Intelligent Computational Ecosystems for Digital Transformation Based on Explainable Argument Assistant Systems

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ABSTRACT

This work presents the current state of the Computational Ecosystems for Digital Transformation research project, financed since 2022 by the Secretariat of Scientific Research and Transfer of the Vice-rectorate for Innovation, Research, and Postgraduate of the Universidad Siglo 21 of Argentina. The topic seeks to boost digital transformation and business digital maturity of the Argentine productive system, which shows a deceleration compared to the global media observed in the last years in other regions, according to the UN 2030 Digital Agenda for Sustainable Development. One of the research project's lines is discussed, aimed to integrate Intelligent Computational Ecosystems including Argument Assistant Systems of Explainable AI as an inference metaphor based on data analytics in situations where the information to be considered is potentially inconsistent and/or incomplete, thus enhancing decision-making and processes of Business Intelligence aimed at improving the problematic situation under consideration.

KEYWORDS: Digital transformation, Digital business maturity, Explainable AI, Argument Assistant Systems

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1. INTRODUCTION

Digital business maturity (DBM) (Aras & Büyüközkan, 2023) is a decisive socio-economic factor linked to digital transformation (DT) set by the UN 2030 Digital Agenda for Sustainable Development (UN, 2015) and, in particular, the corresponding Argentine 2030 Digital Agenda. In fact, the business digital maturity concept deals with going beyond the incorporation of robotic or automated computational ecosystems to resignify the idea of business, company, marketplace positioning, management, and business process, helping organisations to assess and understand their level of maturity in terms of adoption and use of technologies and strategies characteristic of the industry 4.0 and the emergent Society 5.0 (Peres et al., 2020; Ochoa-Urrego & Peña-Reyes, 2021). This is why the concept of business digital maturity is strongly related to innovation and the implementation of new management models based on data analytics (Thordsen et al., 2020; Nasiri et al., 2022).

While at a world level, DT related to business maturity increases exponentially (Zaoui & Souissi, 2020), some regions only reach a moderate or low level, such as the case of the Argentine Republic (Vélez, 2022; Vadell. 2023; Grainger et al., 2024). The undeniable presence of big data in the Argentine business processes further increases the relevance of these issues. Moreover, it raises the need to incorporate new strategies, tools, and ecosystems of intelligent software that appropriately support and accompany DT as a pathway toward reaching a high level of regional digital business maturity that will enable the country's development. In this context, intelligent computational ecosystems (ICE) are part of the foundation needed to build better economic models, pillars to a new highly-globalised social network focused on people and geographically delocalised (Deguchi et al., 2020), where digital platforms allow direct interaction and collaboration between different agents or units (Rosário et al., 2021; Song et al., 2022; Krishna Kaiser, 2023).

To cope with the above situation, this research project aims to support and help sustain the pressing process of corporate DT that Argentina must face in the coming years. In particular, it seeks to influence decision-making and business management actions based on data analytics, proposing a computational strategy

transversal to the current organisational culture capable of improving with simplicity and at a low operational cost the processing of incomplete and/or potentially inconsistent information present in the daily work tasks of Industry 4.0 and Society 5.0. In addition, it seeks to establish and/or consolidate the synergy between academia and the working world necessary not only to maximise the impact sought but also to lay the foundations for a knowledge economy in line with the provisions of the 2030 Digital Agenda of Argentina, in line with the UN 2030 Digital Agenda for Sustainable Development. In particular, it seeks to:

a. Carry out constant situational diagnosis both regional and nationwide in Argentina to detect the level of corporate DT associated with digital business maturity.
b. Consolidate the ICE characterisation that enhances a high DT level based on improving Argentine digital business maturity, advancing in the incorporation of AAS within the previous ICE as an analytical (inferential) metaphor that allows the handling of incomplete and/or contradictory information within the business decision-making processes.
c. Compare the solutions that arise from this research project with similar approaches.
d. Perform proofs of concept of the above to determine both the feasibility and scope of what has been defined
e. Favour interdisciplinary and collaborative work within Universidad Siglo 21 of Argentina, fostering the continuous training of its actors.
f. Improve and/or promote new academia-company synergies that establish or reinforce solid bases for joint work and mutual benefit.
g. Spot and define new lines of action and research that arise as a corollary of the work done.

This work summarises the work done, the tasks carried out, and the results obtained. First, it describes the actions aimed at determining an Argentine regional situational diagnosis that establishes, at different times, the average degree of digital business maturity associated with the country's business DT, considering the different actors involved in the production process. Next, it is outlined the "*Marketing Inteligente Basado en Argumentación Rebatible*" (MIAR), an ICE proposed for 2022 and 2023 as a solution to the problem detected, specially designed for the business management of intelligent marketing, but highly transferable to other business DT processes. Following, what was proposed is briefly compared to other similar approaches. Then, the first proof of concept carried out during 2023 and 2024 is summarised. This proof includes a feasibility study and the application to a real case of what was previously developed. A Discussion Section is included with the objective of establishing the current scope and potential of the developed ideas. Finally, conclusions reached to date are presented, and future lines of action and challenges to be faced in the short and medium term are outlined.

