The project-based organisation: an ideal form for managing complex products and systems?

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Abstract

This paper examines the effectiveness of producing so-called CoPS (i.e., complex high value products, systems, networks, capital goods, and constructs) in a project-based organisation (PBO), as compared with a more traditional functional matrix organisation. A simple model is developed to show how the PBO relates to identified forms of matrix and functional organisation and a case study is used to identify some of the strengths and weaknesses of the two organisational forms for CoPS production. On the positive side, the PBO is an intrinsically innovative form as it creates and recreates new organisational structures around the demands of each CoPS project and each major customer. The PBO is able to cope with emerging properties in production and respond flexibly to changing client needs. It is also effective at integrating different types of knowledge and skill and coping with the project risks and uncertainties common in CoPS projects. However, the PBO is inherently weak where the matrix organisation is strong: in performing routine tasks, achieving economies of scale, coordinating cross-project resources, facilitating company wide technical development, and promoting organisation-wide learning. The PBO can also work against the wider interests of corporate strategy and business coordination. Strategies to stimulate organisational learning and technical leadership include the deployment of coordinators along functional lines to cut across project interests and incentives. Project tracking and guidance at the corporate level is also important for achieving broader business goals. The paper illustrates the wide variety of organisational choices involved in producing CoPS and argues that the nature, composition, and scale of the product in question have an important bearing on appropriate organisational form. © 2000 Elsevier Science B.V. All rights reserved.

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1. Introduction

In contrast to the functional and matrix organisation, the project-based organisation (PBO) has been put forward as a form ideally suited for managing increasing product complexity, fast changing markets, cross-functional business expertise, customer-focused innovation and market, and technological uncertainty. This applies particularly to high value, complex industrial products and systems (or ‘CoPS’), the sophisticated high technology capital goods, which underpin the production of goods and services. Some studies suggests that the PBO is a natural organisational form for CoPS producers, especially when several partner suppliers are engaged with the user through the various stages of innova-
Existing firm-level research explores the potential advantages of PBOs, tensions between project- and corporate-level processes, PBO suitability for producing service-enhanced products, and the nature of PBO behaviours and structures (Brusoni et al., 1998; Gann and Salter, 1998). Focusing on the project rather than the firm, the new product development (NPD) field points to the benefits of strong projects in NPD, the leadership requirements for ‘heavyweight’ project teams (Clark and Wheelwright, 1992), and the need for the greater professionalisation of project management as projects assume increasing importance across various high technology industries (Pinto and Kharbandha, 1995).

So far, however, there has been little research on the scale or pace of diffusion of the PBO form, or how the PBO actually operates in practice in the management of CoPS. We know very little about the PBO or how its processes differ from those of various matrix/functional forms of organisation or how disadvantages of the PBO can be overcome in practice. Nor has there been much discussion of the various different types of PBO (e.g., large vs. small PBOs, single project vs. multiple project PBOs).

The aim of this paper is to identify some of the features of the PBO by looking in depth at how CoPS projects are managed in one large PBO, comparing this with CoPS produced in a functional division of the same company. The purpose of taking a ‘bottom up’ project perspective is to explore the dynamics of project structures, processes, and performance in the PBO vs. a functional organisation. Although it is outside the scope of the paper to examine corporate-level structures and processes, the case illustrates some of the key advantages and disadvantages of the PBO in the execution of major CoPS projects and draws attention to tensions between project and company-wide processes in PBOs. The paper also suggests how some of the problems intrinsic to the PBO form can be overcome in practice.

One of the problems of case study research of this kind is the counterfactual difficulty of knowing what would have happened (e.g., in terms of performance) if another organisational structure had been applied. It is also difficult to attribute particular behavioural and performance attributes (e.g., flexibility, effectiveness, efficiency, and return on investment) to particular factors such as organisational form, rather than other factors (e.g., project leadership, company culture, product market differences, and senior management support). The method adopted to overcome some of these difficulties is to take the case of a single large CoPS supplier which, for particular historical reasons, operates a mix of both project-based and functional/matrix forms, addressing similar product markets and clients with the same senior management team. The paper analyses and compares two CoPS projects of similar value, duration, technology, and customer, in the two distinct strategic business units, one PBO and one functional/matrix. By identifying process differences, as well as the advantages and disadvantages of both forms, the paper points to some important limits of the PBO in the management of CoPS projects. It also identifies a modified form of the PBO, termed here the ‘project-led organisation’, which has been used to overcome some of the limits of the pure PBO.

The paper is structured as follows. Section 2 examines the nature of the project management challenge in CoPS. Section 3 then provides a working definition of the PBO and develops a simple model to show how the PBO differs from and relates to other forms of organisation identified in the literature. Section 4 then presents the case of a producer of highly complex, particle accelerator systems (Complex Equipment Inc.) to illustrate the advantages and disadvantages of the PBO structure, focusing on project processes, problems, and performance. Section 5 interprets the evidence arguing that the PBO provides a concurrent and outward-looking approach to project management, while the functional/matrix form embodies a more linear, inward-looking and less flexible approach. Section 5 also comments on the underlying economic motivations for adopting a project-based form for CoPS and

1 Although the case study design allows an in-depth comparison of the different structures and projects within the same firm, the method cannot fully overcome the problem of project uniqueness and history (see Section 4.1 for a discussion of the limitations of the method and possible ways of overcoming these in future research).
indicates strategies which can be used (e.g., the deployment of a milder form of PBO, the ‘project-led organisation’) to resolve corporate strategy and company-wide learning problems inherent in the PBO.

2. Innovation in CoPS

2.1. What are CoPS?

CoPS are the high-technology, business-to-business capital goods used to produce goods and services for consumers and producers. Unlike high volume consumption goods, each individual CoPS is high cost and made up of many interconnected, often customised parts (including control units, sub-systems, and components), designed in a hierarchical manner and tailor-made for specific customers (Hobday, 1998; Walker et al., 1988). Often their sub-systems (e.g., the avionics systems for aircraft) are themselves complex, customised, and high cost (Mowery and Rosenberg, 1982). As a result of their cost, physical scale, and composition, CoPS tend to be produced in projects or small batches, which allow for a high degree of direct user (sometimes owner-operator) involvement in the innovation process, rather than through arms-length market transactions as is normally the case in commodity goods.

During design and production, small design changes in one part of a system can lead to large alterations in other parts, calling for more sophisticated control systems, new materials, and novel design approaches. Once installed, some CoPS (e.g., intelligent buildings and computer integrated manufacturing systems) further evolve as users expand, optimise, adopt, and operate the system (Gann, 1993; Fleck, 1988).

Product complexity, of course, is a matter of degree. Hobday (1998) puts forward various dimensions of product complexity, including numbers of components, the degree of customisation of both system and components, the number of design choices, elaborateness of system architectures, the range, and depth of knowledge and skill inputs required, and the variety of materials and information inputs. According to an amalgam of these dimensions, some products can be categorised as ‘extremely complex’, embodying many highly elaborate, customised sub-systems and components, new knowledge and multiple feedback loops in both design, and production (e.g., a new generation military aircraft). At the other end of the spectrum, there are less complex products where the boundaries of uncertainty are better understood, architectures and components are relatively well-established, reducing the risk inherent in the production of each good (e.g., a new model flight simulator). In between there are ‘highly complex’ and ‘moderately complex’ goods. In all cases though, ‘complex products’ can be distinguished from simpler or even complicated products, where architectures are relatively simple, components are relatively few in number (and usually standardised), the degree of new knowledge required for each product is fairly constrained, and production tasks can be codified, routinised, and automated to produce process efficiency and cost reduction based on volume (e.g., a bicycle or toaster could be described as ‘simple’ products, whereas a passenger vehicle could be described as ‘complicated’ but not complex, as defined here.

Technical progress, combined with new industrial demands have greatly enhanced the functional scope, complexity, pervasiveness, and performance of CoPS (e.g., business information networks, tailored software packages, and internet super-servers). The nature of CoPS can lead to extreme task complexity, which, in turn, demands particular forms of management and industrial organisation.

