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Exploration and exploitation of an IS in the engineering projects automotive industry: a synthesis of a clinical research

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Exploration and Exploitation of an IS in the Engineering Projects Automotive Industry (PAUT): a Synthesis of a Clinical Research

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Abstract

This paper uses a clinical study that suggests that exploration versus exploitation strategies have a mechanistic aspect that can be dysfunctional when managing large automotive and IS projects in highly turbulent cyclical environments. The clinical research demonstrates that the results of the strategies tuned to mechanical systems and ERP sustained systems were short-sighted and were suitable only for simple automotive projects (Bernard, 2013). In the current complex landscape, the management should adopt a cyclical view of their complex project landscape that recognizes that IS projects can be improvised and then switch to a mechanical system (Qiu, Gopal & Hann 2017). 20 years after the start of the study, the main result is that the timing of the switch between exploration and exploitation of the IS projects and automotive project is a key success factor (Azan, 2003). 20 years later, the simple PAUTs are successful and the complex PAUTS stopped. This contribution explains the role played by the IS.

Keywords

Exploration, exploitation, ambidexterity, performance, IS project, cycle, clinical research, ecosystem, switch, ambidexterity.

Introduction

The French car industry, particularly Renault (the alliance between Renault Nissan and Mitsubishi), has enjoyed phenomenal success in recent years. The company overtook Volkswagen as the world's largest automaker in 2017 with 10.61 million cars sold versus 10.53 millions for the German Group. This represents a remarkable turnaround for a company that was until recently a struggling regional player. The role of IS (information systems) in that achievement cannot be overestimated (Bughin et al. 2010, Xue et al. 2012, Nambisan et al. 2017). IS development programs are typically viewed as a collection of projects intended to achieve a common goa (Chang and Gurbaxani 2012, Alnuaimi and Maruping 2010, Cho et al. 2011). In that case, IS goals evolved in a fast changing environment.

The regular successes of this global player cannot occur deep and regular cycles. The IS face exploration and exploitation usages, the automotive projects (PAUTs) might adjust and compensate for changes in both the external and internal environments. Indeed, the changes in the internal environment can arise from PAUTs. In highly turbulent environments, the *switch* between bricolage and a mechanical view of IS projects is driven by the overall business environment. Attempts to control this improvisation is based on a simplistic mechanical view can fail to take advantage of this bricolage or anticipate cycles. When the companies' environment changes quicker than the companies themselves. A mechanical view of the IS is focused on repetitive activities that achieve high quality outputs with minimum cost and time. According to the mechanical view of the IS, information systems engineering process must begin by discovering the real problems that need to be resolved by a manager or a team of expert. The IS engineering involves finding solutions to these problems map, simulate and implement them with minimum costs.

The above-mentioned papers reveal a close link between IS and the enterprise cognitive dimensions of firms, where this link is a source of increased rigidity and of selection among organizations. Nevertheless, we think that some organizations, fit for a turbulent environment, are to reinvent their IS if required. In this paper, we will illustrate that a company's ability to manage its periodically changing knowledge heavily affects its performance (Azan et al. 2017). In the long run, this exploration phase in the IS and cyclical automotive projects is critical. There is a lack in the literature to evoke the cycles' influence on the conception and implementation of the IS.

IS, engineering projects and production organizations are often characterized by an exploration logic (Xue and al. 2012). The principle of requisite variety suggests that efficient adaptation requires sufficient internal variety (Ashby, 1957). Internal variety, in turn, is associated with exploration (March 1991) and involves the search for new organizational routines and the discovery of new approaches to technologies, companies, processes or products. The relevance of internal variety is acknowledged in several theoretical traditions where it is seen as essential in acquiring new knowledge while improving current output. It is notably the central element in approaches based on bounded rationality, knowledge mobilization, and evolutionary models. Briefly, exploratory learning is essential for organizations to generate variety and ultimately adapt. According to March (1991), exploration encompasses aspects such as search, variation, risk taking, experimentation, play, flexibility, discovery and innovation. Exploitation, in contrast, is associated with refinement, choice, production, efficiency, implementation, execution and an overall simplistic 'mechanical' view of an organization. Exploitation increasingly returns to past experience, or mutual positive feedback between experience and competence, in favor of refining familiar technologies rather exploring and piloting new ones (Lenfle 2008, Levinthal and March 1993, March 1991).

