Balancing work– bidding strategies and workload dynamics in a project-based professional service organisation

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Abstract

Project-based professional service organisations supply their services as tailored or one-off projects for specific clients. The particular form of their organisation, the character of their relationships with their clients necessary to deliver highly customised projects and the non-routine, creative nature of the work come together in a way which makes the management of these service firms particularly demanding. A common challenge is fluctuation in the workload. While this is partly influenced by changes in demand, the external environment does not provide a comprehensive explanation and the interaction between business processes and project processes needs to be examined. In providing a generic explanation of the causes of workload fluctuation as well as an assessment of different bidding strategies based on a system dynamics model, this paper aims to help to advance the theoretical understanding of the project-based professional service organisation and ultimately to help to provide tools for its managers.

Keywords: Project-based firm, professional service organisation, workload, project, portfolio

1. Introduction

Professional service organisations that provide customised services as projects for specific clients depend crucially upon bidding for, or negotiating discrete task-oriented packages. Architectural practices, consulting engineering practices or management consultancies are typical examples of such organisations.

This paper presents a generic model of a stylised project-based professional service organisation.

This paper aims to provide insights into the causes and managerial implications of the workload fluctuations in a project-based professional services organisation. The paper also shows how formal modelling can add to case studies and non formalized, appreciative theories in the management literature. The relationship between what happens on the level of individual projects and on the level of the organisation which has been argued for in the literature on project based firms can be examined with a system dynamics approach.

The underlying research is part of a wider portfolio of research projects investigating the management of project-based organisations, and particularly those providing design services in the area of the built environment, i.e. architects and consulting engineers. The initial motivation to investigate the relationship of bidding and workload in detail came partly from several prior projects studying project-based organisations in the construction industry. By working closely with a range of organisations in this sector, in several cases over long periods of time and with different levels in these organisations, we were able to carry out extensive empirical work. Through workshops, interviews and the observation of work practices we studied in detail how professionals in these organisations work, how they are managed and how learning from and across projects is possible. In the course of this empirical work the relationships and frequent tensions between project and business processes came into sharp focus. Since project acquisition strategies and resource allocation at project level are important concerns shared by many in this industry, these issues are the main focus in this study. Prior work had surfaced some related issues: the high investment and high risks of bids for projects (company specialising in customised smoke detection and ventilation), cycles in workload and significant overruns (large construction company engaged in major infrastructure projects), difficulty to predict workload (fire engineering consultancy practice), the large degree of autonomy of design professionals in bidding and project execution, making central management extremely difficult (large consulting engineering company).

In this paper we have engaged with one of the largest architectural practices in the UK. We conducted a series of interviews both with the finance director and the associate director with responsibility for project management for the practice. Altogether these face to face interviews were in excess of 14 hours, were held over several months and complemented by telephone and email exchanges. We also discussed our model with the chairman of the company. We have a long-term relationship with this particular practice and could therefore also draw on insights generated in prior research and parallel discussions, including board level workshops focusing on more general areas of innovation and strategic management. The architectural practice made detailed data on their project portfolio (including resource use over time for all their projects) and their administrative costs available. While the proportion of time allocated to projects and bids in this practice had before our discussions not directly been recorded, it is possible to estimate[1] this distribution from the available data. The graph below shows a fluctuation over time of both time allocated to bidding and project work. (figure 1).

Figure 1 about here

From the field work we learned about some basic problems facing the practice:

- excess work, overruns are a frequent (and growing) problem;
- overruns have a knock-on effect on subsequent projects, in particular in regard to resourcing problems;
- inappropriate staff assigned to subsequent projects (due to lack of resources) increases chance of problems, in particular overruns in these projects;

- problems can subsequently arise throughout portfolio.

Our model is designed to capture these features and help us to analyse causes and potential policies to better deal with workload fluctuations. The model we present here is however not parameterised to match this particular architectural practice, in order to avoid the disclosure of confidential information.

A particularly interesting aspect of our fieldwork – familiar probably to many system dynamics practitioners – was that the company found that the process of engagement with us had already lead them to make changes (e.g. the collection of more detailed data on their bidding effort or a process improvement drive informed by insights in the rework cycle).