2.2. Industrial innovation in CoPS

CoPS are often produced within projects which incorporate prime contractors, systems integrators, users, buyers, other suppliers, small- and medium-sized enterprises (SMEs) and sometimes government agencies and regulators. Often, these ‘innovation actors’ collaborate together, taking innovation (e.g., new design) decisions in advance of and during production. Sometimes users and suppliers engage in co-engineering throughout the production process. Prime contractors and systems integrators are responsible for managing CoPS projects, which amount to temporary multi-firm/user alliances. Given the nature of CoPS, systems integration, and project management competencies are critical to production
effectiveness and efficiency. The project is a widely used form of coordination in CoPS. The project is a focusing device which enables different types of innovation actors to agree the fine detail of CoPS development and production. The project is responsible for realising the market, for coordinating decisions across firms, for enabling buyer involvement, and for matching technical and financial resources through time. The project exists to communicate design and architectural knowledge and to combine the distinctive resources, know-how, and skills of the collaborators.

Because production is oriented to meet the needs of large business users, the project management task is fundamentally different from the mass production task. As Joan Woodward (1958, p. 23) put it in her research into UK project-based companies in the 1950s: “those responsible for marketing had to sell, not a product, but the idea that their firm was able to produce what the customer required. The product was developed after the order had been secured, the design being, in many cases, modified to suit the requirements of the customer. In mass production firms, the sequence is quite different: product development came first, then production, and finally marketing.”

The specific CoPS in question will shape the form and nature of the project. In the case of very large engineering constructs, entire project-based industrial structures can be called into being by various stakeholders for the purpose of creating a single product. The Channel Tunnel, for example, entailed a massive task of financial, managerial, and technological coordination involving hundreds of contractors, at least 208 lending banks and around 14,500 employees at its peak (Lemley, 1992, p. 14, 23). By contrast, with smaller CoPS (e.g., flight simulators and telecommunications exchanges) much of the project task is carried out within the managerial span of control of a single firm.

In CoPS, design-intensity and product complexity lead to many extremely complicated, non-routine tasks (Hobday and Rush, 1999). Users frequently change their requirements during production, leading to unclear goals, uncertainty in production, and unpredictable, unquantifiable risks. Success and failure are multifaceted and hard to measure. Managers have to proceed from production stage-to-stage with incomplete information, relying on inputs from other suppliers who may be competitors in other projects. In some cases these challenges have led firms to re-organise their entire business activities along project-based lines, leading to project-based organisational structures.

3. The nature of the PBO

3.1. Definition and key propositions

In contrast to the matrix, functional, and other forms, the PBO is one in which the project is the primary unit for production organisation, innovation, and competition. Although the PBO is commonly used in private manufacturing enterprise, it is also deployed in other organisations (public and private), including the legal profession, consultancy firms, marketing, the film industry, and advertising. While a project can be defined as any activity with a defined set of resources, goals, and time limit (e.g., for information technology or new materials), within a PBO the project is the primary business mechanism for coordinating and integrating all the main business functions of the firm (e.g., production, R&D, engineering, NPD, marketing, personnel, and finance).

Within a pure PBO (i.e., an organisation in which no other form is present), major projects will embody most, if not all, of the business functions normally carried out with departments of functional and matrix organisations. In some cases, the project involves a consortium of companies (e.g., Sematech, Airbus, the Channel Tunnel, and the Millennium Dome). In other PBOs, much or all of the project may be carried out within the boundaries of a single company. Because core business processes are organised within projects rather than functional departments, the PBO is an alternative to the matrix, where business functions are carried out both within projects and along functional lines. In the PBO, the
knowledge, capabilities, and resources of the firm are built up through the execution of major projects.

Project managers (PMs) within the PBO typically have very high status and direct control over business functions, personnel, and other resources. PMs and directors are senior to resource coordinators (the nearest equivalent to the functional manager in the PBO), whose role is to support the needs of projects and PMs and, sometimes, to coordinate business functions across various projects (e.g., technical, human, and financial resources for project bidding, management, systems engineering, and so on).

Because the project is a temporary organisational form, the PBO is inherently flexible and reconfigurable in contrast with the anti-innovation bias of large integrated, hierarchical organisations described by Williamson (1975) and Teece (1996) and the core rigidities identified by Leonard-Barton (1992).

Within the PBO a project is often a major business endeavour and the normal mechanism for creating, responding to, and executing new business opportunities. Each project is likely to involve a specific well-defined product and one or a few identified customers. In many cases, the customer (often a user or owner—operator) will be closely and directly engaged in primary innovation and production processes, as each project will tend to be critical to the business functioning, performance, and profitability of the user. The PBO is widespread in traditional industries (e.g., construction, shipbuilding, and major capital projects), industries that have been regenerated through new technologies (e.g., aerospace and telecommunications), newly emerging industries (e.g., information and communication technologies) and many other examples of business-to-business, high-technology, high value capital goods.

In principle, the PBO is not suited to the mass production of consumer goods, where specialisation along functional lines confers learning, scale, and marketing advantages. However, within large manufacturing firms the project form is used to organise specific non-routine activities and complex tasks such as R&D, NPD, and advertising campaigns. Also, some large multiproduct firms embody both PBO and functional divisions (or strategic business units) to deal with different types of products, technologies, and markets (e.g., producers of both telecommunication handsets and exchanges). Thus, particular projects may be ‘large’ for a small or medium-sized firm or ‘small’ for a large or very large firm, implying that the manner in which project organisations are established, perceived, and deployed varies with firm characteristics.

PBOs organise their structures, strategies, and capabilities around the needs of projects, which often cut across conventional industrial and firm boundaries. In CoPS industries, there are many different categories of PBO, ranging from large prime contractors, which specialise in project management and systems integration, to tiny specialised sub-contractors, which supply tailored components, software or services. Any one project may combine these groups in a variety of roles, with the same firm acting as prime contractor in some projects and sub-contractor in others. Not all firms within a project are necessarily PBOs. Also, PBOs can range from firms servicing one single project to firms which execute many hundreds of projects at any one time (e.g., in construction).

The structures and business processes of PBOs are likely to be shaped by the changing profile of projects, especially their size, complexity, and duration. Some PBOs (e.g., in construction) are likely to derive most of their income from large projects over which they exercise little direct span of control (Gann, 1993). In other cases, firms may direct and control particular projects, largely from within the firm, as noted earlier. Major new projects become central innovation events in some CoPS industries, giving rise to new business opportunities and novel technological trajectories.

3.2. Research perspectives on the PBO

Various bodies of research help inform our understanding of the position, nature, and advantages of the PBO. At the project level, research on NPD has long recognised the importance of the project for integrating business functions and responding to complex technical challenges for the purpose of developing new products. Clark and Wheelwright (1992), for example, describe four basic types of organisational structure for NPD: (1) functional; (2)
lightweight project structure; (3) heavyweight project structure; and (4) project-based. In conventional functional/lightweight project structures, PMs tend to be junior to functional managers and have no direct control over resources. In the heavyweight project approach, functions such as marketing, finance, and production tend to be coordinated by managers across project lines, but PMs have high status and direct control over financial resources and people.

In their analysis of the influence of management structure on project success, Larson and Gobeli (1989) show how both project management structure and other variables such as new technology, project complexity, managerial competence, top management support, project size, and well-defined objectives impact on project success. Pinto and Prescott (1988), analyse how critical success factors vary over the life cycle of projects, while Pinto and Covin (1989) show how such factors depend on the type of product and activity in question. Shenhar (1993) provides insights into the importance of new knowledge in project risk and uncertainty, comparing low with high-technology projects.

Focusing on the benefits of the project form, some innovation scholars have argued that projects and project management are the ‘wave of the future in global business’ due to increasing technical and product complexity, shortening time to market windows, and the need for cross-functional integration and fast response to changing client needs (Pinto and Kharbanda, 1995). It is certainly reasonable to assume that as market change, risk, and uncertainty increase, the project form will grows in importance in a wide range of industries and tasks.

