

UVa

Agent Based Modeling Engineering Complex Systems

Business and Project Management Organisational Cybernetics

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INSISOC is an Excellence Research Group of Castilla y León (GREX 251, 2004) and has passed the evaluation as a Consolidated Research Unit (UIC 086). Its members are located at University of Valladolid and University of Burgos (Spain).

Our interests are focused on the study of **complex systems**. We have applied different methods to characterize complexity in different research fields.

The study of complex physical and social systems requires a multidisciplinary approach that integrates various inputs from economics, sociology, engineering, geography, etc. Moreover, the methodologies developed in recent years on artificial intelligence and within the field of systems thinking allows to construct models to help understand complex systems.

With this approach and under the name **InSiSoc Group**, a group of professors at the University of Valladolid, have been developing research work from the second half of the '90s. His work has been reflected in numerous publications in prestigious journals, also participate in various research projects nationally and internationally.

Years of research looking for excellence in the treatment of complexity in Project Management, Institutional Design, Environmental policies related with water management and/or CO_2 emissions, artificial financial markets, industrial policy, supply chain management and intelligent manufacturing; endorse our advances in complexity studies. We have contributed interesting results throughout competitive successful research projects and main journals and publications.

INSISOC has been pioneered in the design of mechanisms that enable agents interactions in simulated models of complex systems. By this way, we have "engineered" the emerging behaviour of the system we study in a generative way ("the third way"). These results provided the basis to name our group: Social Systems Engineering Centre.

Our purpose of study and research are complex systems. Applying techniques and tools to pursue treatment of the complexity characterizing and modeling the aggregate behavior of the system under study.

We benefited from artificial intelligence, multiagent systems, experimental economics, system dynamics, cybernetics, and the generative approach from simulation to complex systems. We consider that the most powerful "tool" to apply in complex systems research is the consilient approach: Engineers, economists, sociologists, philosophers, geographers... are welcome to join, whenever they are interested in:

- Designing of market institutions.
- Bargaining.
- Industry dynamics and policy.
- Project Management.
- Experimental economics.
- Learning and organisational change.
- Agent based modeling.
- Study of negotiation processes.



INSISOC also hosts the **post-graduate Master in Project Management** (since 2005, Official at University of Valladolid since 2018), and the **International Construction and Engineering Project Management Workshop (CEPMaW)**.

More detailed information may be found on our website.

www.insisoc.org

Feel free to contact us, we'll really appreciate your interest.

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Complex Social Systems

Research in Complex Social Systems needs an integrative approach from Engineering, Social Sciences and Management. Agent Based Modeling and Agent Based Social Simulation provide the framework we have adopted to deal with complex systems. Our main interests are:

- Industrial organization: the study of strategic interactions of competing/cooperating firms or agents in different market and regulatory frameworks. This line can provide decision support on issues such as pricing, advertisement, product lines, target quality, response to competitors, alliances or market regulation. These studies are often carried out combining (agent-based) simulation with (evolutionary) game theory and network theory.
- Enterprise Complex Systems: Governance. Learning and organisational change.
- Policy Rehearsal and Industry Dynamics.
- Artificial Economics: Market institutions. Auctions.
- Artificial intelligence: learning algorithms

Agent Based Modeling and Agent Based Simulation

Agent based simulations provide a new and exciting avenue. Researches and advisers can compare and explore alternative scenarios and institutional arrangements to evaluate the consequences of policy actions in terms of economic, social and ecological impacts. But as a new field it demands from the modellers a great deal of creativeness, expertise and "wise choice".

Agent based Modeling allows us to study the interactions between the individuals and the institutions. The simulation is focused in the dynamics of the processes, more than in the existence of equilibrium. Out of equilibrium dynamics are far more interesting than static equilibrium into which the system could be finally absorbed. Transients are no more difficult to study than equilibria. Agent-agent and agent-environment interactions are at the core of the approach according to simple local rules, dispensing of ex-ante "super-agents" to assure the emergence of equilibrium patterns. Space is distinct from the agent population in contrast with the differential equation models. The agents are heterogeneous and truly individualistic, whereas in mechanistic models one has to assume group behaviour to make the models analytically tractable. They compete in rigour with mechanistic modeling. If the programme is based upon production rules, it will be as internally consistent as it is the logic used. If it is not, it can be checked for internal consistency, before feeding it with the actual model.