Can clinical research (Schein 1996) provide an important addition to the existing well established IS theories and IS research methods ?

- Can the clinical-study perspective combined with a long-term lens be used to refine the IS literature? Can it help provide a better evaluation of the use and misuses of technologies in their ecosystem the same way cardiovascular and anticancer drugs in their long-term clinical use, it s
- When should the switch between exploration and exploitation occur in a turbulent environment?

We report the details of a research project leading to a subsequent industrial clinical research in which an automotive manufacturer deployed a program of IS projects to cope with increasing turbulence in their market and supply chain. After initially adopting a strategy of designing the projects along the rational lines of exploitation versus exploration strategies implemented into an ERP, the participants encountered a cycle (Benner and Tushman 2003, Karimi and Walter 2015) that requires exploration.

The paper presents the empirical case, which is based on more than 20 years of follow up work, of a cycle. Finally, the paper discusses the implications of the switch, explores how adopting a cyclical perspective can be beneficial in managing large scale IS projects in highly turbulent and innovative industry contexts.

Exploitation and Exploration in the IS Projects Literature

In this section, we detail a list of the most relevant articles in the IS literature about exploration and exploitation (see Table 1). The IS literature does not take into account that the IS 'cognitive maps' held by members of automotive projects become increasingly rigid and dominant solutions are applied to all problems (Xue et al. 2012, Siren et al. 2011, McGrath 2001; Clark and Fujimoto 1991, Crawford and Ward 2006, Lenfle 2008, Atkinson et al. 2006, Gregory et al. 2016).

The IT project myopia of the knowledge transfer is a factor of a poor exploration and increases the inherent risks of this kind of activity (Alhawari et al. 2012, De Bakker et al. 2010, Đurković and Raković 2009).

Authors in IS	Exploration/Exploitation	Methodology	Constructs	Theory
Aaltonen and	Wikipedia presents an increasing reliance on policies and guidelines, thus signalling a certain	1. The authors carried out an analysis of the ratio of discussion page activities to encyclopaedia articles and to policy/guideline contributions and the ratio of talk page	Coordination	Critical social theory

Kallinikos (2013)	stabilization in the knowledge making processes underlying the encyclopaedia (exploitation).	activities to encyclopaedia articles and to policy/guideline contributions. 2. There was also analysis of the gap between the number of monthly content contributors and total contributors in English Wikipedia.		
Xue et al. (2012)	Exploration: In environments with higher levels of complexity, IT asset portfolios are associated with a greater increase in innovation (i.e., the development of new products and processes, and the exploration of growth opportunities). These results provide insights about how firms could realize strategic alignment by tailoring their IT asset portfolios towards an efficiency or innovation focus.	The study operationalized an IT asset portfolio. The author apply the mainframe price index across all types of IT hardware, including non-mainframe technology. For the authors, regarding software, the IT productivity literature uses three times the IT labour expenses as a proxy for the IT capital related to software, training, and labour expenses.	IT asset portfolios, IT programmes	Theory of adaptation, Contingency theory, Strategic choice
Tiwana (2010)	The study opposes the *clan control* to the *formal control*. It relies on the values and beliefs shared between customers and suppliers to align their interests and objectives in the context of a project.	120 outsourced IT application development projects were analysed. The data are collected from two informants, the lead project manager and a client firm manager responsible for the project.	Ambidexterity in IS projects	Clan control, formal control, informal control
Sidhu et al. (2007)	There are three intrinsic dimensions in the exploitation and in the exploration that involve both science and technology.	Data were collected in two waves from publicly and privately held companies in the metal and electrical engineering sector.	Dimension	Contingency Theory
Montelagre and al.(2019)	There is a contradictory tension between exploration and exploitation that affects digital infrastructure	29 nterviews	Case study	Innovation theory
Ciborra (1998)	IS project is emergent ('bricolage process')	Case studies (e.g., Olivetti)	Bricolage	Actor network theory, Sensemaking, Ethnology
Azan Bootz Rolland (2017)	IS project is a combination of cognitive architecture and hierarchical architecture	Case study	Switch off	Community of pratice
Gregory and al. (2016)	The authors theorize that ambidexterity is a dynamic capability that rests on the abilities of its leaders to articulate an IT strategic intent and vision and—more importantly—to manage the inherent tensions associated with incompatible organizational architectures.	Case study	Exploration, ambidexterity	Innovation theory

Table 1. Literature Overview

There is a lack in the literature concerning the implementation of IS in the context of complex projects.