As we have indications from prior work that these particular challenges are common in other project-based organisations, we have also discussed the model and our analysis also with a range of professionals in other such organisations in the construction industry, which is a particular area of interest for us. This part of our work is ongoing, but initial discussions with senior personnel (CEO and knowledge manager respectively) of two of the world's largest consulting engineering companies indicate the relevance of the basic model structure and some of the insights particularly to this type of organisation.

From this empirical work and in line with the growing management literature on project-based organisations (Gann and Salter 1998; 2000; DeFillippi and Arthur, 1998; Grabher, 2002; Hobday, 2000; Keegan and Turner, 2002; Prencipe and Tell, 2001; Cacciatori, 2004) the importance of the project-based nature of their activities for understanding the behaviour of these organisations becomes manifest: merely examining the organisation level and ignoring the project level does not suffice. Our modelling work allows us to build an explanation that operationalises the relationship between the project level and the organisation level. We link behaviour at the project level and performance at the portfolio level to an organisational policy. In addition, simulations of our model provide insights into the choice of organisational policy.

Starting from the key issues identified in our engagement with the architectural company, we concentrate on a set of issues that challenge project-based professional service organisations: bidding strategies, resource allocation to projects and workload fluctuation. Periods of low capacity utilisation are often followed by periods of excessive workload when 'fire-fighting' becomes a standard activity and meeting demanding project schedules is increasingly difficult. The variation in workload over time is influenced by changes in the demand for services. However, we contend that the external environment alone does not provide a comprehensive explanation of workload dynamics and that in particular the time allocated to bidding is an important influence.

Often workload fluctuations are ascribed to external fluctuations in demand. Our modelling shows however, that fluctuations can also be created by the firm's internal processes, i.e. choices over bidding, even in a stable market. These workload fluctuations present difficulties for the management of such organisations. Taking on temporary staff or outsourcing might help, but is often not feasible; hiring more permanent staff might lead to difficulties when the workload decreases. Moreover, hiring takes time and new staff require training and time to gather experience in the practice to become fully productive. However, trying to resource the workload with too small a workforce leads to delays in project completion. As staff in professional organisations tend to work on several projects in parallel, delays will be experienced throughout the portfolio. In addition to the direct delays, which assume that productivity (tasks completed per person day) and quality (rework required per task done) remain the same, feedback effects can affect productivity and quality of project execution, as will be investigated in more detail.

In providing a generic explanation of the relationship between bidding strategies and workload fluctuations, this paper aims to advance the theoretical understanding of the project-based professional service organisation and ultimately to provide tools for its managers. Such a generic explanation requires a linking of the organisational and the project levels as their interplay determines the behaviour of the firm. The explanation which we put forward and our recommendations are based on a system dynamics model combining an organisation level structure (for staffing and project acquisition) with a project model representing project execution. We investigate the influence that bidding behaviour (in particular the time allocated to project acquisition and execution) has on workload fluctuations using this system dynamics model of a stylised project-based professional services organisation.

2. Project-based professional service organisations

A fluctuating market environment, decentralised decision-making structures and the uncertainties of project execution make the management of project-based professional service organisations in general, and the management of their workload in particular extremely challenging. The potentially low probability of bidding success (Gann and Salter, 2000) combined with the non-storable nature of a service make the management of resource availability both important and challenging. The 'lumpiness' of projects, i.e. the relative size of a single project compared to the total volume of the activities of a firm can make project-based organisations particularly vulnerable.

While project-based professional service organisations are a substantial and increasingly important part of the economy, they are less well understood than the near-archetypal Chandlerian manufacturing firm (Chandler, 1990). Management literature on project-based firms has however been slowly growing. This literature, in conjunction with studies of the work of architects and engineers, can provide some guidance in constructing and analysing a system dynamics model.

Key insights from this literature include:

1. Decision-making in individual projects has a large degree of autonomy and coordination across projects is often weak.
2. The non-standardized nature of projects increases the potential for errors; overruns are frequent.
3. Project-based organisations are more than a collection of independent projects: projects depend on shared and partly contested resources.