We provide an introductory online tutorial in a public blog available at

https://sites.google.com/site/manualnetlogo/

Project Management

The Research in Project Management is focused on the development of new methodologies and techniques to design monitor and evaluate project oriented organizations. In particular, our interests are:

- Project Based Organisations.
- Business Administration. Value. Stakeholders. Governance. Project Management Office.
- Portfolio and Program Management. Control and monitoring.
 Program Management Office. Multiproject Management.
- Risk Management.
- Training and education in Project Management.

System Thinking and Organisational Cybernetics

The main lines of research within the area of systems thinking are:

- The Application of System Dynamics and Organisational Cybernetics to the study of Complex Systems.
- To develop software tools to facilitate the systematic application of different methodologies (VSMod®, Team Syntegrity, System Dynamics, VSMM, etc.).
- To develop software applications to capture and represent knowledge (CoI-KCap) and online Delphi studies (Interdelphi).
- To develop software for information exchange and communication through the Internet (Collaborative Networks, Iberfora, etc.).



Social Systems Engineering Group University of Valladolid & University of Burgos (Spain) INSISOC SOCIAL SYSTEMS ENGINEERING CENTRE

 To produce Internet-based tools for information dissemination (Navegador Colón) or for the creation of university networks in specific fields (universities of Brazil, Portugal and Spain from the Tordesillas Group) to promote collaboration in science and technology (Tordesillas Group).

Also this group has been particularly active in using some of the tools described above for networking and research collaboration in academia (national and international). As an example of some of the established networks of special relevance to mention the Red lberfora (www.iberfora2000.org), the official website of the Ministry of Foreign Affairs, Spanish Agency of International Collaboration on the provision of postgraduate studies in Spain (www.buscadorcolon.org), the network of Organisational Cybernetics (www.platformforchange.org) or the Network of systems thinking (www.redtemps.net)

It should also highlight the extensive involvement in research projects both domestic and international, such as REDTEMS (Systemic Thinking Network) from the MCyT or IBERFORO (A model system for the exchange of information and decision making) from the CICYT, or "Management Systems and Cybernetics (Msc)" and "Computer Based Modeling, Simulation and Graphic Representation Of Technology Innovation Networks", both from the European Commission.



ACCESS

Application of Agent-Based Computational Economics to Strategic Slot Allocation

ACCESS (Application of Agent-Based Computational Economics to Strategic Slot Allocation) was a research project within SESAR WPE Long Term and Innovative Research which addresses the problem of airport slot allocation from the perspective of complex adaptive systems.

Due to the complexity of the **combinatorial assignment problems** underlying primary slot auctioning and secondary slot trading, agent-based computational economics provided a particularly suitable framework to undertake a rigorous and formal study of different alternatives for **market design**, allowing the **modelling and exploration of features** —such as bounded rationality, evolutionary behaviour or asymmetry of information that were not properly captured by classical approaches from economics and operations research.



INSISOC provided its know-how in agent-based modelling and simulation, auction theory, game theory and evolutionary learning. We analysed, designed, modelled and simulated market mechanisms for the slot allocation problem.

INSISOC led several work packages, and supported the execution of simulations. We also participated in dissemination activities.



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INSISOC's PORTFOLIO

ABARNET

Algorithms Based on Artificial Agents to optimize the capacity of Railway Networks

In a context of liberalization of the Spanish rail sector, the objective of the project is to investigate and develop **new** methodologies for the allocation of sections and hours of use of roads between the operating companies of the system. In particular, the suitability of using combinatorial auctions is studied along with agent based modelling methodologies.

The main deliverable is a **pilot model of combinatorial auction** applied to a sample of lines of the Spanish railway network, and a set of recommendations, derived from the simulation of different scenarios, of how **to design the allocation process**.

