R&D PROJECT TEAMS: CONTROL MECHANISMS AND KNOWLEDGE INTEGRATION PRACTICES

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Structured Abstract

Purpose

The purpose of the paper is to analyse how the organizational control mechanisms adopted within project teams in R&D settings influence the effectiveness of knowledge integration processes. In our research we analysed the functioning of project teams within an organization operating in the industry of turn-key devices for power plants. Our unit of analysis is the project team, a setting where it is possible to identify the presence of knowledge integration practices (Fong, 2004; Huang and Newell, 2003) and the implementation of control mechanisms (Clegg, Courpasson, 2004).

The concept of knowledge integration practices refers to the joint exploitation of distributed knowledge in a way which permits the access to, and utilisation of, individuals’ specialised knowledge in undertaking a collective effort (Enberg, 2007). The project team is a highly specialized knowledge setting where people with different competencies work together in order to get to a common goal.

Design/methodology/approach – The research unfolded considering a single case study, as this approach was considered useful in gaining in-depth, holistic understanding of the phenomenon studied, and in general is a preferred method when an organization finds itself in a new or peculiar situation, and special characteristics of this situation are to be studied (Yin, 1984).

In order to investigate the relationship between control mechanisms and knowledge integration processes we decided to conduct semi-structured interviews, standardising the most important...
questions, concerning 1) the use of different typologies of control mechanisms, 2) the nature and the characteristics of the relationship between control mechanisms and knowledge integration practices.

We chose a company working in the construction of turn-key devices for power generation plants operate in a very competitive industry, in which the peculiarities of the industrial product development process, and the number of suppliers involved, trigger complex and mutually interdependent R&D projects. Highly expensive industrial projects are typically led by a steering company that has developed over the years a strong competence in mastering the processes applied in the products to be supplied, and in integrating different knowledge bases (Lampel et al., 1996).

**Originality/value**

There is a little of research focused on the topic of relationship between organizational control mechanisms and knowledge integration practices (Ditillo, 2004; Nieminen and Lehtonen, 2008). Our paper tries to fill the gap of empirical studies on the topic. Our initial investigation witnesses that, in highly structured heavyweight project settings, formal control mechanisms may instead play the role of administering information exchange in order to achieve outcomes and effective knowledge integration.

**Practical implications** – The implications of this study to project managers are primarily related to the interconnectedness of control mechanisms and knowledge integration practices. Different control mechanisms can be used to support knowledge integration. However, it is important that the alternative mechanisms are coherent and not conflicting.

**Keywords** – knowledge integration, project management, control

**Paper type** – Academic Research Paper
1 Introduction

The ability to create knowledge usable for new products represents a crucial feature for the success of high technology firms (Keller, 2001). Firms nowadays have to handle increasing levels of competition and decreasing product-life cycles: because of that, the skill to support a continuous stream of innovation may play the most important role (Dougherty, 1996).

In this perspective there is a consolidated stream of literature that stresses the importance of soft managerial assets for improving performance and gaining a sustainable competitive advantage (Barney, 1991; Grant, 1996; Miller et al., 2007). For the purposes of this paper, we can define innovation in heavyweight industries as the recombination of existing ideas or knowledge to create a new idea that is useful and contains practical implications (Ancona & Caldwell, 1987; Chen et al., 2008).

As a consequence, the adoption of project teams within the R&D domain has become a frequent solution in many organizations (Iansiti and West, 1999; Thamhain, 2003).

There is a strong relationship between the increasing relevance of innovation as a tool to cope with competition, and the strategic significance of the project teams (e.g., Ancona & Bresman, 2007) that operate in environments characterized by technological change and uncertainty (e.g., Edmondson, Bohner & Pisano, 2001; Bresnen, 2007).

In the entrepreneurial world, the diffusion of models of highly project-oriented organizational macro-structure (Hobday, 2000) is associated with the creation of complex products/services, which for their development require competences localized in different functional areas and, typically, in markets characterized by a relentless change and by high-technological uncertainty (Gann & Salter, 1998; Canonico, De Nito, Esposito, Mangia, 2007).