2. METHODOLOGY

After setting out the problems inherent to the research project reported here and establishing an adequate theoretical framework, a series of actions were defined to set the state of the art regarding the level of average DT in the Argentinian business sector, in particular, the use of ICE or similar strategies for the treatment of inconsistent and/or contradictory information present in business management based on data analytics. For this purpose, an experimental rigid and quasi-experimental design was adopted since assigning the companies in the sample to be considered randomly is impossible. An explanatory experimental design was adopted regarding the type of result sought. The trigger research questions presented for the situational analysis were: Have, during the past two years, more than 40% of medium or large Argentine companies included in their business practices aimed at achieving digital business maturity the consideration of incomplete and/or contradictory information? Do they manage this type of information with intelligent strategies based on ICE and data analytics? Medium-sized or large companies are defined as companies that meet one of the following requirements: Companies with more than 50 employees, or Companies with more than 10 branches in different geographic regions, or Listed companies or Unicorn companies. To answer the research question, the following hypotheses were defined:

Hypothesis 1 (H1): In the last two years, more than 40% of the Argentine companies included, in at least 60% of their practices, standards or strategies to achieve business digital maturity related to DT.

Hypothesis 2 (H2): In the last two years, over 40% of Argentine companies have included digital treatment of incomplete and/or inconsistent information using data science strategies (data mining, Google Analytics, etc.) in at least 60% of their practices.

Hypothesis 3 (H3): More than 40% of Argentine companies report the use of some ICE that includes some Argument Assistant System (see the notion of Argument Assistant System at Section 4) during the last two years.

To collect data, a situational analysis where performed, including three different strategies and their corresponding samples:

a. 100 companies of diverse areas and nature answered an anonymous survey using a web form as a resource. An attempt was made to cover

different regions of Argentina, balancing the geographic distribution. The aim was to spot the self-perception of the Argentine productive sector regarding business DT and the practices aimed at digital business maturity, including key associated factors. The survey was carried out considering the patterns proposed by (Mugge P, et al., 2020) and adapting it to the Argentine context. Enterprises like Pan American Energy (energy provider, 200 employees), Toyota S.A. (car industry, 2000 employees), Cooperativa Obrera (supermarket, 5000 employees), MEGA Company (hydrocarbons, gas, and petrochemicals sector, 10,000 employees), Bodgas Bianchi (wine sector, 1000 employees), Condor Estrella (passenger transport, 5000 employees), La Anomina (supermarket, 8000 employees), Acon Timber (export lumber sector, 2000 employees), Grupo Ledesma (agribusiness in the sugar sector, 6000 employees), Vista Oil & Gas (energy company, hydrocarbon export, petrochemical, 2500 employees), Barrick Gold Corporation (miner sector, gold, 4000 employees), Claro (telecommunications and TI sector, 10,000 employees) participated, among others.

b. Direct observation was implemented in 10 Argentine companies in the insurance area –since it is considered a sphere where daily business management involves, as a critical success factor, dealing with contradictory and/or incomplete information from different sources, including contradictory stories of customers who are going through emotionally stressful situations.
c. 500 academic programs of subjects belonging to Argentine university degree career on science were observed to detect digital-oriented talent gap as one possible cause of the digital transformation slowdown in the region.
d. Interviews with business sector representatives were conducted.

To validate the low or inexistent level of DT observed in the 3 samples considered, progress was made in the analysis of related job applications from 35 job boards belonging to public and private universities in Argentina during 2023.

3. RESULTS FROM SITUATIONAL ANALYSIS AND DISCUSSION

As a general observation, it is worth pointing out the general reluctance of the companies and representatives of the Argentine business sector reached, who showed a high level of mistrust and very little interest in participating, including the 10 companies of the direct observation. Out of the 100 companies contacted, only 30 answered. A summary of the main results obtained is shown in (Grainger et al., 2024), including statistical data shown in **Figure 1, Figure 2, Figure 3**, and **Figure 4**. As posted by Graingeret al. (2024), despite the well-known importance of digital transformation, collected data reinforces the previous hypothesis supporting a very low level of digital transformation even for large-sized Argentine enterprises. Direct data collection coming from the 10 Argentine companies followed the tendency shown in the survey. As regards the interviews, only 5% of the businesspeople agreed to be interviewed. Respecting the 500 academic programs of subjects belonging to Argentine university degree careers in science, if careers in Computer Science or Informatics, Data Science, and Technological Innovation are not considered, few references for competencies or skills regarding digital transformation could be determined (less than 5%). In all cases, competencies focus on specific traditional software usage more than in regarding industrial processes, in discussing changes in communications and monitoring possibilities, in Artificial Intelligent tools usage and possibilities, or in global comprehension of the novel business rules of the basic contracts underlying Argentine population moving from 4.0 to 5.0 economy (Grainger et al., 2024).

In conclusion, respecting the hypothesis, whereas H1 can be proved, H2 and H3 cannot be shown as valid. It is essential to notice that senior executives were contacted in all cases, and the opinions of employees outside the business management of each company were omitted. Besides, considering the validation associated with the analysis of related job applications from 35 job boards belonging to public and private universities in Argentina during 2023, it was found that only 8% of the job applications on the job boards of the Faculties of Engineering of many universities include, among the required skills, those related to the use of ICE without clearly specifying the use of AAS. Percentages close to 6.4% were observed for the same professional profiles in the Argentine Engineers Centre job board in 2023; this decreases to an average of 4.6% if job board demands of Professional Boards of Engineers of different Argentine provinces are analysed.

4. SOLUTION PROPOSAL

As posted before, one key problem to purse Argentine DBM practices, and therefore Argentine enterprises DT, is associated with the low business capacity to take advantage of the large amount of incomplete or contradictory data everyday collected as a crucial input of the innovation and the implementation of new management models based on data analytics.