At the firm level, traditional innovation writers have long recognised the advantages of flexible project-based organisational forms. Burns and Stalker (1961) made the classic distinction between organic and mechanistic organisational forms, arguing that if a stable routine environment prevailed and the market was fairly predictable, then firms can reap advantage from mechanistic, functional organisational forms with clearly defined job descriptions, stable operational boundaries, and Taylorist methods of working. However, in the case of rapidly changing technological and market conditions, then open and flexible (‘organic’) styles of organisation and management are required which are able to link functions such as R&D and marketing.3

3.3. A simple positioning framework for the PBO

In order to understand the relationship between the PBO and other types of organisation, Galbraith (1971, 1973) describes a range of alternatives from pure functional form through to pure product form, where management structures are centred upon each product (equivalent to the PBO). Building on Galbraith’s work, Larson and Gobeli (1987, 1989) describe three distinct types of matrix. First, is the functional matrix, where the PM is confined to coordinating resources, monitoring progress, and reporting into one or more functional managers. Second, is the balanced matrix, where responsibilities and authority for each project are shared between functional and PMs. The third is the product (or project) matrix, where the PM has authority over personnel,
finance, and other resources. Finally, the pure product/project-based form is an extreme form where the business is organised solely around product/project lines.

Interpreting the above literature, Fig. 1 provides a description of six ideal-type organisational forms ranging from the pure functional form (Type A) to pure project form (Type F). The various functional departments of the organisation (e.g., marketing, finance, human resources, engineering, R&D, and manufacturing) are represented by F1 to F5, while notional CoPS projects are represented by P1 to P5. Type B is a functionally-oriented matrix, with weak project coordination (as described in the case study ‘FMD’ below). Type C is a balanced matrix with stronger project management authority. Type D is a

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**Key:**

* F₁, F₅ = various functional departments of the organisation (e.g., Marketing, Finance, Human Resources, Engineering, Manufacturing, R&D)

* P₁, P₅ = major projects within the organisation (e.g., CoPS projects)

* SM = senior management

**Note:**

* The number of functions and projects will vary according to the organisation in question. Various permutations are used here for illustration.

Fig. 1. Positioning the project-based organization. (A) Functional, (B) functional matrix, (C) balanced matrix, (D) Project matrix, (E) Project-led organization, (F) Project-based organization.
project matrix, where PMs are of equal status to functional managers.

Beyond the project matrix, lies a form not identified in the literature (Type E), called here a ‘project-led organisation’, in which the needs of projects outweigh the functional influence on decision-making and representation to senior management, but some coordination across project lines occurs. Finally, Type F is the pure PBO as defined in Sec. 3.1, and illustrated below in the case study ‘PBD below’. Here, there is no formal functional coordination across project lines; the entire organisation is dedicated to one or more CoPS projects and business processes are coordinated within the projects.

The positioning diagram helps to contrast the various forms of organisation available and to highlight those most suited for different types of CoPS, accepting that a mixed organisational structure is possible even within a single business unit. Forms A to C are unsuitable to managing the CoPS, because they are not appropriate for performing non-routine, complex project tasks in an uncertain, risky, and changing environment. CoPS projects require ‘super-heavyweight’ professional PMs (or directors), capable of integrating both commercial and technical business functions within the project and building strong lines of external communication both with the client (often the source of the innovation idea) and other collaborating companies. These external innovation actors typically have different goals, structures and cultures, and the task of the CoPS project director is to skilfully negotiate a path towards successful completion.

The pure PBO is probably best suited for large innovative projects and single project firms, where resources have to be combined and shared with other firms in the project (the multi-firm CoPS project). The PBO is a form suitable for meeting innovative needs, responding to uncertainty, coping with emerging properties, responding to changing client requirements and learning in real time. By contrast, the PBO is weak where the functional matrix is strong: in coordinating resources and capabilities across projects, in executing routine production and engineering tasks, achieving economies of scale and meeting the needs of mass markets.

More broadly the framework implies that in choosing an appropriate organisational form the nature, scale, and complexity of the product must be considered. With a balance of small batch, CoPS, and mass produced goods, organisational choices become messy, complex, and dynamic. Mistakes can be very costly. As the product mix evolves, organisations need to change in order to respond to product market needs.

3.4. Gaps in the literatures

While Galbraith (1971) and others provide useful tools for positioning the PBO in relation to other organisational forms, they fall short of examining the PBO itself and do not analyse its advantages and disadvantages. Surveys of project success/failure factors are generally unable to explore intra-project dynamics and tend to ignore the informal, human (or ‘soft’) side of project progress which are so important to performance (Katz, 1997). Much of the literature tends to assume products are being developed ‘for the market place’ whereas CoPS are usually transacted with the user (and other suppliers) in unique combinations and rarely, if ever, transacted in an arms length market setting.

Similarly, while studies of NPD and project performance help disentangle the many facets of project success and failure, they do not explore PBO processes nor do they tend to distinguish between complex capital goods and mass-produced products. Nor does the project success literature tend to examine the changing nature of projects through time. This issue is especially important for CoPS projects, which involve several outside innovation partners in different ways through the various stages of the project cycle.

To contribute to an understanding of innovation management in CoPS, Section 4 illustrates how one PBO deploys its resources to create and deliver single complex products. By comparing the progress of CoPS projects in the PBO and functional matrix forms, the case shows how well suited the PBO is for creating and executing large and risky CoPS projects. However, the case also highlights the difficulties PBOs face in capturing and transferring project knowledge with pressures, structures, and routines crowding out learning from one project to another.
4. The case of complex equipment inc

4.1. Case objectives, method, and limitations

The purpose of the case study is to assess CoPS project performance and processes and to look at the nature, strengths, and weaknesses of the PBO in comparison with the functional form through the lens of two major projects, one in a PBO division and one in a functional division. The case also examines how PBO disadvantages can be overcome in practice.

The case study is a large German-owned pan-European firm (Complex Equipment Inc), which employs around 4000 people and produces a wide range of advanced, high-cost scientific, industrial, and medical equipment. For some years, the company had experienced serious problems (delays, cost over-runs, and customer dissatisfaction) in producing CoPS within its functional matrix division (called FMD here) in one of its strategic business units, which produced both CoPS and small batch, simpler products. In another strategic business unit, which reports to the same senior management, a pure project-based division (called PBD) had been converted from a matrix organisation to deal solely with large CoPS projects.

The senior management wished to learn from the operating experiences of PBD, which had been in pure PBO form for around 2 years. PBD had proved highly successful in meeting customer needs and project performance targets. A key strategic decision was whether or not to implement a pure PBO in FMD, a larger division. The management felt that there were lessons to learn from the good and bad experiences of both organisations. Although both PBD and FMD produced similar CoPS equipment, for geographical reasons the physical merging of the two sites was not an option in the foreseeable future.

The research method involved examining the experience of two similar, complex projects (termed project P in PBD and F in FMD) in order to review and compare project processes, problems and performance and to draw lessons for both organisations.

The CoPS in question was an experimental form of synchrotron particle accelerator which is used in sub-micron semiconductor R&D and other scientific applications. The price of each unit was in the order of $10 million each and the duration of the projects was around 18 months in each case.

The research involved three stages: first, a structured questionnaire was used to gather the views of a sample of practitioners in each project, including scientists, engineers, draftsmen, technicians, and PMs. Views were sought on the detailed, actual experiences of PBD project P and FMD project F and on perceptions of the wider strengths and weaknesses of both organisations. Second, interviews were carried out with senior managers and directors on their perceptions of the projects and each organisation’s strengths and weaknesses. Third, a workshop was arranged with both groups to feedback results and check the findings were consistent with the experiences of the staff, many of whom had worked for both parts of the organisation and other strategic business units within Complex Equipment Inc.

Twenty interviews were conducted for each project. Information was gathered on origin, history, structure, management, client relations, supplier links, project processes, and performance. The sample consisted of a ‘slice group’ (i.e., representatives of most main functions and seniority levels of the two projects). Within the case, the research focused on:

- Organisational structure,
- Project management and leadership,
- Team identity and coherence,
- Client and client management,
- Risk management.

