.

An equally important aspect to consider is that all calculations for the economic impact are performed at level two on spending programs executed and not the budgeted expenditure, in order to obtain the real economic impact of the programs under study. This part is considered in the KMMEI model within Level 3, which allows us to make predictions of economic impact based on budget and to make comparisons with respect to the actual execution of such investments.

Some of the simplified interfaces in our support information system for the KMMEI model are shown here, where we can observe the different functions from a common graphical interface that allows analysts to interact with different levels of the model.

The following Figure 5 shows the zero level, where the analyst can get the data from the different investment programs and the source data of the National Statistics Institute, the information corresponding to the input-output framework and segregated information of general government sector and the Department of Defense.

The system has an interface that allows access and editing of this information. In the next figure some data and graphs available in real time can be observed. In addition, due to increase friendliness of the application in the main graphic interfaces KMMEI scheme shown and the level where we are, as can be seen in the figure to the right of the interface corresponding to the zero level.

FIGURE 5: INTERFACES OF THE SYSTEM SUPPORTING KMMEI LEVEL 0.
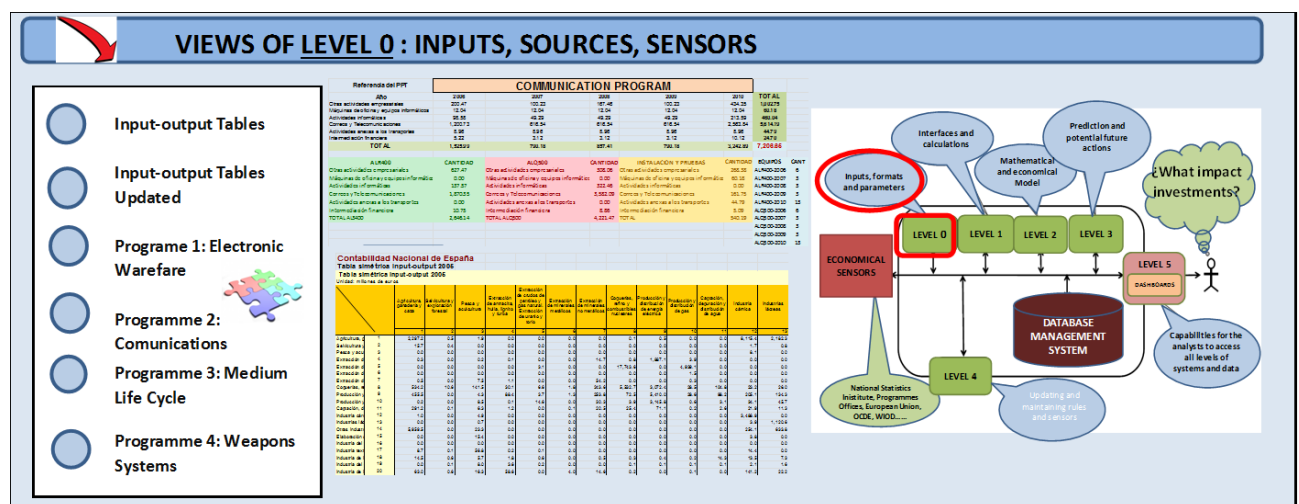
From the interfaces corresponding to level one the analysts can view and edit further details such as the technical coefficients, the intermediate matrices for simulations or aggregated for each year of investment inputs. With regard to support interfaces to level two, the system allows the visualization of data from the specific application of the input-output framework and the mathematical model simulated at this level, such as multipliers or demand vectors.

The interface supporting each of the levels obtains all in a graphic and user-friendly form for the analyst and are all built on level five, from where the users can see the final graphics, as the Figures 1-4. In each of the interfaces, the level corresponding to the KMMEI model has been included in order to facilitate understanding of the overall process for non-advanced users of the system such as the managers or the Project or Programme Managers.