In the literature debate, there is a research stream that stems from the idea that using project driven organizations facilitates innovation in a better way than using solely directives and routines. The main idea is that including within a single group diverse sources of knowledge and expertise can produce a positive effect on a firm’s capacity of innovating (Boutellier, Gassmann, Macho, and Roux, 1998).

We focus our analysis on a firm that manufactures special conveyors for hot and abrasive material, applied in particular in power generation plants.

Internal production processes in such company must be constantly sustained with a strong research endeavour, in order to develop continuously new products to be patented, that can meet customers requirements. Our aim is to analyse how the organizational control mechanisms adopted within project
teams in R&D settings influence the effectiveness of knowledge integration processes.

2 R&D project teams and knowledge integration in the coal fired power plants industry

Companies working in the construction of turn-key devices for power generation plants operate in a very competitive industry, in which the peculiarities of the industrial product development process, and the number of suppliers involved, trigger complex and mutually interdependent R&D projects. Highly expensive industrial projects are typically led by a steering company that has developed over the years a strong competence in mastering the processes applied in the products to be supplied, and in integrating different knowledge bases. These projects often contain innovative and unprecedented features which make costs and benefits hard to estimate: each project is made up of technical and economic aspects that are to some extent unique. Contractors, designers, or equipment suppliers that propose innovations to customers must therefore overcome additional difficulties in persuading them to accept their solutions (Lampel et al., 1996). The coal fired power plants industry adds on this scenario two further features. First, product development is in a sense a unique incremental process: R&D is an intrinsic feature of the activities carried out in the industry and new products are constantly introduced, even if, much often, as a recombination or adaptation of previously developed technical solutions. Therefore, companies have well structured product development processes and manage incremental innovation to meet customers’ requirements. Second, the industry is characterized by the need of bringing to the market the latest up-to-date available technology. In the industry of turn-key devices for power generation plants, therefore, the knowledge integration activity appears as crucial. Typically project managers in this industry deal with large projects with dozens of entities involved, and arrange on site activities in order to set up purpose-built innovative technical solutions. The process is structured around well-defined phases (Davila, 2000); each phase ends with a decision-making meeting where management decides about the future of the project. A typical product development project starts with a planning phase in order to establish the requirements of the project. During this phase, the organization defines the target market and the characteristics of the product. These characteristics include quality, costs, and expected release time.
The outcome of the initial phase is a broad description of these characteristics. The second phase - concept design - goes into more detail to specify the product specifications and the requirements of the development project: target costs, technological performance, customer interfaces, and organizational resources. The third phase - product design - is the actual development of the physical product. The process is iterative: product specifications or even the product concept can be re-evaluated in light of new information generated throughout the process.

The turn-key building of devices for a power plant is usually divided into subtasks, which relate to the type of activity performed and the actual outcome to be produced (design, shipping, civil construction, building construction, mechanical installation, tanks installation, electrical installation, turn-key start-up). A master schedule of the main milestones and their execution time is prepared at the beginning of the project, a detailed schedule is then prepared with the activities to be performed. Project updates show the change in project completion time due to the management of non-conformities.

A plant contractor usually engages a number of subcontractors, special suppliers, and manufacturers performing the construction works and procurement. This multiple-contract arrangement implies that a turn-key plant contractor is endowed with a strong knowledge integration capability. Moreover, contractors working at international level are committed to procuring skilled technicians in order to mitigate the impact of the poor performance of local labour force (Lampel et al., 1996).

Common working knowledge is primarily created within the project team, before being diffused throughout the organization.