Empirical Study: from the Successful Transformation of a Company to the End of the Dream for the Complex PAUTs

In this section, we specify the research methods. The enterprise system should help an industrial firm to better exploit its resources. As a result, the IS was supposed to improve the exploration phases in the automotive projects.

In the present paper, the theoretical framework to be used in the Progitech case has been approved by a convention with the National Association for Technological Research (ANRT). The whole problem in the image of recent media trials is to understand if the properties of the prescribed remedies are proven. The originality of the study here is that it addresses this question over two decades. The first research project,

called SICPARI (Simultaneous engineering In Car Production And Related Industries), ran from 1993 to 1996 and analysed the potential of simultaneous engineering in the automotive industry in terms of competitiveness. The University of Strasbourg, France conducted the project in collaboration with BMW, Mercedes-Benz and Industrie Werke Karlsruhe Augsburg (IWKA). The project identified the opportunities for optimization for various players in the automotive industry. Two of the authors of this paper were members of the SICPARI project team, and the one of them led the IT part of the project, namely, the multi-project integration, interaction design and simulation. The adopted methodology and some results of the SICPARI project is presented in the next paragraph including information collection and simulation, some results and consequences. A steering committee, associated with the University of Strasbourg and coordinated by the ANRT, was appointed to assess the progress of the project.

Project category	Projects of low and medium complexity	Highly complex R&D projects	sub-projects
Total time spent in project meetings	70 hours	78 hours	51 hours
Part of total time spent (%)	19 %	53 %	28 %
Number of evaluated projects	98	26	44
Part of total of evaluated projects (%)	58 %	15 %	26 %
Total budget for projects (euros)	6 million	74 million	15 million
Total budget for projects (%)	35 %	39 %	26 %
Average project team size	5-10	30-120	10-30

Table 3. Project Groups and Summaries from 1997 to 2000

In the long run the PAUTs revealed the tension between the exploration and exploitation project types. The ERP implementation formalization process illustrated well the fundamental differences between small and mid-sized projects and complex projects that were more characterized by a mix of fixed prices and moving targets in term of the requirements and changing partners. For complex projects such as the welding and the assembly installations, there are more project meetings and they always happen with more than ten project actors. In contrast, for simple projects, there are always three actors only (a factory manager, a sales manager and a business manager). As far as we are concerned, we spent 78 hours in formal and informal meetings on the complex projects (39 % of the total time spent in project meetings) for a profit centre that reached 77 % of the activity.

Due to the complex project's (exploration) increasing uncertainty, small projects were more important to guarantee or recover the lost margin in those turbulent times. At the end of the third phase, the ERP project was successfully implemented from a technical point of view, but it did not provide the expected results from the management point of view. There was a strong resistance from Progitech's employees to use the new system. The lack of financial transparency prevented the Progitech management from making the right decisions and adjusting the company to the rapidly changing carmakers' requirements.

Effectiveness	The members of the steering committee focus on the effects of the research, i.e. the results of the intervention in relation to the objectives defined ex ante.

Efficiency	It is about appreciating the results of the research in relation to their cost. This control is double. On the one hand, in the case of a contracted and funded research, the company wonders if it got value for money. On the other hand, the efficiency is measured according to the respects of the deadlines on which the researcher is committed at the beginning of the intervention. However, this may reveal new research tracks that are more relevant than those originally planned. The delay then increases because the objectives have been redefined.
Relevance	The relevance relates to the object and the field of research. Are they relevant ex ante? More specifically, the control of the relevance will be exercised on: The accuracy of the initial diagnosis co-constructed by practitioners and researchers. What is its relevance to the subject, the field and the research process? Are the objectives of the research adapted to the subject and field during the course of the work? Intervention devices are also critically examined: are they adapted to the purpose and scope of the research? Are the staked deadlines not too far away or too close? Are the indicators in place relevant?
Consistency	The control of coherence results from the absence of contradictions and impossibilities in the results produced by the research

Table 2. Criterion of Internal Validity of the Research (Azan, 2004)

Discussion

In this part, we discuss the relationship between an exploration project and its IT support. We believe that this cross-functional perspective over time of Progitech's case will be helpful for engineers and managers (Nambisan et al. 2017). Why was in the long-run the group of simple projects successful and why was the group of complex projects more and more unsuccessful in the same firm ?