The project lasts 3 years with extension. The achievement of the objectives of the project involves substantive and objective **innovations in the area of capacity allocation in the railway sector**, as there are not in reality sufficiently satisfactory models that integrate the complexity of real constraints and conditioning of the railway system. The challenge of the project is to show that by means of agent based modelling, this complexity can be incorporated.

The project team consist of **9 people** who integrate experience and youth. It has extensive research **experience in agent based modelling and combinatorial auctions**, having participated in projects to assign capacities in airports and in resource allocation in multiproject environments.

The project has as **interested companies ADIF** (the manager of the railway infrastructures in Spain) and **2it Ingeniería** (consulting company in the field of railway infrastructures).







Change of tion mechani

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Add more constraints

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YES

Is it to add r

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WDP WDP time NO

Simulation

VES IS



https://www.insisoc.org/index.php/ins-abarnet-home/

2005 - 2008 SIGAME

Agent-based Simulator for Water Management in Metropolitan Scenarios

The main challenge in water management has traditionally consisted of ensuring the fulfillment of a certain, preset, demand of water with an often insufficient water supply. As such, domestic water management has been historically focused on supply side policies. Nowadays there is an increasing awareness that a wide range of socio-economic factor play an influential and important role in urban water use, and also that these factors may be somewhat shaped and harnessed to design and implement better policies.

Through this project, sponsored with Regional Administration funds, we applied the **combination of agent-based modeling and simulation** to deal with the complexity derived from multiple factors with influence in the **domestic water management in emergent metropolitan areas**.

Different social submodels, models of urban dynamics, water consumption and technological and opinion diffusion, were adapted and integrated in an agent-based model, which was linked with a geographic information system (GIS).

The result was a **computational environment** that enables **simulating and comparing** various water demand scenarios. During this project, it was particularized for Valladolid metropolitan area (Spain), and it was shown an accurate prediction capability by this tool, which may be adapted to any other case or even to a more general domain (e.g. Smart Grids).







SIMULPAST

Social and environmental transitions: Simulating the past to understand human behaviour

SimulPast was a five-year interdisciplinary research project started in January 2011 and funded by the **Spanish Ministry** for Science and Innovation (CSD2010-00034) within the framework of **CONSOLIDER-INGENIO 2010**, part of the Spanish National Program for Fundamental Research.

The aim of the project was to develop an innovative and interdisciplinary methodological framework to **model and simulate ancient societies and their relationship with environmental transformations**.

The project included 11 Research Groups from 7 different Institutions with more than **60 researchers from several fields** (archaeology, anthropology, computer science, environmental studies, physics, mathematics and sociology). The leader institution was the IMF-CSIC in Barcelona.

The combination of archaeological data (including environmental and climatic data), together with the **supercomputer-based feedback process** was the most powerful approach for methodological development in social simulation. The strength of this approach was the feedback loop: the constant update of the starting hypothesis and the subsequent formalized models as they are applied to specific case studies.





Agent-based Simulator for Water Management

This project was useful to compare the features of two wellknown ABSS platforms: **SDML** and **Repast**. Based on our previous experience in financial and water resources management modeling, using SDML, Swarm and Repast, we presented a **general framework** that provides guidelines for replication and consistency analysis in **social simulation**.



FIRMA Freshwater Integrated Resource Management with Agents

The aim of the project, funded by the European Commission in FP V, was to improve water resource planning through the use of multi-agent models that integrated physical, hydrological, cognitive, social and economic aspects of water resource management. This task was specified through specific objectives:

- Promote co-operation between water resource decision makers and experts in water resource management and in agent-based social simulation.
- Ānalyze hydro-social issues of waste water treatment, water scarcity and integrated catchment planning in selected regions, and assemble the data required to develop agentbased models for these applications.
- Carry out participatory integrated assessments in five selected regions. Compare the management of water and develop methodology for the agent-based simulation of water resource issues in Europe based on experiences.