This situation is closely related to one of the main challenges of Computer Sciences and Informatics, in particular, that of artificial intelligence (AI): The issue of knowledge representation and the reasoning related to said representation (Prakken & Vreeswijk, 2001; Vassiliades et al., 2021). Within the framework

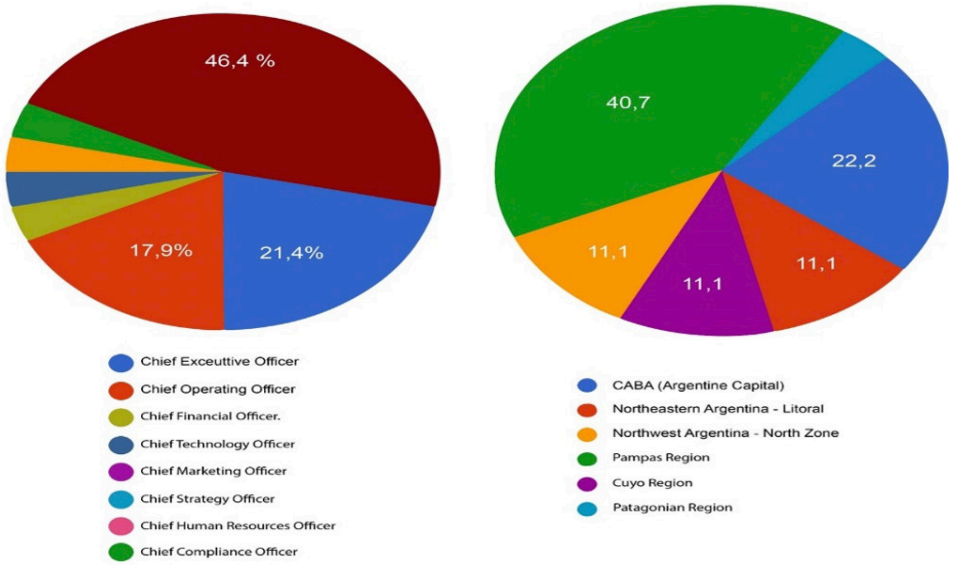

Figure 1: *Role of the person who represents the company and Geographical distribution of surveyed companies (left).*

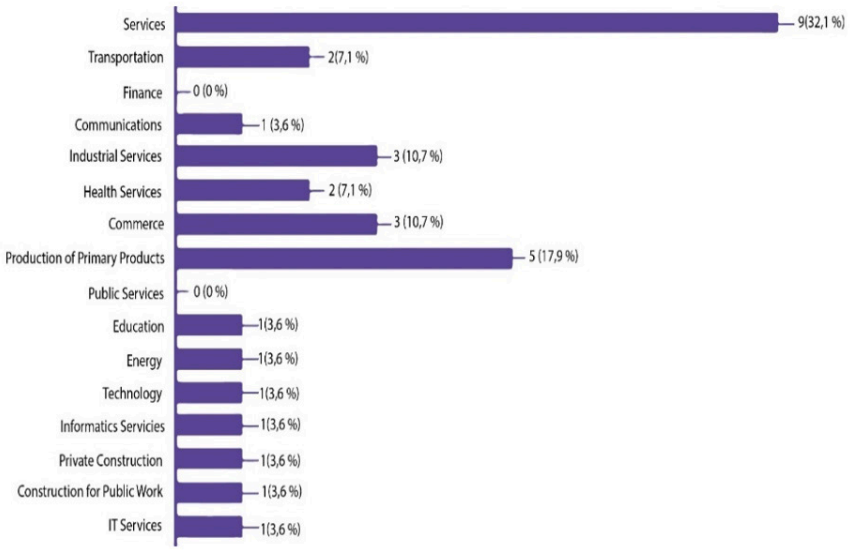

Figure 2: *Surveyed economic sectors.*

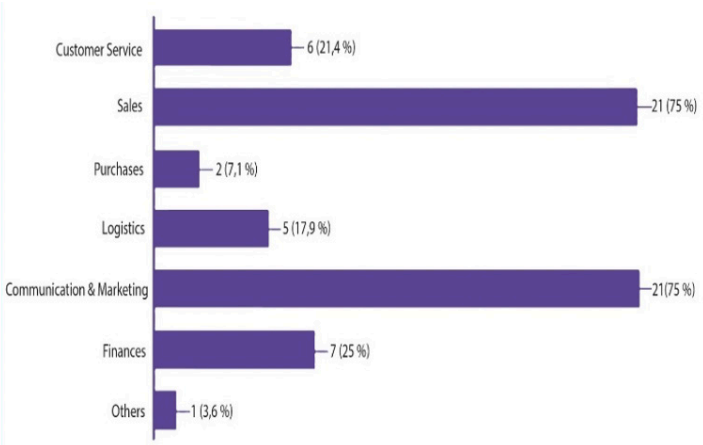

Figure 3: *More relevant processes in the company that have suffered a digital transformation during the last 4 years.*