The viewpoint initially adopted was short sighted, because, initially, there was no intention to follow the case for twenty years. In the clinical research, exploration and exploitation require substantially different structures, processes, strategies, capabilities, and cultures for their pursuit and may have different impacts on firm adaptation and performance (He and Wong 2004). In particular, exploration is associated with organic structures, loosely coupled systems, path breaking, and improvisation (Ciborra et al. 1998).

The clinical research is based on a cognitive interaction between the PERP (ERP project) and the PAUT. These inquiries were manifested in the form, structure, goals, and conceptualization of the IT artefacts (e.g., an ERP system implementation) (Orlikowski and Iacono 2001). We argue that this clinical research method explicitly recognized artefacts as ensembles emerging from the design, use, and ongoing refinement in the context (in this case, an automotive engineering company). Although design researchers have already acknowledged this need, no standardized method exists to provide the required guidance and rigor. Beyond the clinical aspect, this research is a collaborative, rigorous and iterative process that goes through several phases in several cycles (Baskerville and Myers 2002, Davison et al. 2004). This is why this long period of time (20 years overall) of witnessing the initial project findings and subsequent phases was seen as an opportunity to perform an unusually long temporal analysis of several theoretical frameworks (exploration vs. exploitation projects and clinical research). In the long-run, the case of the simple exploitation projects reveals large inter-dependencies with the environment and a faculty to adapt them to the changing environment. The automotive project team members adopt the process and framework of the ERP.

Exploitation is determined by the handling of complexity. The takeover of Progitech was a definitive indicator of a turbulent environment and increased our strong interest to follow the research case over a long period. What initially appeared to be a mechanistic model of IS projects in a highly complex network of parameters: interacting decisions and projects, the available technology and its implementation (e.g., ERP) organizational changes (e.g., Progitech's takeover), and the environment’s evolution (customer needs, geographical spread, etc.). Loosely coupled system between car maker normalization Peugeot, Renault, Volvo, Skoda production system forced Progitech to adopt to focus on exploitation during acceleration phases of the PAUTs.

In this cloud of complexity, Progitech missed the ecological signals of this emerging organization and turned over the cycle for the complex PAUT. In terms of Levinthal and March (1993), there is myopia in the management learning process. The management that was successful at one time did not ensure the evolution of the company's governance structure. More importantly, they did foresee the future step of IS urbanization (the exploration phase). Efforts to reduce the complexity that arose at the intersection of the PERP and the PAUT clouded the recognition of the collective ecosystem. While being strongly anchored in the published theory fueled by the SICPARI research project, the program design (i.e., the project organization) sought to form a decentralized developmental organization. Despite the confidence of the clinician, these projects continued to evolve and affect both their environment and other projects.

In the long run that was actually myopia in the learnings of the IS that led to underestimating the impacts of the project interdependencies and the effects on programs, especially for complex exploration projects. For example, the mechanistic perspective led to the underestimation of the importance of an ideal organization and its IS implementation. The mechanical governance structures were neither appropriate nor effective for adapting the IS to the more global markets and supply chains. The risks were undervalued because Progitech underestimated the burden of the large programs. For example, the IT programs were disconnected from their parent organization KUKA, thereby losing advantages that should have been natural to the emerging ecology of the organization. As a result, the program organization did not anticipate the strategic changes (exploration), the evolution of the automotive market (e.g., China and emergent markets) and the evolution of carmakers' sourcing strategy from simple commodity projects to complex strategic partnerships based on contracting. The program's design and the outcome were initially successful, but they subsequently failed because the mechanical structures (that were well suited to simple projects) that resulted from exploration could not adapt to the rapidly emerging ecology (i.e., no period of exploitation followed) where complex projects were the major part of the business (Bughin et al. 2010).