Our main results were:

- Regional application reports about water resource policy issues in each case study area.
- Regional models, software, role-playing games and documentation.
- Synthesis of modeling methods: guidelines for participatory agent-based integrated modeling.



http://cfpm.org/firma/

The project aimed to develop a **managed market**, using **combinatorial auctions**, where to acquire products made with **3D printing** (additive manufacturing technologies).

This market facilitated the organization and coordination of collaborative offers among customers to receive bids from manufacturers or 3D printing service providers.

First, this market allowed customers to obtain better prices from the manufacturers. On the other hand, manufacturers could optimize their installed production capacity, and they could reduce the operating costs in each case, and depending on the technology. start-up, energy, etc.

3D printing is a set of manufacturing technologies within the socalled **Industry 4.0. The market for 3D printing products was not sufficiently well developed.** When a private or company was interested in obtaining a product by means of 3D printing, it should **look for** potential suppliers **in repositories** (e.g., www.3dhubs.com), select among different suppliers (e.g., www.shapeways.com, www.sculpteo.com), or resort to marketplaces (e.g., www.imaterialise.com). They could also use **local 3D printing services**, which did not always have the necessary technology neither were they competitive, to ask for offers.



In all cases, they should refer to the technical documentation by means that **did not guarantee neither confidentiality nor intellectual property** of the product to be manufactured. This limited the possibility of obtaining good prices, of making a comparison between the different offers and also **limited the competitiveness** and the sources of advantages for the final users of additive manufacturing technologies.

The research group has more than 15 years of experience in "auction development" and "market institutions". This is confirmed by the latest projects financed in European and national competitive calls, in which the mechanisms to build an airport slots market (European SESAR funding) and the slots on a railway line (National Plan) have been designed. Work has also been carried out on the liberalization of the electricity market, emission rights, financial markets, etc. On the other hand, It has participated in several research contracts on printing3D and industry 4.0, and also in a European project to develop services of Digital Company and Digital Supply Chain with Impression3D with the company DIMA3D S.L. (FIL3D project).



LONJABD Lonja de Impresión 3D para la Industria 4.0 y la Empresa Digital Ref.: VA049P17

Engineering

https://lonja3d.com/

Junta de Castilla y León

INSISOC participated in this project as a subcontract of **DIMA3D**. DIMA 3D S.L is a firm devoted to manufacture 3D printers and provide 3D printing added value services.

The objective of this project was to provide the spare parts industry with an **open platform** to support a paradigm shift to a Digital Supply Chain (DSC) where a "virtual stock" was 3D-printed on demand by local producers.

The core of this platform is a FIWARE-enabled service that covers the whole logistics chain by **integrating all the actors involved**: big industrial manufacturers (IPR owners), local manufacturers/dealers and customers. It incorporates Generic and Specific FIWARE Enablers, leveraging assets from the FITMAN platform.

The service works as follows:

i) Customers order the parts they need using the platform.
 ii) The system searches and processes the required 3D models in

 a Database (taking into account Intellectual Property Rights, IPR).
 iii) The job is assigned to the chosen certified local 3D printer,
 which prints and delivers the order.

These factors **reduce the cost** associated to the spare parts activities, generating savings for industry and customers, and improving the **quality of the service** delivered.





2010 - 2012 **CivPro** Regional Strategies for Disaster Prevention

Over the last few years, many regions in Europe have suffered from **natural and man-made disasters** such as forest fires, floods and droughts. Their devastating effects on citizens' lives, environment and economy have led European, national and regional authorities dealing with **Civil Protection** to strongly focus on response and recovery measures. However, there is also a need for more actions and efforts on **disaster prevention strategies**.

The CivPro project, which brought together **12 partners from 11 EU countries**, was designed to respond to this need. The overall objective was twofold. First, it aimed to improve the **coordination** and effectiveness of regional policies **in preventing disasters** and mitigating their consequences. Second, the partnership wished to further **develop instruments** and establish modalities to strengthen the link between disaster prevention and crisis management.