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4 The name of the company, as well as project names, have been changed to protect confidentiality.

5 PBD corresponds to type P in Fig. 1, while FMD corresponds to type B. The firm provides an unusual opportunity to compare a PBO with an FMO in a single company, with the same company culture and senior management.

6 Project processes refer to patterns of managerial, technological, and operational practice: the ‘way things are done’, within the project, including both formal and informal routines. At the broader firm level, processes occur within and across the various functions of the firm (e.g., marketing, production, finance, engineering, R&D, and personnel) and occur both formally and informally, shaping the efficiency and effectiveness of a firm.
Formal and informal tools and procedures,
Organisation-wide learning and coordination,
Project performance,
Organisational strategies and solutions.

Each of these issues is reported upon below in turn, contrasting the functional matrix with the PBO division.

Regarding scope and limitations, the research took a ‘bottom up’ look at two real projects, but did not systematically research the broader company processes or functions (e.g., corporate strategy, quality systems, bid processes, production, purchasing and cross-departmental communications). Nor could the study look systematically at the relations between project and wider company business processes. Both projects were carried out largely under the control of the firm (e.g., the degree of co-engineering was low), so although other partners and users were actively involved, the case is not an example of an extensive multi-firm project where developments are shared more equally between partners. In addition, the case refers to the type of PBO conducting a small number of major CoPS projects, rather than the case of a PBO carrying out large numbers of smaller projects simultaneously. Even within this category, the case issues cannot claim to be generally applicable to other large firms producing small numbers of elaborate, high value CoPS.

In addition, while the case study design enables an in-depth comparison of different projects within divisions of the same firm, the approach cannot fully overcome the problem of project uniqueness and history, as noted in the introduction. Even within the same firm with the same company culture and senior management, each project is still subject to specific factors, which shape overall performance, success and failure, and it is very difficult to normalise for these factors. However, alternative methods of assessing project success factors (e.g., cross-sectional surveys) are also limited as they cannot look in-depth at the evolution of projects through time, informal practices, and ‘soft’ issues, which are critical to project success. One way of overcoming these difficulties in future research may be to expand the number and type of intra-project studies of PBOs in order to identify more CoPS project success factors.

Accepting these limitations, the case design was able to illustrate some of the features of the PBO for CoPS compared with the functional matrix and major differences in project processes, advantages, and disadvantages of the two organisational forms. The case also yielded insights into some of the wider organisational issues, especially organisational learning, which featured as a major problem in the case of PBD. Some of these key issues are illustrated below using quotations from PMs, engineers, and other practitioners.

4.2. Organisation structure

FMD was run as a functional matrix with lightweight PMs. Projects were resourced by the heads of the functional departments. While PMs were nominally in charge of projects they had no direct staff or control over resources, nor a regular reporting mechanism into senior management. Within the matrix, PMs for CoPS reported in to one of the functional managers usually engineering. Traditionally, FMD was heavily biased towards the needs of the functional departments and standard product lines produced in small batches. However, increasingly CoPS were being processed in FMD leading to problems, as noted earlier.

In contrast to FMD, PBD had been organised along project-based lines for about 2 years, with PMs in direct control of project resources, team-building, and project outcomes. The PBO had been an experimental move and was widely viewed as a success. As noted earlier, the directors of Complex Equipment Inc wished to learn the lessons for the rest of the company and in particular wanted to assess whether or not to implement a PBO to resolve CoPS problems at FMD.

4.3. Project management and leadership

Because of its functional orientation, the PM of project F (as with other PMs in FMD) had little direct control over project resources, nor a heavy-
weight representation into senior management. This lightweight PM structure had been introduced some years earlier to run alongside the functional organisation to deal with CoPS projects. This led to problems, as described by the PM for project F: “I had no people working directly for me. They [the heads of the functional departments] took people off the project without telling me. The bosses didn’t come to project meetings and didn’t really know what was going on in the project.” Similarly, the senior manufacturing engineer noted: “In project F I was not involved or consulted about the original budget estimates. There was no time to do this job [the estimation] properly. This happens far too often. It [the project] should have been resourced properly at the outset but there were conflicts between Jim [the PM] and the resource [i.e., functional] managers.”

Given the number of functional departments (and bosses) in FMD, each with standard reporting systems and procedures, a wide range of reporting requirements and sometimes conflicting demands were placed on the PM for project F. There were five main functional departments: engineering, manufacturing, marketing, finance, and human resources. Reporting into the five departments absorbed a great deal of time and energy, leading to a reactive, rather than a proactive stance towards risk, client management, product design, manufacture, and so on.

As discussed below, customer relations were also difficult, with the PM looking to functional managers for answers to technical and schedule questions raised by the client, but with little direct contact between the functional managers and the client. This led to delays in dealing with client problems and also to some confusion. In some instances, the two main sets of client demands (commercial and technical) were in conflict (e.g., new technical specifications were called for alongside demands to maintain costs and keep to schedules). These demands led to difficult negotiations with the functional managers and frequently placed the PM for FMD in a difficult position with the client.

By contrast in PBD the heavyweight PM had direct control over resources and team personnel, as well as a strong and direct representation into senior management (the company directors). The PBD PM for project P was more senior to other staff in PBD and on equal terms with functional managers in FMD. The PM for project P dealt directly with the client, having both control over, and responsibility for, all technical and commercial issues.

PBD/Project P was particularly strong on the intangible, informal activities essential to project success in uncertain environments (e.g., project management, close customer relations, good communications, open honest meetings, and mutual respect among team members). In PBD/P a good level of communication and trust was built up with sub-contractors, both large and small. The PBD/P team was as flexible and responsive to changes in specification, risks, and so on, as one would hope from a well-managed PBO.

As the PM for Project P put it: “In PBD we set up a new team for every project and we tend to work on one or two builds at a time. As the PM I do the overall plan and delegate tasks to team members. I talk to the engineers and technicians every day because working relations are vital. Its a matter of mutual trust and respect.” A manufacturing technician for Project P further explained: “It was a good management set up. She the PM knew exactly what to do even though it was a very difficult project. One of the suppliers let us down, so Jane [the PM] went down and ordered a new one from another supplier. She had to bypass the finance department and tell them afterwards. That’s not following the rules, but she judged it necessary to get the job done on time.”

However, there were difficulties not only within the project but also in the wider organisation. These were proving difficult to address within the PBO structure (see Section 4.8 below).

4.4. Team identity

The FMD/Project F team felt that the project was under-resourced, given its size, complexity and development nature, and that insufficient numbers of full-time technical staff worked on the project at any given time. Most individuals worked on more than one project (some as many as six) and few, apart from the PM, felt any identity with Project F. Some team members were under great pressure and two resigned from the company, partly due to the demands of Project F.
As one Senior Engineer on Project F stated: “There was not enough team spirit partly because of all the politics between different people in the various departments. Most of the team worked on several other projects. They were in and out.” And from a different perspective: “I had no feeling of ownership, neither did the other team members. Jim [the PM] was running the project using resources provided from the departments as and when. It should have been handled differently from the outset” (Electronics Engineer, Project F). The PM concurred with these views adding: “The engineer responsible for testing, where we had major difficulties, became overstressed and left the company. We managed to get a replacement from another division, who then discovered serious technical problems with the system, which had further knock-on affects.”

Overall, the project suffered from weak team coherence, poor team spirit, and fragmented communications. This was due in part to initial project under-resourcing, itself a reflection of the weak bargaining position of the PM who was unable to insist upon a dedicated team within the functionally-oriented organisational structure. These problems were seen as resulting from the functional structure and had occurred before in CoPS projects in FMD, leading to the decision to consider introducing a PBO structure similar to PBD.

By contrast, in PBD/Project P the team felt they had achieved a highly effective and professional approach to project management and implementation, with strong team coherence and close identity with Project P. Most of the team were dedicated to Project P and all felt allegiance to it. Project leadership and management were viewed as strong by team members and internal communications proceeded well.