The turn-key responsible company in such complex engineering projects occupies a central position in the system of entities participating in the project. From this position it is able to exercise influence on the analysis of problems and the type of solutions that are proposed as remedies. This capacity may be constrained by two factors. The first is the degree of available internal expertise to evaluate problems and solutions. The second factor is the willingness to actively become involved in the complex and detailed work of developing and implementing solutions for each single technical problem arising. In the absence of internal expertise, turn-key responsible company is forced to rely on other organizations to develop solutions. To ensure that solutions are fully implemented, these organizations become involved in detailed engineering and supervision, or delegate these responsibilities to other organizations (Lampel et al., 1996).

From this brief description, it emerges the relevance of knowledge integration in this setting.
3 Control issues and knowledge integration implications in R&D project teams

Control in organizations has long been a topic of interest for researchers and practitioners alike, who generally recognize that control mechanisms are needed to ensure that organizations may achieve their goals (Kirsch, 1996).

According to Kirsch (1996), it is possible to distinguish two main categories of control mechanisms: formal (behavioural based and outcome based) and informal (clan and self control).

Formal mechanisms control are directly related with the possibility of managing information. In particular, the behavioural mechanisms are based on the control of the transformation processes, whose knowledge is the key variable. Ouchi (1979) states that only when you have a perfect knowledge of the process, you can implement a behavioural control. The output based control mechanisms can be used when it is possible to measure the organization’s results.

Lindkvist et al. (1998:940) state that the frequent adoption of “tests and other similar forms of formal control mechanisms can create a sense of shared responsibility for vital sub-parts of the system and encouraged interfunctional dialogue and compromise”.

There is a direct relationship between the degree of formalisation and of standardisation and the extent of application of formal control mechanisms (Walton, 2005).

Informal mechanisms are based on social and cultural values. Ouchi (1979) identifies the concept of clan as social mechanism to control organizational members. It is clear that, in this hypothesis, shared and common values play the main role, producing a sort of “isomorphism” in the members’ behaviour.

The last typology is defined as self control (Kirsch, 1996) and reminds the idea of self-management. Each single member behaves autonomously, setting up his own goals, monitoring his own work and rewarding and sanctioning himself if necessary (Kirsch, 1996).

The conceptualization of managerial control within projects can be done emphasizing different aspects, ranging from standardised mechanisms (procedures, formal rules…), to organizational culture and individual identity. Typically, in the managerial rhetoric the maximum emphasis is devoted to the design and implementation of impersonal, bureaucratic mechanisms, whereas culture identity are significantly less addressed (Alvesson, Willmott, 2002). Following the idea of control within project management stated by Clegg & Courpasson (2004), it is possible to identify three different typologies: -reputational;
Reputational control is composed by two different components: the first is hierarchical, the second is a peer-based one.

Reputational control, in which high reputation of members is used to maintain certain positions and marginalise those with lower reputation, is likely to work in large networks where there might not be shared values and beliefs.

The category of calculative control mechanisms include accounting systems that can be introduced to assess the performance gained by individuals within the project group. The calculative mechanisms can be focused both on behaviours and outputs (Kirsch, 1996). In other words, these mechanisms aim at checking if objectives (in terms of behaviours and outputs) have been effectively respected.

Sometimes, calculative mechanisms can be used and managed by people who do not belong to the team. In this sense, external calculative control mechanisms (Clegg & Courpasson, 2004) impact both on learning process and on internal dynamics. Clegg and Courpasson state: “In project management the aim of external calculative control over the project is to ‘gain enough known-how to reduce the impact of a potential surprise’ (Landau & Stout, 1979)”.

If we focus our attention on the nature of calculative control mechanisms, we can better understand how it is possible to conceive the project management itself as a “…system for controlling costs and achieving objectives. Control procedures are pervasively and powerfully embedded into the regular and efficient reporting of actions and decisions made. Reporting is essential to the project objectives and is considered by the governing bodies an indication of the successful operation of the project” (Clegg & Courpasson, 2004: 538).