The partnership was exchanging experiences, know-how and good practices on risk mapping, early warning systems, risk screening models and awareness-raising policies. Partners were also working on the development of a strategic approach to prevent and reduce any potential threat and damages resulting from natural calamities and man-made disasters. Overall policy recommendations and tailor-made local/regional Disaster Prevention Policy Plans developed on the basis of a pre-defined model tested at regional level were the final aim and challenge of the CivPro cooperation.



In this project we dealt with the shop floor control problem in job shop manufacturing systems based on multi-agent systems. The application of these techniques to production management

Distributed Control of Job Shop Manufacturing

Systems Through Multiagent Systems

The application of these techniques to production management produced an important methodological advance providing intelligent decision support systems. Thus, modern organizations could exploit the benefits of current information technologies and to improve the performance of business organizations.

The increase in efficiency of shop floor control is a very important task within the manufacturing process. As consequence of the growing competitiveness, speed and reliability in product delivery is essential, especially if this has to be done without any influence in cost and quality of the final product.

Shop floor control affects to the good working order of the system as a whole, and hence relatively small improvements could result in very important global savings. We had to keep in mind that the difficulty in the design of these control systems was highest when we faced with flexible job shop configurations. This was due to the **computational complexity of operations scheduling** in this plant configuration, together with the instability of the conditions in which these systems work.



2011

The aim of this project was to justify and to illustrate with two case studies the use of **agent-based modeling** (ABM) as a modeling tool for domestic water management in metropolitan regions.

As opposed to traditional water planning models, which are usually based in consumption projections and supply-side policies, there is a growing agreement on the need to include a higher diversity of factors in the models, especially socioeconomic aspects, and to study natural resource models in an integrated fashion.

From a theoretical point of view, agent-based modeling offers a set of features that make it an especially **suitable methodology** to be used in this domain. This work revises the main advantages of this methodology and illustrates its practical application through **two real cases**: the **FIRMABAR** model (López-Paredes, A, Saurí, D., & Galán, J. M. 2005), designed to study domestic water management in the **Barcelona Metropolitan Region**, and the planned adaptation process of this model to the **Valladolid Metropolitan Region**, which is currently being carried out.

In this project we have underlined the practical importance and relevance of a **spreading field of research**: agent based modeling and simulation. In our opinion, using this methodology instead of other traditional modeling methods is justified by its realistic and intuitive computational representation of social phenomena, based on the direct correspondence between the entities we observe and the model we are studying. This approach permits building small computational laboratories to get a deeper understanding of the studied real systems.

This modeling approach facilitates a detailed representation of the individual participants in the system, capturing their heterogeneity and representing social processes with realism; it also allows the explicit representation of the space and the local interactions between agents. However, modelers have to pay a price for this series of advantages: agent based models are often analytically intractable and it is necessary to turn to simulation to study their behavior. We have also underlined the possibilities of ABM to allow an interdisciplinary approach to model development and to integrate participatory processes with stakeholders. These two features, together with the current scientific agreement on the need of an integrated study of environmental issues (incorporating the human dimension to the physical and technological ones) make ABM especially suitable to be used as a modeling tool for water management.

We have presented a concise outline of two agent based models for urban water management. The first one was developed for the Barcelona Metropolitan Area and is made up of two linked submodels, the territorial and the social model, implemented with Java-Swarm over cellular automata.

The second model substitutes a coarse grain abstraction of the region by a VisualMap GIS integrated with RePast libraries. **GIS/ABM coupled techniques** have a huge potential not only for exploring individual behaviors and their associated environments but for support assisting policy makers tools.



SiCoSSys

Agent-based Tools for Modeling and Simulation of Complex Social Systems

The goal of this project was to provide a well-sound methodological framework for the treatment of complexity by policy makers and social scientists, endowed with an updated theoretical body of knowledge, a set of tools that would enable scenario simulation, and a collection of case studies to guide and demonstrate the applicability of the framework. This framework was based on agent-oriented modeling and simulation methods and tools.

Agent oriented modeling provided a conceptual framework for analysis and simulation of complex social systems. This came from the fact that agent related concepts allowed the representation of organisational and behavioural aspects of individuals in a society and their interactions. This motivated in the last years the development of a wide range of software languages, shells and libraries to simulate agent-based models.