4.5. Client and client management

The FMD/Project F team had developed poor and confused relations with their client and felt ‘unlucky to have a bad client’. Early on in the project’s development, the PM had reacted to new client demands for changes in specification by attempting to please the customer. However, the PM did not have the time nor authority to carefully negotiate full costings or rescheduling, or to carry out the detailed internal planning needed. This had resulted in unclear business relations. Conflicts developed as team members felt their customer was unwilling or unable to divulge essential information on detailed requirements or to sign off pieces of work when requested to: “They [the customer] interfered far too much with the design. They argued about every single nut and bolt. They set the pattern of being able to dominate the design and make us take the risk. This eventually led to the point where the customer didn’t trust Jim [the PM].” (Senior Mechanical Engineer). Similarly, “we tried to get feedback from the client but we got no help. We decided it was better to be late on delivery than have a system fail in the field” (PM, Project F).

Team members also felt let down by their own PM and senior management who did not seem able to sort out the difficulties. To them, seemingly arbitrary changes in specification were called for causing delays in delivery and severe technical difficulties: “The specification was not properly dealt with. The company was afraid to talk to the customer. You need a high level PM from a business point of view on this type of project. Jim [the PM] was down on the shop floor fire fighting too much” (Manufacturing Technician, Project F).

However, official client procedures and behaviours on FMD/Project F were not dissimilar to those of PBD/Project P, coming from a different division of the same buyer organisation. FMD/Project F team members reacted defensively to client demands, putting problems down to internal customer politics and commercial inexperience on the client’s part. Project F members perceived requests for changes as the placing of unreasonable demands on the project team who were already stretched and under-resourced.

In the absence of clear ‘rules of engagement’, expectations on both sides of FMD/Project F were difficult to manage and potential risks materialised to the detriment of the project. Team members felt that the responsibility for dealing with these issues rested with the various functional managers (e.g., manufacturing for delivery, finance for costs, and engineering for specification changes), while some senior functional managers felt that the PM should have dealt with these problems or highlighted them earlier. All
agreed that client relations were difficult and unclear. A draftsman on Project F summed this up: “We need better contracts and better specification procedures. We have them internally but we don’t have them with the customer. We’re too soft on the customer — we accept costs to us too easily and lose money. Being a big project, it exposed weaknesses in our approach.”

By contrast, PBD/Project P members felt that they were fortunate to have a ‘good client’, who was willing to entrust design and development decisions to them. This was partly due to the involvement of PBD engineers in an early design study for the client, which specified some of the system. However, the team had also developed a shared business ‘negotiation’ mentality, now common in PBD. This assumed, for example, that any requests for changes to specification had to be negotiated between the PM and the client, fully costed and, if necessary, reflected in extended delivery schedules: “We have very good client relations but if they want to make changes [to the specification] we stop the clock, and price it.” (Engineer, Project P).

Although this approach had developed informally in PBD (no explicit systems or detailed contractual arrangements existed over and above those in FMD), the negotiated approach had become standard practice because it helped meet the needs of engineers, especially when confronted with large complex projects where frequent iterations with the client were needed. The rules (e.g., on specification changes) were alluded to in the contract as in the case of FMD but also, and more importantly, communicated through the ‘tone’ of day-to-day channels of communication at all levels of the project. This, in turn, required team ownership of the project and good internal communications. By establishing project ground rules at the initial bid stage, changes to design, day-to-day misunderstandings and other uncertainties could be dealt with in a systematic professional fashion.

In PBD/Project P, most of the liaison with the client was carried out or co-ordinated by the PM who was able to build a good working partnership. As the project progressed, more team members became involved directly with the client as the PM entrusted particular team members, at various stages, to take actions with members of the customer’s team.

As a result, Project P team members felt that relations with the client were orderly and understood.

4.6. Risk management

Regarding risk, three types of risk were identified in both divisions: (a) those wholly outside the control of the project (external); (b) those wholly within the ambit of the project (internal); and (c) risks subject to negotiation/internalisation (negotiated risks).

In FMD/Project F, the PM was unable to establish a pro-active approach to risk, particularly in relation to risks inherent in customer–supply relations (e.g., major changes to specification), common in CoPS. Organisationally, the PM felt he “was being torn limb from limb” by the various demands of the functional bosses, unhappy team members and the client. As a result, the PM was unable to establish an orderly business framework for managing client relations from the outset. Failing to meet changing needs, the project team had developed defensive relations with the client. The team members were unable to manage internal and external risks well, and allowed negotiated risks to emerge. Because of the lack of team coherence and resources, the PM and senior engineers were unable to regularly visit the customer or key suppliers to avoid risks (e.g., delays in the delivery of sub-systems). Because management systems (e.g., internal design reviews) were not carried out regularly, as they should have been, problems of risk were intensified by the failure to share information either in formal or informal meetings.

By contrast, partly due to its tightly integrated project structure, PBD/Project P members managed internal and external risks well, and increased their control over negotiated risks. The PM and senior engineers paid regular visits to key suppliers and helped to resolve delays in the delivery of components and sub-systems. Referring to sub-contractor relations, as one senior engineer on Project P said: “You have to spend a lot of time on this. I went through 19 different suppliers to find two or three really good ones. You pay them a visit and ask questions. It usually takes one min to tell whether they are good or not. And it’s nothing to do with firm size — some of our best suppliers are small
companies.” The team avoided risks by sharing information in their formal two-weekly review meetings, informal meetings and conversations, and regular client and customer visits.

The business approach made possible by the ‘super heavyweight’ project structure, allowed PBD/Project P to deal with two major sources of external risk (supplier and client relations), allowing space for dealing with unexpected events and scope for internalising negotiated risks. The Project P team felt pleased with the informal way most problems were handled, the only formal risk management tools being a two-page weekly reporting form and the two-weekly project meetings. In the event, despite some problems, Project P progressed well and was delivered on schedule, but slightly over budget (see Section 4.9).

On the negative side, senior management at Complex Equipment Inc felt that they “did not really know enough about PBD/Project P”, given its importance as a new product line for the company as a whole. This had also been the case for other projects carried out in PBD. The lack of regular reporting into senior management created some tensions between project progress and corporate-wide strategies and goals. Company directors felt a degree of project isolation in PBD had created risks in terms of overall marketing strategy and business coordination. Their solution (see below Section 4.10) was to set up more regular reporting with PMs along the lines of FMD.

4.7. Formal and informal tools and procedures

Both FMD and PBD had fairly typical tools and systems mandated by the company for bid review, cost, and risk management, internal design, and specification change management. In both organisations, there were formal systems for project recording, controlling, and reporting. In FMD, detailed procedures were laid down by the functional departments, each with their different goals and needs, leading to a heavy administrative load for FMD projects.

In FMD/Project F, actual procedures followed (‘what happened in practice’) diverged considerably from formal tools and company best management practices (‘what should have happened’), as reflected in senior management views and contained in a company toolbox and quality manual. Procedures for the early bid stage, internal design reviews, reporting to senior management, cost tracking and control, progress monitoring, and risk management were officially in place but were not applied. This was put down to the absence of a coherent team, under-resourcing, time pressures, weak incentives for team members (who reported to functional bosses), and the ‘firefighting’ mode of the PM and team members: “there were no internal design reviews held to ask ‘are we doing the right thing’. This was a very large complex project. Jim [the PM] was dropped right in it with no commercial backup” (Mechanical Engineer, project F).

While Project F was a fairly extreme case, the divergences between formal and actual procedures occurred in other CoPS projects in FMD. Tools and reporting were seen as an added bureaucratic burden, unhelpful in the managing of the project.

By contrast, in PBD/Project P the PM was in charge of implementing company tools and procedures. The ‘leaness’ and flexibility of formal tools and systems within PBD, which involved no functional reporting or negotiating with departmental bosses, meant that tools and procedures were seen as helpful in getting tasks completed, although again there were some differences between official procedures (what should have been) and real practices (what actually went on), particularly in terms of the informality in the use of tools. Some tools were deployed very sparingly indeed and there were differences in the ways PMs within PBD used company tools and followed procedures.