Decision-making structures in project-based professional service organisations often allow little power to the centre and leave considerable discretion to project managers and baron-like group leaders (Gann and Salter, 2003). Hobday (2000) identifies the coordination of processes, resources and capabilities across the organisation as an inherent weakness in a project-based organisation.

Despite the many available project management tools, projects delivering services are difficult to manage because of their non-standardised nature, which increases the potential for errors, their dependence on potentially changing client briefs, and a culture that values professional autonomy and creativity as well as ‘individual heroics’ (Perlow, 1999). Some professions such as architecture might even be opposed to planning *per* *se* (Winch and Schneider 1993). Project overruns in budget and time are therefore frequent.

Only in very extreme cases such as independent movie production (DeFillippi and Arthur,1998) is the project a free-standing entity, and even then it is enabled by the wider institutional and social environment. Generally – and this is our interest here – projects are carried out by one or several collaborating organisations, each with their own structure. 'No project is an island': projects are history dependent and organisationally embedded open systems whose performance is influenced by their relationship to competing activities and the norms and routines of the organisation (Engwall, 2003). Business processes (including resource allocation, bidding routines, human resources (HR) management) and project processes (including scheduling, execution) are interrelated and have to be analysed in terms of their interrelatedness. This is recognised in the emerging literature on project-based firms (Gann and Salter, 1998; Brusoni et al., 1998; Turner and Keegan, 1999, 2001). Isolating projects conceptually, disregarding their embeddedness in an organisation and ignoring the competition for resources between projects might have benefits for some purposes, but does not allow us to understand the overall performance of a project-based professional services firm.

The system dynamics model for a project-based professional service organisation suggested in this paper includes therefore – as will be discussed below in more detail – both structures representing individual projects and the overall organisation in a way which includes the competition of individual projects for resources (staff). In presenting an analysis which includes the interaction between the level of the project and the level of the organisation this paper locates itself between the literature on professional service organisations (Maister, 1997; Winch and Schneider, 1993) and the project management literature (see also Williams, 2003). While in these literatures projects are essentially treated as closed entities separate from the rest of the firm, what is attempted here requires including the interaction in order to explain important features of the macro-behaviour of project-based professional service companies. Resources (staff) are exclusive to the project to which they are assigned at each moment in time. As a consequence, the performance of one project can influence others in the portfolio: missed deadlines and excessive staffing demands as a result of problems in a particular project limit the availability of resources for other projects and may be deleterious to their performance.

With the model we translate the generic insight of the importance of the interaction between the project and organisation levels in the literature for the specific case of organisational workloads in such a way that the causal mechanisms of this relationship and their effects become comprehensible. We connect a stylised representation of bidding and HR at the organisation level with project execution. This modelling approach allows us also to produce recommendations for managing workloads (and thus for capacity utilization) in project-based professional service firms.

3. System dynamics approaches to professional service organisations and projects

A considerable amount of research in system dynamics has focused on the dynamics of project execution. Project modelling (Graham, 2000) work has examined many different types of projects including military (Cooper, 1980, Lyneis *et al.* 2001), civil engineering (Ogunlana *et al.* 1998), software development (Abdel-Hamid and Madnick, 1991). Both academic and consultancy work concentrates on single projects. This work considers cost escalations, project overruns, rescheduling as a consequence of changes to specifications and staffing based on the dynamics caused by the rework cycle and feedback effects on the quality/productivity of work execution. This literature adds a valuable dynamic dimension to the traditional project management literature with its focus on planning tools. The project modelling work is convincing in explaining why projects often do not go according to plan – why projects overrun, why there are periods in the life of a project that show no apparent progress, etc. Project models have been extensively used in litigation cases to determine the causes of time and cost overruns, as well as for project planning and review purposes.