However, all presented two difficulties for being widely accepted by social scientists: the end-user should have certain programming skills, and these software frameworks had been implemented forgetting the social specifications.

INSISOC gathered its wide experience in the application of agent-based simulation tools for the study of complex social systems in order to define the scientific method for the analysis of social phenomena and policy making.



SiCoSSys project produced a set of tools and simulation models of social systems using techniques of agent-based modeling:

• The meta-model editor INGENME

http://ingenme.sourceforge.net

- The systems editor self-managed self-MML
 http://selfmml.sourceforge.net
- The social network simulator Krowdix
 http://sourceforge.net/projects/krowdix/

This was accompanied by a **library of mechanisms for social interaction** ready to reuse, and a **collection of case studies of interest** for both social and computer scientists, which could benefit stakeholders in public administration and EPOs.

Case studies integrated the sociological foundations (developed by UAB) of artificial societies, with a methodology where a modeling framework provided by UCM played a central role.

We also developed models of complex systems that validated SiCoSSys methodology in several application areas: water management, financial markets, changing values in society, social networking, team working, flexible manufacturing systems and emergency management.

The project generated a prolific scientific output: more than 40 articles in journals indexed in JCR, and over 50 international conferences.

This also facilitated the participation in **project consortia** and **networks of excellence** in the Seventh European Research Framework Programme.



http://www.insisoc.org/sicossys/

SPPORT

Computational Models for Strategic Project Portfolio Management

In order to become competitive in a globalized economy, firms needed to define innovative strategies and to translate these strategies into a portfolio of projects. Therefore, **Project Portfolio Management (PPM)** discipline had become more and more important during the last decade.

In this R&D project, we developed computational models to help firms to manage their project portfolios, including project selection, prioritization, portfolio balancing, risk management and also more operative issues like project scheduling, resource allocation and portfolio monitoring.

Mainstream Project Portfolio Management (PPM) models were concerned with project selection and prioritization, in order to align projects with the strategic objectives of the firm. But most of the models did not take into account how those processes were also related to more operational issues, like project scheduling, the influence of external and internal risks, cash flow and resource interactions among projects, etc. In practice, the integration of the strategic and operational dimensions were quite difficult because of the heterogeneity and complexity of the particular situations that could be found in real projects (delays, new projects, strategy changes, etc.)

We dealt with this complexity by means of an innovative bottom-up approach to Project Portfolio Management, so that we could model real complex situations. To this aim, we used **Multi-Agent technologies**.



Therefore, our models integrated both the PPM strategic and operational dimensions, helping managers to take real decisions about the portfolio. The main deliverable of the project was a pilot software implementing the new models.

Project results were useful for firms involved in several projects at the same time, as the models helped them to implement their corporate strategy and to optimize resources allocation.



ABACO-GEMA

Computational Techniques for the Management of Multi-project Environments

The purpose of Project ABACO was to achieve a definitive international scientific recognition in the field we have been encouraging: the paradigm of agent-based models in the analysis and feasibility of complex systems. Emphasis is placed on fundamental research aimed at strengthening INSISOC scientific network connection nationally and internationally. That was consistent with a considerable effort of relationship and network with scientists and experts.

The project had two pillars, corresponding to two national competitive projects: ADAPCOMP and SICOSSYS (Agent-based Tools for Complex Social Systems Modeling and Simulation), both funded by the Ministry of Science and Innovation.

In this project we explored and developed new methodologies for multi-project management environments that exceeded the limitations of previous methodologies.

Specifically, we explored agent-based methodologies (multiagent systems) and programming through the analogy of "combinatorial auction". We also developed substantial improvements in the monitoring and control of multi-project environments. We developed and implemented models that reflect the results of previous research and its results were validated.

It took as its starting point two hypotheses related to the use of distributed computational methods that were eventually confirmed:

- Computer models based on agents are a valid methodology to address the problem of multi-project scheduling environments.
- Models based on the analogy with social and market mechanisms allow modeling the complexity of the problems of "real" multi-project programming.



http://www.insisoc.org/abaco-gema/

Multi-Project Management with Artificial Agents

Project Management has focused fundamentally on the development of tools and methodologies for individual projects. Notwithstanding, firms generally work in multi-project environments, where several projects are simultaneously executed using a common pool of shared and limited resources.