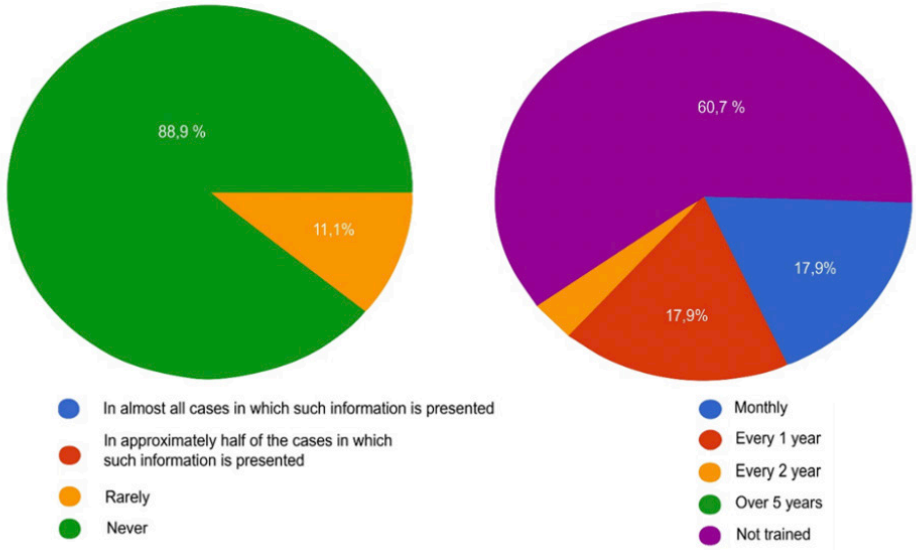

Figure 4: *Cases on which Data Science Techniques or Tools are used to process available information (left) and Frequency of digital training (right)*

of this issue, the goal is for an intelligent agent to have the ability to make possible conclusions based on incomplete information, to manipulate rules with exceptions, and to handle in an adequate way information that is potentially inconsistent and, thus, emulate common sense reasoning of humans. Classical logic's known limitations in reaching this goal motivated the development of different alternatives. Among them, the so-called defeasible argumentation (Mogdil et al., 2013, formalised using argumentative systems, has consolidated in the last two decades as a particularly attractive approach, with successful applications in legal reasoning, multi-agent systems, recommendation systems, sentimental analysis and decision-making systems, among many others (Chesñevar et al., 2009; Rani et al., 2021; Prakken & Sartor, 2023).

Theoretical advances in the area have enabled the creation of different computational models of arguments, setting the basis for the development of platforms and software solutions for defeasible argumentation called Argument Assistant Systems (AAS) (Verheij, 2003; González et al., 2010; González et al., 2011; Leiva et al., 2020). These systems automatically calculate a specific value of truth associated with a hypothesis that can dynamically vary according to different items, providing a justification (often a graphic one) when more than one possible course of action can be suggested (González et al., 2010; Vlačić, 2021). In this way, AAS provides a valuable aid in analysing which assumptions in our knowledge base actually gave rise to inconsistency or harmless. Besides, the AAS allows arguments consideration when incomplete and potentially contradictory information is included. In fact, AAS non-monotonicity can be seen in the fact that an argument that is justified can be unjustified if new information or new arguments are added. The difference between AAS and totally automated reasoning systems must be established. While the latter is focused on the automated calculation of arguments, the AAS does not seek to replace the user's reasoning but to assist it in the dialectic reasoning process by considering many possible arguments that interact with each other () (Verheij, 2003; González et al., 2010). Consequently, the AAS crystallises a formal argumentative theory, providing a scenario favourable for defeasible argumentation for non-experts (Rizzo, 2020). Some AAS examples are Araucaria (Reed & Rowe, 2004), el DELP (Garcia & Simari, 2004), AVERS (Van den Braak et al., 2007), Cohere (Shum, 2008), Compendium (Okada et al., 2008), and DAQAP (Leiva et al., 2019), currently in evolution to include argument probabilistic calculation (Leiva et al., 2020; Leiva et al., 2022).

Despite the evident connection, adequate characterisation of the inclusion of ICE based on AAS within the Argentine DT processes aimed at improving the level of digital business maturity has not yet been proposed (as far as it is possible to establish). In particular, when AAS can be considered as an analytical (inferential) metaphor capable of drawing plausible conclusions based on incomplete information, manipulating rules with exceptions, and adequately handling potentially inconsistent information, and thus emulating the common-sense reasoning of humans. Based on what was explained, the novel ICE MIAR shown in **Figure 5** was developed during the first stages of the project, integrating an AAS within a larger framework, thus enabling the joint use of data that come from different sources.