Following the idea stated by Arnaboldi et al. (2004), formal control mechanisms are necessary in order to increase the effectiveness level of the project. Arnaboldi et al. (2004: 221) state: “Two further instruments helped in avoiding project failure: continuous communication and the definition of a management control system. Both formal and informal communications, such as official reports and frequent meetings, allowed the circulation of information at all levels, informing constantly on the results of the project. The defined measurable indicators was fundamental: particularly for convincing the steering committee and maintaining the needed commitment”.

The nature of professional control mechanisms can be understood by considering the fact that the functioning of a project group implies the introduction of a “reticular professional supervision” (Clegg

Remarking the fact that the project leader observes each other behaviours (Clegg and Courpasson, 2004), we think that the effect produced by the internal dynamics of project groups implies that each single member can exercise a sort of surveillance on the other members.

It seems possible to state that the more is the longevity of the group, the intensity of shared knowledge, the reciprocal trust, the more is the effectiveness of the professional control mechanisms. In other words, as Clegg & Courpasson (2004) claim, professional control can be considered as a supervisory tool: project leaders (but also each individual) can push or constrain the other participants to behave in the desired way.

Considering projects taking place in R&D heavyweight industrial settings, literature on control mechanisms is twofold. One line of research is inspired by accounting concerns and focuses on monitoring the effectiveness of how R&D departments spend the financial resources they get allocated from corporate level (Rockness & Shields, 1984).

A second stream of research, closer to organizational studies, deals with organizational issues coupled with the need of exercising control on R&D units. Kamm (1980) defines control as “the set of criteria, policies and procedures established to standardize operations and to make possible measurement of performance to insure achievement of organizational objectives” (p. I-12, I-13). Rockness and Shields (1984) study the relationship between types of control and project characteristics. Following Ouchi's framework (Ouchi, 1979), they classify R&D projects according to the level of knowledge of the transformation process and the measurability of the output. Then they predict a relationship between these characteristics and the type of control used: input, behavior, and output control. Kamm (1980) states that “researchers do not necessarily exhibit more innovative behavior when they perceive relatively loose administrative control than when they perceive tight control” (p. IV-11).

However, formal control systems have proven to be useful tools in R&D environments characterized by high levels of uncertainty. Formal control systems affect the ability of integrating knowledge in highly technological industrial setting, in which procedures and organizational routines are often not easily replicable because of the initial barrier of harnessing technical complexity.

To this extent, Grant (1996:381) points out that “the greater the scope of knowledge integrated, the harder it is for competitors to replicate the integration capability”: the scope of integration may be effectively defined as “the level of complexity underlying the integration of differentiated knowledge” (Huang & Newell, 2003:169).
Simons (1987) reports that high performing prospectors rely on the information provided by frequently updated formal control systems to drive organizational learning (Dent, 1990).

Davila (2000) provides an explanation for the apparent contradiction between the results for R&D environments, where management control systems seem not to be relevant, and other industrial settings. The explanation lies in a different interpretation of management control systems. R&D studies interpret these systems as control tools to reduce goal divergence rather than as information tools to deal with uncertainty.

These findings are in line with the concept of clan control (Ouchi, 1979). Clan control emphasizes informal control mechanisms and relies less on formal systems. When uncertainty is high, clan control is preferred to solve goal congruence problems (Ouchi, 1979).

Furthermore, there is a relationship whit the concept of information. In fact, in a new product development setting control mechanisms can be interpreted as sources of information that are used to close the gap between the amount of information needed and available. In coherence with this idea, Tushman and Nadler (1978) state that control mechanisms within organizations can be considered as tools in order to cope with the degree of uncertainty: the main idea is that control mechanisms provide data and information that may reduce Galbraith's “information gap”. It is also expedient to consider that control mechanisms may mismatch, when there is a sort of incoherence between the information they provide and the degree of uncertainty the product development manager has to cope with. In this case, the most important information can be gained through experimentation (Pisano, 1994) or informal communication (Allen, 1977; Dougherthy, 1990).