Informal methods, experience, and trust were viewed as more important than tools and formal procedures on Project P: “The fancy 3D CAD tools are really ‘boss dazzlers’. The main thing [in project success] is delegating the right tasks to the right people and keeping in close touch. I use my imagination. I sketch things out in order to work out the best way of doing the job before doing the detailed design. We have a process manual but it doesn’t help with detailed design problems. Its experience that matters” (Senior Engineer — Project P). Similarly, a veteran engineer working on the detailed design of Project P explained: “You go down some routes, abandon others, create new ones and so on. You have to proceed even though the next steps are often uncertain.”
PBD managers, over the past 2 years, had modified and simplified company tools and systems to suit their project needs and successfully resisted the introduction of more elaborate formal management tools and systems.

4.8. Organisation-wide learning and coordination

In FMD, organisational learning (involving informal knowledge sharing, training, reviews, personnel development, and technical leadership) was centred on the functional departments. In this area FMD as a whole performed well. Younger engineers felt that they had good overall technical leadership from the senior engineers and functional managers. They could see a career ladder within the organisation. Senior engineers had incentives and resources to recruit, train, and retain new younger engineers and technicians for their departments. Much of the knowledge sharing and communications occurred in informal settings although there were also training programmes and official seminars and meetings. Informally, groups of engineers exchanged tacit knowledge and problem-solving tips through narratives, in what is sometimes called communities of practice (Seeley Brown and Duguid, 1996). In this important area, FMD out performed PBD.

In PBD, despite very good individual project performance, in the previous two years the high pressured work environment had left little space for formal training or staff development, either in technical or commercial areas. It was apparent that many of the formal and informal activities associated with organisational learning, and improvement (e.g., post-project reviews (PPR), technical mentoring, and informal communications) were not being performed: “Since we became project-based, I’ve had no incentive or time to train anyone up. Previously I always looked after two or three younger engineers. In the old [functional] organisation we had space for training and staff development.” (Veteran design engineer, Project P).

Lessons learned from particular projects were not shared formally because there were no structures or incentives for cross-project learning or communications. It had become hard to learn from project-to-project, leading to worries within PBD over its long-term effectiveness. The learning ‘silos’ (represented in FMD by functional departments) were absent in PBD’s pure PBO.

The PPR was viewed by the company as an important mechanism for learning from project-to-project. The official procedure called for a PPR involving all major project contributors, from the bid stage onwards. The PPR should have operated in PBD as a mechanism for capturing lessons (good and bad), sorting out problems (e.g., closing the loop between bid stage decisions and project outcomes), and building up wider company communications (involving project outsiders and senior managers). However, few PPRs had occurred in the past 2 years due to work pressures and the lack of structure and incentives within PBD. Internal markets had developed for good people and the most persuasive and senior PMs often get them, sometimes leading to a skewed performance among projects.

At least three other problems of learning and coordination were evident in PBD. The first concerned technical leadership. In FMD, this role was played by senior engineers and department managers. Younger and newer recruits in PBD were concerned over career development and professional progress because of the dispersion of technical leadership across projects. Insecurity was highest towards the end of a project when staff were not sure ‘where they would go to next’. Related to this was the lack of incentives for human resource development. The PBD structure had reduced the incentive for senior engineers to bring on younger engineers as they had previously done under the functional matrix as a fairly natural thing to do. In FMD there were concrete incentives to groom young staff to improve the performance of various departments, but these incentives did not exist in PBD and no senior individuals had responsibility for this task. The functional departments served this role in PBD allowing space (and time) for the sharing of knowledge and experience.

A second problem was revealed in some of the small projects undertaken in PBD. While the organisation was suited to large complex projects, it was overly elaborate for dealing with small routine projects: ‘using a sledgehammer to crack a nut’ as one engineer put it. In particular, there was no real need for a senior PM and a dedicated team to control smaller, especially more routine projects. Treating
smaller projects ‘as if’ they were major projects had led to heavy overheads and too much bureaucracy in some cases.

A third problem concerned cross-project integration and senior management coordination and control. Some major projects had ‘gone their own way’ in PBD and it had become difficult for senior company managers at HQ to keep properly informed and maintain some degree of control and consistency across the activities of PBD. Systems had come to vary somewhat from project-to-project, as PMs exercised their discretion over which tools to apply and how to apply them. The basic minimum of formal controls (e.g., for risk management, cost, and design review) were not always adequately applied, as happened in the case of PBD/Project P at the bid stage. Overall, senior management felt that control of PBD had become difficult, especially as the organisation had grown.

4.9. Project performance

In FMD/Project F, the initial underestimation of costs produced a knock on effect throughout the project, leading to under-resourcing and, in particular, insufficient full-time staff. As a result, there were major technical problems, the project came in substantially over cost and delivery was late. Both the client and FMD’s senior management considered Project F a failure.

There were various causes of the poor performance. In FMD, PMs did not report directly and regularly to the senior management team to share problems, responsibilities and so on. In Project F, this led to the initial under-resourcing, which prevented both team-building and the development of a good team spirit. It was also difficult to rectify the problem later, given the PM’s relatively low status in the organisation. FMD lacked the clear processes and procedures needed for controlling large complex projects. The way the project was managed exacerbated problems with the customer and placed unreasonable demands on team members. Because team coherence and commitment were low, risks materialised, and problems were difficult to address. All in all, the functionally-oriented structure of FMD was not suited either for the setting up or execution of CoPS projects. The heavy functional bias was appropriate for small projects and more standard product lines. In scaling up from simpler to more complex products, the organisation needed a heavier PM structure with direct representation into senior management.

By contrast Project P/PBD was considered to be a major technical success and delivered ahead of schedule. However, as noted earlier, the project was completed slightly over budgeted costs, and with a lower level of profit than expected. The costs of two sub-systems had been under-estimated. Neither sub-systems posed special technical or supply challenges, but one probable cause was the informality of PBD’s bid stage/costing process. Team members felt that a slightly more systematic bid process involving more specialists from other projects would have helped avoid bid/costing problems. Also, despite good relations with suppliers, the delivery of some items was late. These problems were dealt with by visits to supplier sites by the PM and senior engineers and risks to the project schedule were averted. Again, the team felt that a little more formality in dealing with suppliers could have avoided some of these problems.

Overall, problems on Project P were fairly minor and both the senior management and the customer were pleased with end results. However, there were wider concerns about long-term learning and technical developments as discussed earlier.

4.10. Organisational strategies and solutions

In order to overcome the ‘mismatch’ between organisational structure and the needs of large projects, FMD’s management decided to move to a heavyweight project matrix structure, maintaining a functional matrix for standard lines (a move from ‘B’ to ‘D’ in Fig. 1 above). The difficult task of allocating resources between functions and CoPS projects was to be undertaken at senior management level, with project directors responsible for negotiating for and controlling resources. Deploying a heavyweight project structure for CoPS was viewed as more suitable than either the existing functional matrix or the pure PBO, given the need to cope with large numbers of standard items. For major projects, heavyweight PMs would report directly into senior management on a regular basis at the same level as the functional managers.
Recognising the burden placed on PMs in CoPS, FMD also decided for very large projects to split the PM function into two with a commercial PM and a technical project engineer (PE), a practice followed in some projects in PBD. The rationale was to increase the scope for negotiating with the client (“good guy/bad guy” and /other routines) and to try to overcome the need for PMs ‘with a super-human range of talents’ as one director put it. The PM would have overall business control of the project, including client relations, progress schedules, tools and procedures, team meetings, and so on. The PE, of equal status to the PM, would be responsible for all technical issues, including specifications, detailed design, construction, sub-system interfacing, and so on. The PE would deal with the client on most technical issues, but would avoid commercial decisions, leaving these to the PM.

Reflecting on Project F, the (then) PM said: “Today a project like that would have a dedicated team of full-time engineers and a full-time PM. We learned a lot from that project [F]. Big projects with a development side must be handled differently, with different professionals in charge of technical work and commercial issues. We now have a project-based structure for all big projects where people can move in and out of teams.”