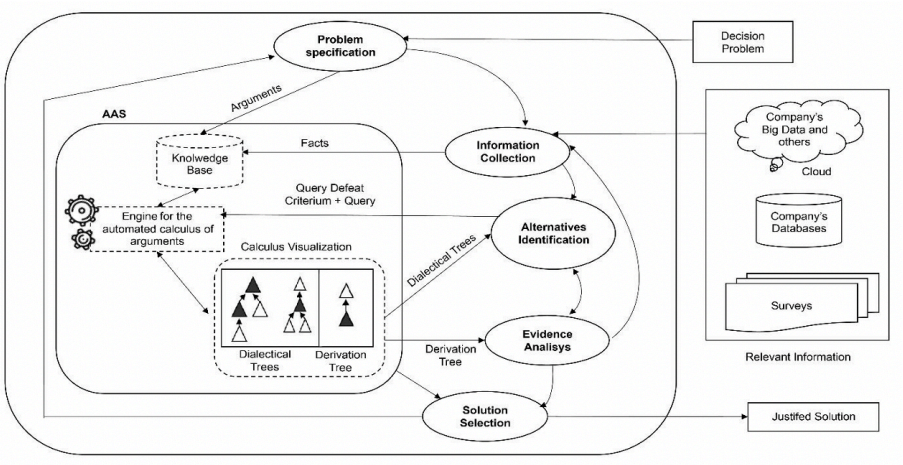

Figure 5: *MIAR intelligent computational ecosystem*

As it is explained by González et al. (2023), at the beginning, a decision problem is identified. Then, in a translation process where the existing knowledge base of similar problems can be reused or used as a basis, the knowledge of strict rules and defeasible rules of the problem (its arguments) is specified in the AAS language chosen, thus creating the MIAR knowledge base. Besides, using data mining algorithms (Otter et al., 2020) and automated processing of natural language (Chowdhary, 2020), different structured and semi-structured data from the companies' own databases and the cloud can be condensed to complete the facts (strict knowledge) of the knowledge base under construction. Once this stage is over, the cyclic process of looking for an adequate solution can occur. For each solution to be explored, different defeat criteria can be considered.

Each query within the MIAR will trigger a series of automated calculus within the AAS, getting, as a result, both the acceptance or refusal of the question asked and the corresponding dialectical tree graphic. The possibility of zooming in over any argument of the derivation tree to observe in detail the derivation tree's graphic that creates the value of each argument, plus the detail of the AAS language of the arguments and counterarguments used will enable the analysis of the evidence that supports the decision automatically recommended by MIAR. At this point, the decision obtained, together with all the associated graphics, can be given back as MIAR output or two possible paths that evidence the cyclical nature of the process may be followed.

On the one hand, it may be found that the original problem was not well posed (because, for example, there are significant arguments that were not considered or there are changes in the company's business policies that may be included as rules), in which case there will be a refinement of the system specification. The whole process described above will be triggered again. Alternatively, the need to collect more data from external sources to MIAR may be identified to enrich or modify the facts of the knowledge base before carrying out new queries. Note that the MIAR ICE can be included in different business contexts.

5. PROOF OF CONCEPT

The first proof of concept was recently completed, and two others are in the definition stage. Within what has already been done, it was sought to go beyond the scope of Intelligent Marketing to cover other highly conflictive business management processes that reflect the need to incorporate solutions such as the one explored in this research project.

For the first proof, the scenario chosen was the Argentine sector of insurance companies because, as it has already been explained, it is a complex Argentine business reality cut, highly conducive for the business management to be cut through by the conflicts that underlie what is tried to be researched. In particular, the case study was controversial in the real world. In particular, the topic was "insurance, double insurance, the multiplicity of insurance, compensation". The real case chosen was the legal decision of the Commercial Chamber of the Federal Capital City, Room "B", dated July 21st, 1995, in the trial "Owen, Luján A. v. La Concordia Cía. De Seguros and others" (Barrato, 1997), based on a conflict of the insurance area that involves one insurance company, a second one and a policyholder. In this real case, the compensatory nature of insurance coverage of damages, on the one hand, and the particular incidence that the principle of good faith has on the insurance contract, on the other,

have led to the situation of "double insurance" being legislated through an express regulation that seeks to meet the requirements imposed by both aspects mentioned above. According to the recitals, the facts sum up the following: An organisation of producer-advisors, which had brokered an automobile insurance policy, informed the policyholder that the insurer of that contract had decided to terminate it as of a certain date. For this reason, a similar insurance policy was arranged with another entity, the term of which began on the date indicated as the date of termination of the first contract. A few days later, the insured vehicle was stolen, which appeared later, although it was without the engine and its accessories, seats, wheels, gearbox, differential, and other vital parts. Having reported the loss to the new insurer, the latter rejected the claim, arguing that the coverage subsisted in the first company, derived from the 15-day notice period imposed by law (sect.18, second paragraph, L.S.). The vehicle owner then goes to the original insurer, which also dismisses the compensation claim, arguing that, although there was a residual coverage, the policyholder had tacitly agreed to the termination when entering into the new contract. Faced with this situation, the policyholder initiated legal actions against both insurance companies and the broker. The first instance sentence condemned the entity contracted in the second place, releasing the other defendants, a decision that was confirmed in the second instance in the central part.

The first principle of Argentine law involved brings with it the application of the compensatory principle, part of the law of torts, that imposes that the compensation covers only up to the amount of the damage effectively suffered in each case, thus avoiding an unjust enrichment. Moreover, the second principle, that of "good faith", prevails in all the Argentine legal sphere but is particularly relevant in insurance matters. It seeks to avoid that said enrichment without genuine cause takes place because of conducts contrary to law and morals. It is interesting to analyse the fundamental aspects of the Chamber's decision. This considers that there was a "double insurance".

However, it sustains that, having the policyholder acted in good faith, the "legal mechanism of nullity" of section 68 L.S. is neutralised, mainly because the second contract was entered into with the intervention of third parties. The case helps highlight a particularity of the Argentine legal regulation, which has solutions that hold some degree of contradiction, an aspect that the ruling deals with, although not deeply enough. However, the Court ultimately reaches a solution we consider just in its central aspect. To summarise, the law does not deal with the topic in a clear and defined way, and the following arguments in conflict can be observed:

a. Argument 1 Expiration (no one compensates the policyholder): On the one hand, in its sect. 67° there is a threat with the penalty of termination in the cases of plurality of insurances, if the policyholder does not notify, without delay, each of the insurers, indicating who is the other insurer and what is the sum insured (since the insurance may be only partially "plural").
b. Argument 2 Nullity (both compensate the policyholder): But then, in section 68, the "plural" insurance is considered null and void, but only when it has been entered into with the intention of unjust enrichment.
c. Argument 3 Commercial Willful Misconduct of the policyholder (no one compensates the policyholder): If it is proven that the policyholder knew this situation, it could be inferred that there is an attempt to charge both companies with the compensation, which would lead to the concept of commercial willful misconduct, thus exempting both companies from paying compensation. For this, it is decisive to establish before whom the person presented the claim of the loss–since it is generally at the moment of the loss when these issues come into the light–and how this was done because this will be the opportunity and the best way to prove if there was an intention of unjust enrichment on their part.
d. Argument 4 Policyholder's good faith (both companies compensate the policyholder): If the policyholder's good faith can be proven, the person accepts the conditions offered by the second insurance company involved without knowing the double insurance they were offered.
e. Argument 5 Unfulfilled Notice (no one compensates the policyholder): In the case being analysed, in the event of termination, the residual subsistence of the first coverage stems from legal and contractual rules that are not well known to non-specialists. However, the 15-day notice imposed to contract termination aims to allow the policyholder to seek coverage with another insurer, avoiding a sudden and untimely termination. It is, therefore, intolerable for the second insurer to invoke the termination of the policyholder's rights because the latter requested coverage within the notice period, even though the notice period was still in progress.
f. Argument 6 Tacit Acceptance of Contract (the second company pays the compensation): The second contract implied a tacit acceptance of the termination. Although such termination did not require any acceptance, since it constitutes a unilateral power that is exercised directly, the argument has a point insofar as it is indicating, in essence, that the new contract removes any basis and cause for an additional term whose purpose has been fulfilled, since it aims precisely to prevent the termination decision from being untimely and to allow the search for risk protection.
g. Argument 7 Contract Term (first company pays

the compensation): The person who requires the coverage is subject to the particular way of entering into an insurance contract, in which the acceptance of the proposal by the insurer does not take place immediately (sect. 4, second part, L.S.), but is typically exteriorised sometime later when the policy is issued and delivered. The insurer usually takes their time to examine and assess the risk, fix the price of the premium, issue and deliver the policy. This means that neither the date of the application for the second insurance nor the date of the beginning of its validity can be taken as the time at which the claim under Art. 67 L.S. must be made.

It is evident that in 1995, the digital business maturity level of any economic entity was far from the level that can be currently reached. However, despite this statement that we will take as tautology (so there is no need to prove it), there is still in Argentina a level of business management based on opinions, feelings and human "expertise" over the rational use of digital data analytics for situations such as the one described in this case, which becomes evident in the situational analysis carried out: While the average level of DBM of the companies in the insurance sector stands out due to sound levels about document digitalisation, the relation with the client and the marketing, and the macro data analysis of the management, there is an almost null business mentality in the intermediate level of the sector, where judicial mediation is still needed due to the lack of consensus, especially when dealing with cases that involve information that is incomplete, or potentially contradictory, that can be interpreted under different groups of regulations, jurisdictions and rulings. What would have happened if, instead of resorting to justice, the business management of the insurance companies associated with this case had introduced an ICE such as MIAR as digital support for analysing the pertinent arguments? It is probable that the relation between the information would have been more apparent for the three parties and that the arguments presented would be separated, to a great extent, of the three particular interests, minimising not only subjectivity but also the costs of a judicial mediation of two instances (even unnecessary) and thus simplifying the negotiation process. We will see how this real case is instantiated in the MIAR if DAQAP software is chosen as a particular AAS (Leiva et al., 2019). The defeasible rules (defeasible arguments) expressed in the logical language of DAQAP are:

- Argument 1: Termination
  ~pays (X) -< insuranceexpired(X).
  insuranceexpired(X) -< isinforce(X), ~notice(X).
  insuranceexpired(X) -< datewithouthinsurance(X)
- Argument 2: Nullity (is valid or notice was sent, but there is willful misconduct because the companies know they are charging double insurance to the client)
  pays (X) -< nullity(X).
  nullity (X) -< isinforce(X), ~notice(X), companywillfulmisconduct(X).
- Argument 3: Policyholder's willful misconduct (it is proven that the policyholder intentionally wants to receive the money for both policies, no one pays them)
  ~ pays (X) -< policyholderwillfulmisconduct(X).
- Argument 4: Policyholder's good faith (the person did not send the notice because of lack of knowledge; there was no willful misconduct)
  pays (X) -< ~ notice(X), ~policyholderwillfulmisconduct(X).
- Argument 5: The policyholder did not send the notice to the companies (no one pays them)
  ~ pays (X) -< ~therewasnotice(X).
- Argument 6: Tacit contract acceptance (the company must compensate the policyholder)
  pays (X) -< tacitcontract(X).
  pays (X) -< ~ tacitcontract(X), ~policyholderwillfulmisconduct(X).
- Argument 7: While still in the hiring time, there is no contract signed between the company and the policyholder (the company does not pay)
  ~payment (X) -< hiringtime(X).

Besides, the facts involved are:

- isinforce(firstcompany).
- isinforce(secondcompany).
- tacitcontract(secondcompany).
- ~therewasnotice(secondcompany).
- ~therewasnotice(firstcompany).
- companywillfulmisconduct(secondcompany).