4 The Magaldi case

4.1 Methodology

The research unfolded considering a single case study, as this approach was considered useful in gaining in-depth, holistic understanding of the phenomenon studied, and in general is a preferred method when an organization finds itself in a new or peculiar situation, and special characteristics of this situation are to be studied (Yin, 1981, 1984). In order to investigate the relationship between PM and control mechanisms within the construction of turn-key devices for power generation plants industry, we decided to conduct semi-structured interviews, standardising the most important questions,
concerning 1) the role played by the project leader, 2) the use of different typologies of control mechanisms, 3) the specific characteristics of control mechanisms used.

4.2 Overview of the company

The Magaldi group was created back in the 1920’s upon the inventive ability of the Magaldi family, which, since the XIX century, have discovered new ways of introducing cutting edge inventions in various businesses.

The founder of the group, Paolo Magaldi, started a large scale industrial activity already in 1929, manufacturing a unique leather transmission belt (the so called Magaldi Supercinghia), patented earlier in 1901 by Emilio Magaldi.

Such device is still very much in use today as an extremely reliable belt to convey stamped steel plates and sharp steel sheets in automotive press shops and cutting plants.

The great achievements of the Supercinghia were confirmed in the 70's by the Magaldi Superbelt, an highly dependable steel conveyor belt. Thanks to its unique design, the Magaldi Superbelt may be used in any application where continuous operation and extremely severe working conditions are required.

In the 80's the Magaldi Group, moving ahead with the evolution of the market and relying on the experience accumulated during the years with the Superbelt, developed the MAC (Magaldi Ash Cooler), a dry system able to handle bottom ashes of solid fuel fired boiler without using a drop of water. This system allows to save tons of water and insures a continuing operation of thermoelectric power plants.

As the group became larger, it was decided to add to the original company Magaldi Industrie S.r.l., a new branch, Magaldi Ricerche & Brevetti S.r.l., focused mainly on developing and researching new technologies.

In 1997 was founded the RRS S.r.l. company, concentrated on the operation of Magaldi systems in accordance to the BOT financing model and producing expert automation systems.

In 2001 the Magaldi Power S.p.A. was incorporated to the Group with the mission to develop and increase the Magaldi Ash Cooler sales in the international markets.

Magaldi Power S.p.A. has sold directly by turn-key basis or through qualified licensee, more than 80 ash cooler systems for a total of more than 23,000 MWe installed.

In 2003 the Magaldi Australia Pty was founded, to establish and consolidate the presence of
Magaldi Group on the Oceanian market.

Such businesses have evolved towards formally autonomous entities registered as distinct companies, belonging to the Magaldi family holding.

A central R&D support office provides Magaldi Group project teams worldwide with necessary technologies and methodologies to market the best products, achieving the optimisation of production processes in terms of performance, safety, cost and environment. Such endeavour may be accomplished pointing at high process effectiveness through the early introduction of new manufacturing processes and optimisation tools in product development, and realising high product targets with low manufacturing costs by selective use of new materials and emerging technologies.

4.3 R&D project teams in Magaldi

Magaldi group has evolved in recent years from a traditional manufacturing company to an engineering business able to provide turn key devices for plants to high tech industrial customers.

In order to be able to manage such evolutionary path, the company has then undergone a deep organisational restructuring.

Magaldi’s operations have more and more been driven under the imperatives of time, cost and quality: these inescapable market needs were heavily supported by a widespread adoption of project modalities of working.

Overall, the company has preserved a functional orientation in setting up organizational units: specialized offices are Technical, Quality, Procurement, Commercial, Human resources.

If this move evokes an idea of distinct accountability of each organizational unit, the main tenet of the new structure is the recurrent use of project teams as, at the same time, drivers for supporting the management of each contract awarded and locus of innovation in terms of incremental development of ad hoc technical solutions.

Typically each PM is responsible of one or more contracts and must make sure that the all providers deliver what is expected from them.

It should be noted that in this vision project teams are in charge of delivering the actual product commanded by the external customer and elaborate new technical countermeasures to meet the specificities of each production site. PM are also in charge of verifying the economic advantage of
recurring to market transactions with external suppliers.