As clinicians, we opt for a fragmented and asynchronous switch between exploration and exploitation phase (which is why we do not use the term balance). The paper above suggests that large IT projects in turbulent organizational environments might best be managed as systems in which components are constantly changing. The sense-and-respond organizational management, the switch off timing, are as important as long-term strategic planning. A more organic form of continuous management was needed to develop long-term successes.

The switch between exploitation and exploration regulates the necessary balance (Mizik and Jacobson 2003) between the two phases. For the theory, maintaining an appropriate balance between exploration and exploitation is a primary factor in the system's survival and prosperity. Companies need to achieve a balance between exploration and exploitation to achieve superior performance (Tushman and O'Reilly 1996). As stated by the Progitech CEO in 2014, 'We failed because we did not adjust our IT environment on time to fulfil the complex project owner's requirements'. The expert capabilities are required for the PAUTs and the future information systems projects because they possess all the knowledge that are transferred in the system. The problem is that these resources are scarce and devoted to the engineering tasks of the PAUTs.

The trade-off requires ambidextrous expert skills among and between the PAUTs and the PERP which is ignored by the literature (Azan, 2003). As concretely noted by O'Reilly & Tushman (2011), it appears that ambidexterity, as a dynamic capability (Karimi & Walter, 2015), rests on the ability of leaders to articulate a strategic intent and vision that justifies exploration and exploitation and to manage the inherent tensions associated with incompatible organizational architectures. These results also extend the previous research that has linked transformational leadership to successful ambidexterity. Nevertheless, this tension requires a 'switch' (Azan and al., 2017) mechanism that associates IT and the organization in order to rapidly adapt to the changing environment that is dedicating engineering resources (and especially knowledge) to exploitation and then to exploration. In the Progitech case, these cycles are simultaneously top-down and bottom-up.

The IS introduces a projective dimension and a dialectic of change (Boudreau et al., 2005; Azan & Huber Sutter, 2010; Azan and al., 2017). The literature associates the destruction of end users' communities and their knowledge due to IS implementation efficiency. Ciborra and al. (1998) goes so far as to discuss a 'boomerang' effect of IS projects that, through the formalization of data, reduces the future interpretative capacities of the organization. In a cyclical activity, this dialectic between exploration and exploitation is contra cyclically coupled with the dialectic of change in complex and simple projects. The dialectic of change

was evidenced in the literature. According to Goodhue and Gattiker (2005), the ERP system introduces interdependence among the units in which it is established.

Their research is aimed at determining the impact of the differentiation and interdependence between units in an organization that implements an ERP. Interdependence is defined as the level of dependence of a unit on the other units of the organization, as measured by the information flow. Differentiation is related to the product and/or market. The higher the level of interdependence, the less the company is differentiated, and the less the introduction of the ERP system instantly provides advantages for the company. The ERP project is dual according to Azan and al. (2017). This research allows for an understanding or anticipation of the moment when the organization will facilitate the exploitation and then the exploration of the simple and complex projects.

The limits of this work are underlined by the literature. Clinical research requires much time and many resource investments and is considered to be less scientific than other methods, which is over emphasized in practice (Avison et al., 2018). After a long data driven study the clinicians medicate IS exploration during exploitation for complex PAUTs and exploitation for simple PAUTs (Schein, 1995).

Conclusion

Far from this fascinating success story, this paper uses a clinical study that suggests that exploration versus exploitation strategies have a mechanistic aspect that can be dysfunctional when managing large programs of IT projects in highly turbulent environments. In such cases, a program of an IS project needs an organic management approach in order to cope with the increasing environmental turbulence.

The clinical research demonstrates that the results of the strategies tuned to mechanical systems and ERP sustained systems were short-sighted and were suitable only for simple project environments. In the current complex landscape, the management should adopt a view of their complex project landscape that recognizes that programs can be an ecological system rather than a mechanical system. Therefore, the Big Data wave might help them to survive in their respective businesses, assuming that they retain the capability to prevent a certain management myopia related to what we call immaterial agency issues.

In this clinical research, the timing of the switch between exploration and exploitation of the complex IS projects and of the automotive project is a key success factor. This clinical research can be interesting to understand other contexts like pandemic context. It can be helpful to analyze why a successful organization making a wrong decision will mechanically faces a disaster five or six years later.

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