After executing the MIAR ICE instanced in DAQAP and with the former refutable rules, the graphic in **Figure 6** is obtained. It can be observed that, without the need to get to a judicial instance, the facts considered were enough to establish that the second company had to compensate the policyholder 100% of the coverage. In fact, it can be seen that the pays(secondcompany) argument is natural because, although attacked with the counterargument contracttime(secondcompany), this counterargument is, at the same time, attacked by the tacitcontract(secondcompany) argument. If an ICE based on AAS similar to the MIAR had been introduced in the business management associated with the loss, the situation would have been more precise, and it would not have been necessary to take it to justice. If the judicialisation had been necessary, providing as a legal argument the conclusions shared by the ICE based on the AAS would have highly accelerated the process in the judicial and commercial chambers that intervene, both in the first and in the second instances, if the second company required it.

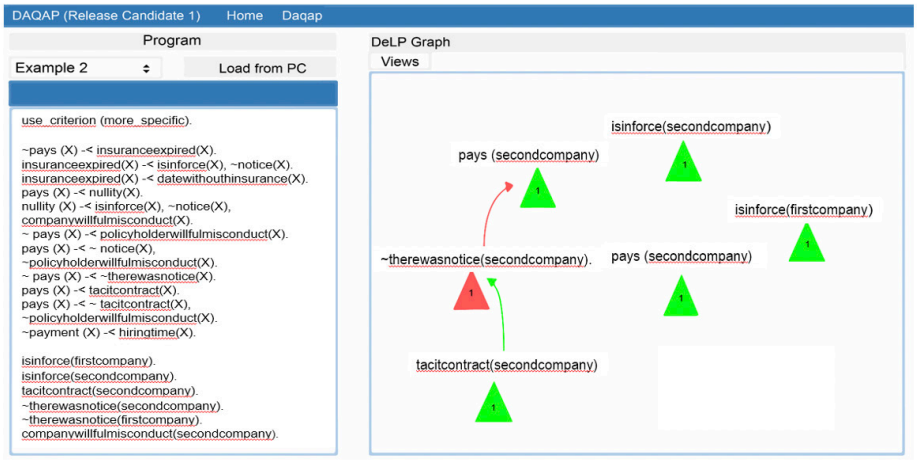

Figure 6: *Interface of MIAR computational ecosystem with AAS DAPAQ executed for the proof of concept*

In addition, other green dialectical tree can be observed with the label pays (second company), indicating other arguments without attacks that support the truth value for pays (second company). Besides, no green tree with the label pays (first company) was depicted, reinforcing the idea that the first company should not pay any percentage of the insurance. The explainability of the AI-based computation emerges by zooming in over any argument (any of the trees). Indeed, by clicking over any tree, the details of the associated calculation are displayed in another blue square at the right of the DAQAP interface. As an example, **Figure 7** shows the details of the calculation when zooming in over the tree with the label pays (second company) in the middle of the blue box.

It can be observed that the conclusions reached when introducing the ICE MIAR match and endorse the two judicial decisions included in the conflict. Indeed, if an ICE based on AAS similar to the MIAR had been introduced in the business management associated with the loss, the situation would have been more precise, and it would not have been necessary to take it to justice. If the judicialisation had been necessary, providing as a legal argument the conclusions shared by the ICE based on the AAS would have highly accelerated the process in the judicial and commercial chambers that intervene, both in the first and in the second instances, if the second company required it. Regarding the feasibility of the proposal, it is worth pointing out that using MIAR ICE had no economic cost and that the AAS DAPAQ is available online. Translating the information available into DAPAQ language did not take more than 10 minutes, and calculating the arguments explained before took less than a few seconds. A second proof of concept aimed at the Argentine tourist sector is currently being analysed. Another AAS will be considered part of the MIAR ICE in this second proof of concept.

6. RELATED WORK

As far as could be appreciated, there is no other similar proposal to the one presented as a solution within this research project focused on characterising the inclusion of ICE based on AAS as an analytical metaphor (inferential) capable of making plausible conclusions based on incomplete information, manipulating rules with exceptions, and adequately handling potentially inconsistent information, and thus emulating common sense reasoning of humans in the Argentine business management aimed at enhancing the DT of the region. In Yau et al. (2021), a similar scheme that uses knowledge bases is presented. In contrast to this proposal, those knowledge bases are included in the consideration of consumer relations. Moreover, handling contradictory and/or incomplete information is not considered.

Using intelligent information systems is a fundamental practice for applying tools, techniques, and artificial intelligence strategies to make decisions based on data analytics (Alago et al., 2019). Many support systems have been proposed, particularly online applications that combine layout, data visualisation, and collaboration. A current example is the platform LucidChart (Vician & Pierce, 2018). However, similar to the proposal described in Yau et al. (2021), these support systems do not allow to deal with contradictory and/or incomplete information as is discussed in this proposal. Additionally, the combination of visual analytics and artificial intelligence must be considered. Additionally, the combination of visual analytics and artificial intelligence must be considered. Techniques such as data mining are increasingly being used (Dam et al., 2019).Nevertheless, its function is related to big data processing rather than the information handling proposed here. Some alternatives begin to include social media audio processing as part of the unstructured data to be considered. This could notoriously enrich the ICE, such as MIAR.