Magaldi encourages the vision of each contract project team as a unit able to deliver innovation. Key roles in the process are played by the following figures: the head of sales department (COM), the Contract project manager (PM), the person responsible of all project managers in Magaldi (CHPM), the head of technical department (TECH), the head of procurement department (PROC), the head of quality department (QUAL).

The COM transfers to CHPM the details of each contract awarded to Magaldi group, and activates the information system purposely built to support the flow of activities.

The CHPM is supposed to assign the contract to a PM of choice among those working in Magaldi.

Such choice relies on items such as previous experience, task complexity, current work load: the formal designation takes place through the information system, that is charged to provide to the newly designated PM the first operative instructions useful to call for the project kickoff meeting.

The PM is then engaged in setting up the project team, verifying the available technical expertise within Magaldi group. The main issue at stake is deciding if it is cheaper to buy sub-products or services from external suppliers or triggering a production line within the company’s own manufacturing plant. If the first option applies, the project team may include specialists from external suppliers legally bound to Magaldi by a contract that disciplines their role in the project team.

The following table resumes the main responsibilities assigned within the process of delivering the contract.

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<th>PM</th>
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<td>Selecting the PM</td>
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<td>Transferring to PM any useful</td>
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<td>information for carrying out the</td>
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<td>activities depicted in the contract</td>
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Weekly control of scheduled activities | X
---|---
Managing non-conformities | X
Overall control of integration | X
Meeting project deadlines | X
Ensuring quality to customer | X
Ensuring technical feasibility | X
Organising quality checks | X
Verifying and arranging external procurement | X | X | X

The process of delivering the contract is seen as the locus in which technical innovation takes place. R&D support staff only facilitates this process as a side actor, but the responsibility for providing a new answer to the customers’ needs relies primarily on the project teams and then on PM and on the CHPM. The different typologies of organizational control mechanisms adopted within R&D project teams in Magaldi can be interpreted in accordance with their degree of formalization. Magaldi R&D project teams are ruled by a routine approach to incremental innovation that relies on formal control mechanisms. Calculative control mechanisms (Clegg & Courpasson, 2004) are not seen in contradiction with the need of generating innovation, but do contribute to assign and verify innovative tasks based on recombination and adaptation of extant technical solutions. In terms of control mechanism, it has been stated that formal control mechanism (Kirsch, 1996) imply a bureaucratic logic (Cardinal, 2001). Cardinal states that “bureaucratic control - assumed to be predominantly a matter of behaviour control – has been viewed predominantly as a mechanism that stifles creativity and fosters employees dissatisfaction” (Cardinal, 2001: 22). In the case of the industry under investigation, formal control mechanisms based on a calculative approach are seen instead as a way to rule out the process of product delivery and enable effective knowledge integration by clarifying tasks and responsibilities. This applies of course also because of
the intrinsically structured modality of working that this industry is called to enforce giving the complexity and the various interdependences of its production processes.

Formal mechanisms control are moreover directly related with the possibility of managing information. In particular, the behavioural/process mechanisms (Turner and Makhija, 2001) are based on the control of the transformation processes, whose knowledge integration is the key variable.

5. Conclusions

In R&D domain, there is a strong debate focused on the variables that affect the real effectiveness of knowledge integration practices. In particular, in our research we analysed the functioning of project teams in an organization operating in the industry of turn-key devices for power plants, in order to understand the influence produced by control mechanisms on the effectiveness of the groups expressed in terms of knowledge integration able to generate new concepts for product development.

Generally, in R&D settings the knowledge creation processes tend to be unpredictable and difficult to design: formal control mechanisms may lead to put “too much emphasis on more incremental projects with more predictable outcomes and faster returns even if these returns are smaller in the long run” (Cardinal, 2001: 25). Our initial investigation witnesses that, in highly structured heavyweight industrial settings, formal control mechanisms may instead play the role of administering information exchange in order to achieve projects outcome and the desired level of knowledge integration.
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