In these contexts, managers should prioritize and select those projects with more added-value to the portfolio, taking into account profits and strategic company objectives but also possible resource and time constraints that could arise in the execution of the projects.

As consequence of new projects, changes in the corporate strategy, or simply the feedback of the system, the list of priorities may vary during time. All these changes may require the reallocation and rescheduling of tasks and resources to improve the performance of the dynamic portfolio.

This project was aimed at developing an intelligent support decision system using artificial intelligence, computational auctions and agent based modeling to help to analyze the workload of resources and the convenience of incorporating new capabilities to the system; This analysis provided insights on the effect of adding or removing projects in a given project portfolio.



Ambidextrous Innovation Strategies & Internal-External Networks

Despite the importance of both kinds of **social capital** and **collaborative networks** and some notable insights provided by existing research from many different perspectives, existing understanding on the phenomenon was still fragmented and incomplete.

In order to contribute to developing a more comprehensive understanding, this research project examined the impact of both kinds of collaborative networks-internal and external social capital- on **innovative ambidextrous strategies** and the innovative performance of firms.

To that end, two relations were analyzed (see figure):

- In Relation 1, we examined the influence of human resource management in the consolidation of internal social capital, in particular, social capital generated among the core employees of the organization and its impact on the innovation capacity of the organization.
- In Relation 2, we studied how strategic R&D alliances can favor the maintenance of external social capital. In particular, we focussed on those collaborative networks established between firms and research and technological centers in order to achieve superior organisational performance in the form of innovation.



In this research project, two different methodologies were used:

- Relation 1 was studied using a quantitative methodology, based on information gathered through a survey on a large sample of innovative Spanish firms (which received financial support from the CDTI in the last years).
- Relation 2 was studied using a qualitative methodology, in particular, the case study methodology focusing on "Dibaq Group as the lead firm of the Acuisost Project- Towards a Sustainable Aquaculture".

The Acuisost Project was a R&D consortium created under the Spanish CENIT Programme, in which multiple firms and research and technological centers take part. In particular, we started with 16 technological centers (universities and others) that collaborate in the consortium and we studied in-depth the collaborative relationship of DIBAQ and CARTIF.



Organisational Cybernetics

2006 - 2010 ADAPCOMP

Multilevel platform to improve the adaptation and learning capacity of social systems in complex environments

The increase in organizations complexity (public and private) has to be faced due to the fast and deep changes of their environments which have put their viability at risk. To cope with this situation, systemic methodologies are required. It is necessary to **unfold the complexity in multiple levels** so it can be handled.

The methodologies are there, but their knowledge and diffusion are still limited. This is one of the reasons why we proposed to build a platform which allows dealing with complexity at different levels, facilitating access to those methodologies as well as communication and exchange of information among the managers and researchers using them.

Some systemic methodologies have developed software which increased their diffusion as well as facilitated their use (eg. System Dynamics with Ithink, Vensim and Powersim software) while others haven't yet. This is the case of Organisational Cybernetics.

This methodology and, in particular, the Viable System Model and Team Syntegrity, are very adequate for the study of complex problems and for decision tanking in multiple levels. Their "recursive" character allows this. For this reason we proposed the creation of specific software to facilitate the application of those methodologies and decision tools. This work was structured in three main modules.

- The first one referred to the construction of a communication and information exchange system to facilitate access to different sources of information (research groups, methodologies, companies, etc.) within the systems thinking field, as well as among the researchers and practitioners.
- The second module consisted of the development of a metatool to allow the loading of different systemic methodologies into it, as well as the posterior use of them by researchers and practitioners. Beer's Viable System Model and Team Syntegrity advanced versions were developed and integrated.
- The third module involved the development of **specific software to facilitate the application** of Organisational Cybernetics, in particular the Viable System Model and Team Syntegrity.