FIGURE 6: INTERFACES OF THE SYSTEM SUPPORTING KMMEI LEVELS 1 AND 2.
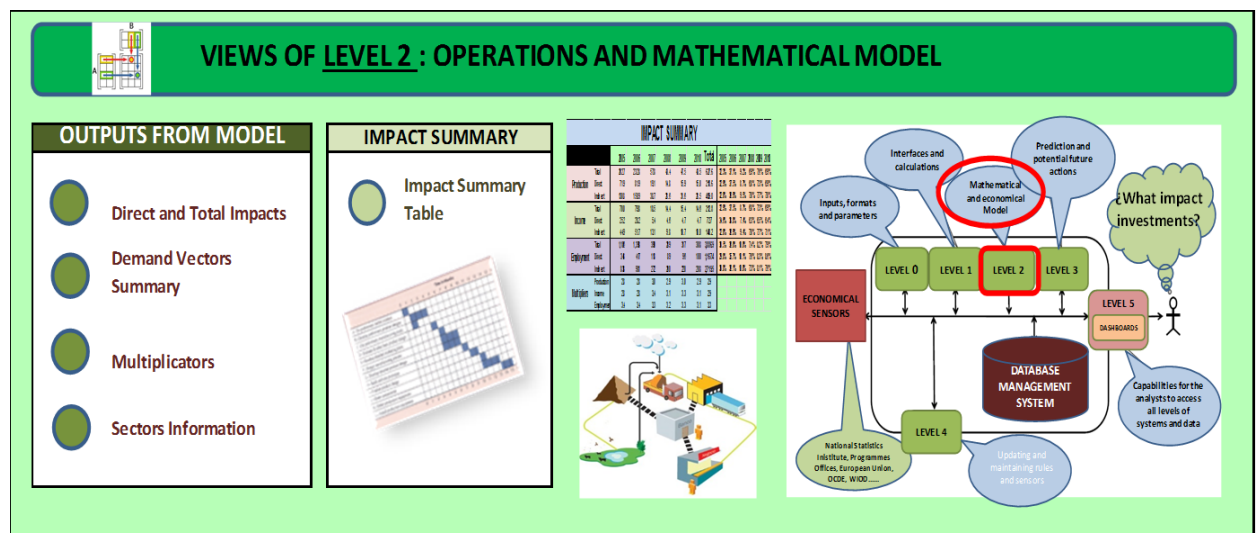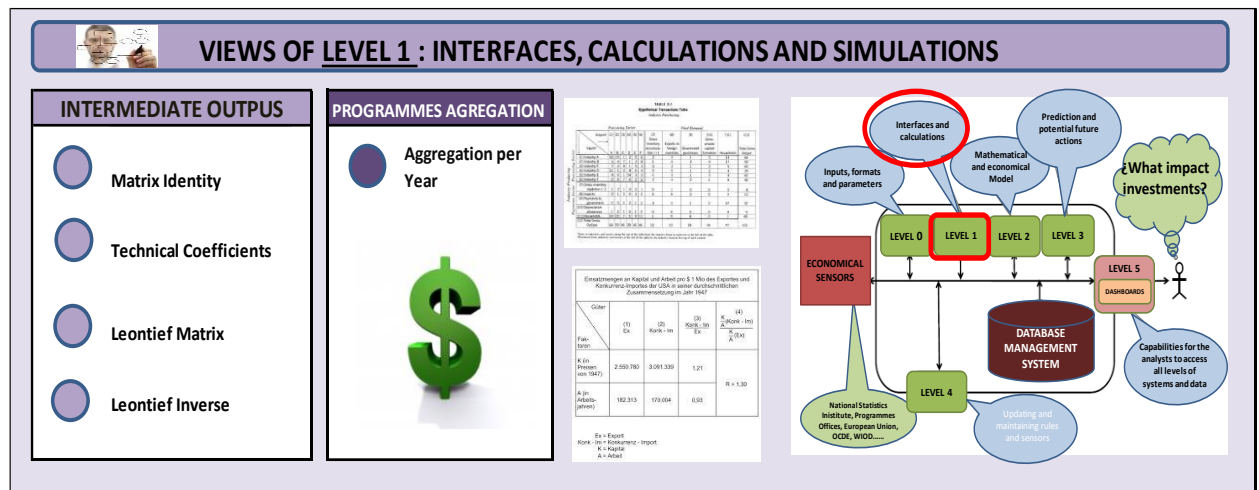
5. CONCLUSIONS

In order to provide better tools for economic management of a public entity, the paper proposes a model of knowledge management called KMMEI (Knowledge Management Model for the Economic Impact), giving the economic impact of public investments. This model is based on the latest trends in knowledge management and the input-output framework.

As a necessary complement to this model, the paper describes the development of an information system that supports this model. This information system uses a technology architecture that allows the interactions from different sources of information. The system obtains the impacts of investments and makes certain economic predictions. Through the integration of this model with a decision scheme presented in this paper, organizations can make use of these techniques and tools to know the status of their investments and the economic impacts involved.

As a case study the model has been used in the defense sector. The findings of this study highlight that the investments in the field of defense have an economic impact of great importance and are focused on key sectors of the economy. The set

of programs involves a great complexity, because it encompasses procurement including technical assistance, consulting, production systems, logistics support, training, construction of materials, development of computer and communications systems, electronic equipment development, financial arrangements and others.

Our model has allowed a detailed analysis of such investments in defense, and obtained both the direct effect and the indirect effect of the programs under study and its impact on key sectors of the economy and employment. The overall impact has been of 3,887 jobs during the six years covered by the study presented in this paper and the overall impact on production has been 627.56 million Euros; relative to the total impact on strategic sectors, high technology and knowledge-intensive, has been 372.89 million euro and 1,553 jobs, which indicates the strategic importance of such programs.

Both the model developed and the information system, although they have been used in a particular case in the field of defense, can be extrapolated to other problems of economic knowledge management of any entity. All these conclusions have allowed us not only the implementation of our model, but also offer interesting data in decision -making within the umbrella of governance programs.

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