The dual PM/PE system has both advantages and disadvantages. For the system to work effectively, the PM and PE have to be willing and capable partners, able to share in strategy, decision-making, and team-building. In some organisations, the system becomes accepted as the natural way of doing business. Sometimes, but not always, the PM is also an engineer (either practising or by background). Regardless of background, the PM is responsible for mastering all the skills of managing projects effectively and efficiently. In some companies, the PM organises commercial training for other team members (e.g., on negotiation skills, new tools, and risk and time management).

In addition, the PM function was to become more professionalised in FMD, not only through training but through the fostering of a commercial PM ethos, which values and rewards PMs. Courses on team-building and project management were being arranged, while individuals were being encouraged to engage in various PM associations and introduce standard PM tools and procedures (e.g., for scheduling, team-building, bidding, cost control, risk management, and negotiation methods), along the lines also being followed by PBD. Regarding tools and procedures, it was decided not to introduce highly elaborate PM tools (e.g., for risk management, design walkthroughs, and cost control), following the lessons of PBD. However, as with PBD, minimum formal processes were mandated. For example, risk management was being built into the design review process so that problems could be communicated, discussed and shared among project staff.

Given the composition of FMD, most PMs would be engineers or scientists who had demonstrated the aptitude, skills, and desire to be PMs. People with flair in this direction were to be encouraged and rewarded to undertake commercial PM responsibilities, sometimes alongside their technical careers. Alongside the new structure, much more attention would be given to developing a systematic, professional approach to managing client relations and needs, including training in how to establish a business framework, manage expectations, and negotiate, again along the lines of PBD. Complex and changing clients needs are not unusual in CoPS; therefore, a pre-emptive, pro-active approach is essential to minimising risks.

Turning to the case of PBD, to address the organisational learning problem, PBD’s management decided to establish a programme to build space for learning, training, staff development and PPRs, and to make time to reflect on important technical and business issues (e.g., new technical developments, project lessons learned, time management and cross-project design reviews). To promote the long-term productivity and effectiveness of PBD, younger team members would be encouraged to learn from more experienced staff and to share in some of the ‘tacit’ knowledge, locked up in the heads of otherwise busy, more experienced people.

Although learning went on informally at the single project level, PBD decided to structure and enable learning to occur in more formal, cross-project settings (e.g., regular cross-project meetings, project management workshops, off-site training and special technical seminars with outside speakers). To ensure this occurred, PBD put specific people in charge of coordinating particular themes and programmes
across projects, forming a weak functional line across the major projects of the unit. Other functional tasks were being considered to help coordinate sub-contractor relations and risk management procedures. The aim was to ensure consistency in project approaches, to share best practices more widely and to keep senior management at HQ better informed through improved reporting procedures. This amounted to a step ‘back’ to a project-led organisation, but fell short of a project matrix (a shift from ‘F’ to ‘E’ in Fig. 1).

To provide incentives for senior people to give up project time (e.g., to bring on new recruits) a formal mentoring programme was set up with incentives for good performance. PBD also restructured desk layouts and coffee spaces to enable more informal communications to occur. Senior management recognised that moves in this direction depended on more resources being made available and some degree of organisational slack in the system. However, the high good performance and profitability of PBD justified this long-term investment in learning.

Whether or not these formal organisational solutions to the problems of organisational learning and career development work effectively remains to be seen. It is possible that moving a step back to a project-led organisation and establishing resource and task coordination may not solve the problem. Ultimately, the success of the approach adopted depends on taking senior (and other) staff away from project work, which could, of course, be resisted by the PMs who are in a powerful position and could potentially prevent ‘interference’ with project operations. Inevitably, this kind of solution introduces its own tensions into the organisation, in this case pitting shorter-term project needs against wider organisational needs. A key factor in whether or not the new programmes and structures work effectively is the health and dynamics of informal organisational structures and practices which, in turn, reflect the particular culture of a company. As shown by Pisano and Wheelwright (1995), informal, personal, and cross-department/divisional relationships play a vital role in ensuring any official form of organisational structure works effectively. Nevertheless, although there can be no ‘mechanistic’ structural solution to problems of organisational learning, it is wise to adopt structures and formal practices that promote learning and match the needs of large projects with organisational structure, which the project-led organisation is formally designed to do.7

5. Managing CoPS in PBOs — interpretation

This section draws analytical lessons from the case study, interpreting the evidence in relation to project coordination for CoPS. The aim is to provide a framework for interpreting the various organisational choices and strategies available to foster innovation in high technology capital goods, networks, constructs, and systems.

5.1. Interpreting the organisational strategies of PBD and FMD

As noted above, FMD was initially a Type B organisation (see Fig. 1), but this led to extreme problems in project management and coordination both internally, and externally with the client and suppliers. In response to the problems, FMD decided to convert to a project matrix (Type D) with a heavyweight PM structure in order to allow CoPS to be managed more effectively within the organisation.

However, it did decide not move to a PBO (Type F), in order to retain the functional departments needed for standard product lines and batch production. The difficult task of allocating resources between functions and CoPS projects could then be resolved by functional and PMs of equal status, with their senior management (in this case company directors). The directors favoured this arrangement because the emerging CoPS were important new business opportunities and needed to be understood and supported at the highest level. Regular, direct feedback on the progress of these projects was vital to the company.

By contrast PBD, organised as a Type F pure PBO, had achieved a very good record at the individual project level, but the overall organisation was concerned for its long-run performance in areas such as technical leadership, organisation-wide learning and communications. PBD’s response was to move back from a pure PBO to a project-led organisation

7 The effectiveness of the formal solution adopted at Complex Equipment Inc is an interesting subject for further research.
(Type E) in which PMs retain the most senior positions but appoint new resource coordinators along functional or generic task lines which cut across project interests and incentives. This strategy was adopted in PBD to stimulate organisational learning and to provide incentives and resources for greater technical leadership. In PBD task force managers could resolve specific problems and help coordinate, monitor, and improve performance across the whole organisation.

5.2. From linear to concurrent models of project management

To illustrate the management advantages of the PBO for CoPS, Fig. 2 contrasts the PM task within a

![Diagram](image-url)

**Key:**
- FM = Function Manager
- TM = Team Manager
- PM = Project Manager
- TMF = Team member/function
- S = Supplier

Fig. 2. Comparing project management in functional and project-based organizations. (A) Functional matrix. (B) Project-based organization (internal co-ordination). (C) Project-based organization (external co-ordination).
functional matrix with the weak PM structure (Type B) deployed in FMD, with that of a pure PBO (Type F) deployed in PBD. Fig. 2A shows the position of the weak PM within the functional matrix, involving multiple lines of communication, control and command, and various department managers.

The PM function embodies a linear or sequential model of project management, in which the project passes through various stages and departments in turn. The model also treats the client and suppliers as external to the project. The PM has to perform a highly complex internal task of balancing the various internal interests and meeting the different demands (e.g., in terms of reporting and quality control of the departments. Similarly, there are many lines of communication with team members on the project who also report (primarily) to departmental managers to whom they owe their career allegiance, and to other PMs (some in FMD worked on four or five projects).

PMs face similar complexities and difficulties in external coordination. To reply to customer requests they often have gain information and commitments from engineering, purchasing, and planning departments. The larger and more complex the project, the more difficult the task of keeping the client informed and responding to requests for changes from the customer.

By contrast, Fig. 2B shows the position of the PM in a PBO in relation to the specialist functions within the project. The PM is the main line of communication and can exercise control to coordinate and integrate specialists and functions in creative new ways, focusing on the needs of the project. Because there are few internal lines of command and communication to interfere with project objectives, the internal coordination task becomes simpler and clearer.

Similarly on the external front, clear strong lines of command and communications can be built up with the client (Fig. 2C). In principle, the PM is able to quickly assess and react to change in client needs and learn from feedback from the client and major component suppliers. The PM has both the responsibility and power to react to unexpected events, negotiate changes with the client and, if necessary, put suppliers of major components together with the customer to resolve difficult problems.

In effect, the PBO embodies a concurrent model of project management. The move to a PBO represents a shift from the linear model of project management, which treats the user and other innovation actors as 'outside bodies', to a concurrent model of project management which is able to integrate all the business functions within the project and includes users and suppliers in the core project processes. For CoPS projects, the concurrent model is potentially very helpful in dealing with uncertainty, risk and emerging properties common in CoPS.