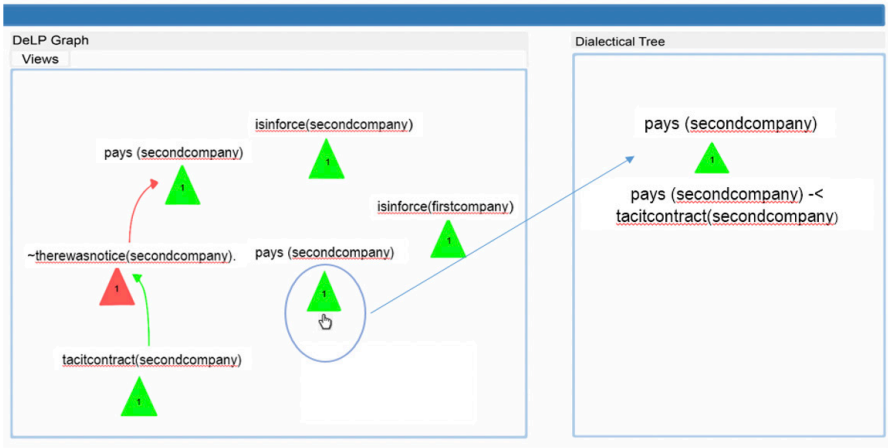

Figure 7: *SAA DAPAQ explainability for the dialectical tree pays(secondcompany).*

7. CONCLUSION AND FUTURE WORK

This work presents the current state of the research project "Computational Ecosystems for Digital Transformation", which began in July 2022 and is financed by the Secretariat of Scientific Research and Transfer of the Vice-rectorate for Innovation, Research and Postgraduate of the Universidad Siglo 21 of Argentina. This is part of the Deanship of Applied Sciences. The general objective is to support and help sustain the pressing DT business process that Argentina must face in the coming years. This is based on an inevitable slowdown compared to global averages observed in recent years in other regions when the UN 2030 Digital Agenda for Sustainable Development is used as a roadmap.

In particular, a computational strategy, transversal to the current organisational culture, has been formulated. This strategy can improve, with simplicity and, at a low operational cost, the processing of incomplete and/or potentially inconsistent information in the daily work tasks of Industry 4.0 and Society 5.0. To achieve this, it was proposed to add strategies and tools that belong to the AAS of Artificial Intelligence within the ICE aim at making decisions and Intelligence Business based on data analytics in situations where the information to be considered is potentially inconsistent and/or incomplete. This way industry challenges related to the introduction of IA-oriented practices can go beyond pattern recognition (more associated with Machine Learning approaches), allowing automatic support for reasoning under uncertainty, helping to remain competitive by enabling smarter, faster, or more efficient decisions using symbolic and explainable AI systems. Especially, industrial digital maturity notably improves when adopting ICE MIAR in a varied set of scenarios, including supply chain orientation in real-time based on customer complaints expressed in natural language (and, therefore, imprecise); optimization in real time on the basis of confusing data coming from suppliers; senior management negotiations mediated by the rationality and transparency of the ICE MIAR approach; among others.

In the same way, alternative economics niches benefit from increasing objectivity at low cost in high transparent agreement actions when inconsistent or very complex information, not always available in the same format, needs to be jointly considered for business decisions based on data analytics. Even society as a whole is out of the scope of the Project presented here (as in general applied scientific projects granted by the Secretariat of Scientific Research and Transfer of the Vice-rectorate for Innovation, Research, and Postgraduate of the Universidad Siglo 21 of Argentina are more oriented to a particular society sector as the productive sector, or the economic sector, or the educational sector), obtained results can be easily extrapolated to cover a wide range of real scenarios where ICE MIAR framework covers much more than the mere application of a SAA system, thus encompassing the entire scenario of rational decision making by providing a low cost, explainable intelligent recommender system.

Some external limitations impact in the project, like the ones related to the Large Language Model bottlenecks, as for example the imperative needs to be able to transparently and automatically translate sentences in natural language into sentences in non-monotonous logic language. Actually, this limitation is perceived as critical by non-computer ICE x users, who are forced to have the advice or support of someone knowledgeable in these mathematical approaches. However, continued advances in the area and the arrival of generative AI promise short-term solutions over the coming years. Another no less important factor to consider that will affect the immediate future of the project is the upcoming regulation of AI in Argentina and its inclusion policies in industry and commerce, currently under debate in the advisory commissions of the Nation's Chambers of Deputies and Senators (Oxford Analytica, 2024). Furthermore, with respect to the

productive private sector many times the companies interviewed are highly reticent when asked about their decision-making practices. For this reason, and due to the existence of confidentiality contracts, the determination of the real situation of companies tends to be overshadowed. Another type of limitation of the project is related to the talent gap that is observed with respect to symbolic AI and intelligent recommendation systems, limiting in many cases the vision of the Artificial Intelligence discipline to the area of Machine Learning.

In the short term, future works include the performance of two new proofs of concept applied to a sample of companies that are different from the ones considered now. One of the new samples includes Argentine companies of medium and large size in tourism, and the other is focused on Argentine middle size health centres oriented towards global programs for improving overall health in the Cordoba city region. In both cases, AAS different from the DAPAQ are considered. Simultaneously, some issues related to Technological Convergence 5.0 are under consideration and must be addressed. In addition, progress continues to be made in the situational analysis, which accompanies all the developments that have been carried out. In this case, progress is made in comparing the change in 2024 to the previous years, paying attention to the particular political and social reality Argentina is going through. In the medium term, the aim is to develop a computational solution capable of being executed using a freely distributed app with low technological requirements. To achieve this, some challenges specific to the AAS must be overcome, including the automatic translation of arguments and facts to the logical languages of the AAS. Research work in this direction is currently underway.

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