The work was completed with the **integration** of the three modules in a platform which facilitates the study of complex problems, accessible through Internet.

A very effective way to start understanding the dynamic complexity and the need to address business and organisational problems from a systemic point of view, is the **study of a generic system of production-distribution** (the process from the receipt of orders from a retailer to the issuance of orders by the retailer to the wholesaler and from there to the factory responsible for developing the product. The process leading to the delivery of the goods once produced is also examined.

In PRODIS we built a simulation game to facilitate the study of **interactions between supposedly rational decisions made by individuals** (e.g. company directors) and the system they are involved in. It comes to experimentally demonstrate through student participation in the game, how the control of complex systems (in this case a production-distribution system of products in a chain of companies or divisions of companies) is impossible without the understanding of how the whole system is set up, its structure and interrelationships by all of the decision makers.

The structure for this system has been incorporated into the business game known as **'Beergame**'. This is a game generally used with students of Alfred Loan School of Business Administration from MIT, London Business Schooland many other business schools, while in non-electronic form, which requires a small number of students (5 to 12 people) not to become unmanageable.

Overcoming this limitation was the aim of PRODIS. We developed a version of the game which can be used through personal computers in local networks (Intranet) or through Internet. This allows all of our students to play the game (particularly in Engineering degrees such as Economics and Business, while the interest is not limited to them). The knowledge that may be acquired through this game can be commonly applied in real world: economic systems, ecological, educational, health, etc.

Automation of the game mechanics in turns prevents errors in log inventory, requests to suppliers or deliveries to customers, and in general all error by misunderstanding of the mechanics of the game, which slowed the development of the game and sometimes even forced to start again.

PRODIS

An interactive business game for Intranet and Internet

^{2011 - 2013} DIAGNOSIS

Design and Diagnosis of Viable Organizations: Platform for the Analysis and Governance of Social Systems in Complex Environments

In the last few decades the world has changed radically. The diverse factors involved in this change and their inter relationship mean that the complexity implicit in such a situation is also enormous. Very often the consequence for organizations and companies (public or private) is one of jeopardized viability.

In order to deal with complex problems of this nature (increasingly referred to as **"systemic" problems**), managers must use tools suited to the size of the problem. Methodologies exist but they are neither well-known nor widespread, and in certain cases it is difficult for managers to implement them.

In addition, although it is now found in many areas of activity, the use of Information and Communication Technologies (ICTs) was still insufficient in some of the system methodologies applicable to the types of problems referred to before. In this project we also attempted to respond to this challenge by means of ICTs both to facilitate visualization of and access to methodologies and use various types, as well as to provide users (managers, decision-takers in general, students) with training tools for identifying and addressing dynamic system complexity.



The methodologies to be considered in this project were mainly advanced versions of Organisational Cybernetics (OC) and Beer's Viable Systems Model (VSM), Beer's Team Syntegrity (TS) and Systems Dynamics (SD).

Their capacity to break this complexity down into "recursion levels" and thus make it easier to deal with them is exceptional. **Systems Dynamics integrated in viable models** enable them to incorporate time effects into decision-taking. TS supplies the means to facilitate our learning, our exchange of knowledge and its collective transformation. **Integrating** these components in a coherent conceptual framework permitted managers to have at their disposal suitable for tackling this complexity.

The project, sponsored with Regional Administration funds, was structured in five modules:

- The first dealt with the **methodology for diagnosing and designing organizations** and included guidelines. It also included diagnosis tools, types of common pathologies and their visualization, and it was incorporated to the platform allowing provision and use of methodologies via Internet.
- The second module was dedicated to two developments. The first one, a software to facilitate the application of OC and VSM, including diagnosis and visualization of pathologies, and its combination with SD. The second one, a software to allow the application via Internet of TS.
- In the third module we looked at the Internet training tools to facilitate identification of dynamic complexity and its effects on the behavior of complex systems.
- In the fourth module, an "Operations Room" prototype was built for management teams (of any organization).
- Finally, the fifth module was concerned with **validating** the previous developments with the support of the various Spanish and foreign EPOs.



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