5.3. Economic motivations and determinants

Underlying the advantages and disadvantages of the two organisational form are economic motivations and determinants. In theory it would be possible to mass produce consumer goods such as camcorders or hi-fi equipment in a PBO, rather than a functional organisation. Similarly, it would also be possible to produce a large CoPS (e.g., a power station or a flight simulator) in a functional organisation. However, in both cases, the costs of production would be far higher than if the more appropriate organisational form had been adopted.

In economic terms, the large functional Chandlerian firm is most effective at achieving production scale advantages and exploiting economies of scope, systematically converting lower value inputs into higher value outputs. However, these economic drivers are largely irrelevant in CoPS production, because the latter are produced either as one-offs or small-batch items. Therefore, efficiency gains must come from other sources, centred on other forms of organisation. The PBO, with its focus and flexibility, can achieve economies of: (a) resource allocation — allocating and re-allocating physical and human resources when and where they are needed to each project; (b) knowledge management — applying the know-how needed to deal with the technology, as well as regulator and client needs; and (c) design optimisation — enabling design cycles to be carried out effectively and efficiently by reducing the number of design/redesign cycles (and costs) associated with

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8 This section draws heavily on ideas and comments provided by Paul Nightingale (SPRU).
additional cycles, caused in CoPS by backward feedback loops from later to early design stages; and (d) quality — enabling the organisation to produce a complex good to the exact specification and needs of the buyer. Its inability to achieve such economies, indicates that the functional form is economically wasteful as a form of production for one-off projects.

As shown above, the PBO can also assist in managing risk and uncertainty, especially important in the many CoPS which exhibit emerging properties (unforeseen and unforeseeable features which occur during design, systems integration and production) (Hobday, 1998). Given that formal planning is limited in its ability to deal with design and production unknowns, then the devolved decision-making allowed by the PBO enables a flexible allocation of resources to alleviate these problems when they emerge. Furthermore, the nature of the CoPS project task often changes as clients realise new needs during the design and production phases, especially in very high value CoPS where production may take two years or more. The PBO, in theory, allows the swift transfer of information to relevant teams and team members who are then in a position to adapt their activities and respond to new contingencies.

In short, the functional Chandlerian organisation is appropriate for the mass production of known products with known processes, where the key task is to optimise the production system in order to transform large quantities of lower value inputs into large quantities of higher value outputs, by reducing unit costs. These economies are essentially scale-based. By contrast, each CoPS product and process involves uncertainty. Economies in production come from reduced design cycles and efficient systems integration, made possible by the flexible and efficient allocation of knowledge and resources to each good being produced. Therefore, in CoPS, as in mass-produced goods, economic advantages are rooted in appropriate organisational form. The PBO, in principle, is an appropriate organisational form for the technological and market environment of CoPS, allowing for efficient project control and resource coordination.

5.4. Innovation advantages of the PBO

Beyond the economic advantages of the PBO, there are dynamic innovation advantages over the functional form. Realising a CoPS is often a creative and difficult task, involving feedback and learning as the project develops. CoPS not only require innovation at the product level but also at the process and organisational levels. Design and production involve many knowledge-intensive, non-routine tasks, and decision-taking under conditions of uncertainty and risk. These intelligent processes cannot be reduced to routine project management procedures and planning. Learning during production is required to assimilate the knowledge required to complete the task of production.

Because each CoPS is different, the innovation needs of the product frequently demand experimentation in forms of project management. In short, project-level innovation is required to produce innovative products. Because the PBO creates and recreates organisational structures and processes around the needs of each product and customer it is, in principle, a highly innovative form. Again, in theory at least, the PBO defies the anti-innovation bias of large functional organisations with their semi-permanent departments and consequent core rigidities.9 The challenge of managing innovative CoPS projects is one of integrating business functions, ensuring flexibility and responsiveness to the needs of customers, and dealing with the emerging properties which inevitably arise in complex products which embody new knowledge. It is also a challenge of thinking beyond current market and product needs to anticipate future needs and especially to convince buyers of the firm’s competence to deliver further new CoPS.

6. Conclusion

Using a case study approach, this paper has compared the efficiency and effectiveness of the functionally-oriented, matrix organisation with the PBO, pointing to both the strengths and weaknesses of the PBO in the management of CoPS. On the positive
side, the PBO has the potential to foster innovation and promote effective project leadership across the business functions. As resources, technical and other, are formally dedicated to the project, both power and responsibility for project success lie with PMs. The latter, who tend to be ‘super heavyweight’, can focus on team-building, meeting the clients needs, dealing with technological uncertainties and making a success out of the project. By contrast, the functional matrix is poorly equipped to coping with the needs of CoPS projects.

Along the spectrum of six functional-to-project-based forms, the paper showed that the PBO is an extreme form, having no functional division of labour or task coordination across project lines. All major business functions, including marketing and finance, are coordinated within the project. The PBO is probably best suited for large, risk-intensive projects, where resources have to be combined and shared with other firms in the project. Because of its flexibility and focus the PBO form is able to cope well with the emerging properties of CoPS by responding to client needs in real time. The case example showed why the PBO form was more effective than the functional form in integrating different types of knowledge and skill, learning within the project boundary and coping with project risks and uncertainties. While the functional matrix embodies an inward-looking, linear form of project management, the PBO embodies a concurrent model of project management which is able to realise innovation in collaboration with clients and suppliers.

Because CoPS tend to be major new business endeavours, simultaneous product, process and organisational innovation is required. The PBO is potentially an effective form because it creates and recreates new organisational structures around the needs of each product and each major customer. Unlike functional departments, the PBO is temporary and is, therefore, not subject to the anti-innovation bias of functional organisations with their rigid demarcations and core rigidities. As Section 5 shows, potentially, the PBO boasts significant economic advantages over the functional form in the production of CoPS.

On the negative side, the PBO is inherently weak in coordinating processes, resources and capabilities across the organisation as a whole. Individual project success and efficiency, although important, does not necessarily enable a firm to continue to execute projects successfully. Indeed, the case study revealed a problem of ‘learning closure’ around major projects, as there were no structures or incentives in the PBO for cross-project learning or communications. The learning silos, represented by functional departments, are absent in the pure PBO. As a consequence, PBOs can suffer from a lack of technical leadership and direction, roles typically played by engineering and R&D managers in functional and matrix organisations. PBOs can also breed insecurity over career development, especially among new recruits because of the dispersion of technical leadership across projects. By contrast, functional departments provide space (and often time) for the sharing of knowledge and experience. In short, the PBO is inherently weak where functional forms are strong: in executing routine production and engineering tasks, achieving economies of scale and meeting the needs of volume production.

Cross-project integration and management control can also become a problem in PBOs if projects ‘go their own way’. Systems may come to vary from project-to-project, as PMs exercise a high degree of discretion over which tools to apply and how to apply them. It may become difficult for senior managers to track, control, and respond to the activities of project teams and directors, limiting the firms overall capacity for effective corporate strategy and business coordination. To be most effective the PBO requires that projects are coherently directed towards company-wide market and technology targets.

The case example identified various strategies for dealing with PBO weaknesses, particularly the problem of project isolation. To improve coordination in areas such as overall company strategy, regular reporting channels into company directors were set up. To enable and encourage organisational learning, cross-project communication and technical leadership the company moved one stage back from a pure PBO to a project-led organisation. In this arrangement PMs retain their senior positions but new resource and task coordinators along functional lines are appointed, cutting across project interests and incentives, in order to resolve specific problems and help coordinate, monitor, and improve performance across the organisation and a whole.
This move back from a pure PBO to a project-led organisation shows the variety of choices involved and the need to match organisational form with the product mix in question. More generally, the paper indicates that the changing nature, composition, and scale of product/s have an important bearing on appropriate organisational forms. The management challenge facing CoPS producers is both to realise the potential of project-based forms for current markets, and to develop the firm’s overall capabilities to exploit and create future market opportunities.

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