The key insight from project modelling is captured in the 'rework cycle' developed by Pugh-Roberts / PA Consulting (Cooper, 1980, Cooper and Mullen, 1993; see also figure 2): not all tasks executed will be done correctly, and some will require redoing (in this conceptualisation tasks are either done or not, completed projects including poorly done tasks are typically not considered.) Which tasks require redoing will not be immediately obvious: a stock of undiscovered rework exists. Because the rework is yet to be uncovered, estimates on work already completed are exaggerated. As the rework tasks are discovered, however, they become rightly classified as work (still) to be done, not as work completed. Productivity (number of task accomplished per time unit) and quality (share of tasks done correctly) are influenced by factors such as schedule pressure, quality of prior work etc. This work typically stresses the importance of having suitable project plans from the outset (timescales and resources), of focusing on quality and quality assurance to keep the stock of undiscovered rework as small as possible and of considering the unintended consequences of any corrective actions.

An important implication of the rework cycle is the effect of staff availability on project progress. Understaffing and the strategies used for coping with it,will affect productivity and quality: frequently changes in staff working on a project will reduce both productivity and quality; pressure to meet increasingly impossible deadlines will increase productivity but reduce quality due to rushed working and, in the longer term, fatigue. Thus, the indirect effects of resource constraints on the quality of work execution are that more tasks have to be redone and the overall work (i.e. total number of tasks done and redone) which has to be completed to finish the project increases. Understaffing will increase the time required to complete an individual project more than would be the case if productivity and quality remained fixed.

Figure 2 about here

In contrast to the extensive work on models of single projects, published work that has looked at the interactions between several projects, and their effect on portfolio issues is very rare. Repenning's (2000) work on the negative consequences of the competition of resource allocation between early and late project phases in an R&D environment where two projects in different phases are undertaken in each moment in time being a notable exception. Weil, Bergan and Roberts (1978) have used system dynamics to examine causes of the oscillating and maldistributed workload between different parts of an R&D organization (e.g. product program vs. product exploration activities). This work does not investigate the resource competition between individual projects or fluctuations in the overall workload of the organisation.

Almost no work on projects in the context of the wider organisation has been done using system dynamics. While some studies have used system dynamics to understand professional services companies at the organisation level, this work has not analysed the projects carried out by these organisations. Warren's model centres on HR issues and the effect of staff experience (determined by staffing decisions) on company performance. (Warren, 1998) Morecroft, Mott and Achi (1983) have modelled an auditing firm and found that the (exogenous) workload seasonality (due to the end of the tax years) in conjunction with the growth of the company leads over time to a declining performance mainly due to the relationship of partner behaviour and its effects on staff.

While the existing system dynamics work does not pay much attention to the relationship between the execution of projects and their organisational environment, the approach is well suited to exploring this link. Prior work on workload fluctuations in a manufacturing firm, Roberts (1977), has not modelled the manufacturing of individual orders (which is similar to representing projects just aggregate as a “backlog”). However, the model required to address the concerns in our paper has to take a different approach due to the different nature of activities we deal with (projects with the potential to overrun as opposed to easier to plan manufacturing, competition of between projects for resources).

4. A model of a project-based professional services organisation

The purpose of the system dynamics model presented here is to understand the effect of choices in relation to a particular business process, i.e. bidding strategies on an organisation’s workload over time. We address this issue by combining an organisation level model (including staffing and project acquisition activities and outcomes) with project models representing project execution for individual projects. With this representation of the project-based professional services organisation we take account of the insights from the project modelling literature. It is not appropriate to view a project as essentially a black box since external influences such as resource allocation can impact on the productivity (tasks per person day) and quality (rework required per task done) of project work. Whether this model captures an appropriate level of detail will depend on the type of project-based organisation: there must be enough relatively similar projects for the generic parameterisation and the probabilistic structure to be appropriate.

The probabilistic organisation level structure determines start date, duration, project size and initial staffing and staff availability for later staff assignments for each of the projects being conducted by the organisation. Project execution is modelled using a project model adapted from Lyneis (2004). Our model of the project-based professional services company comprises the following elements (see also figure 3):

1. A staffing model comprising new and experienced staff in the company
2. A highly stylised model of the project acquisition process.
3. A subscripted project model for the execution of single projects, so that a portfolio of projects can be represented.
4. Some structure adding up the performance of individual projects to result in the performance (rework, overruns) of the portfolio.

Figure 3 about here

The policy choice whose effect is investigated with the model pertains to the amount of time spent on bidding. The model determines endogenously the allocation of staff to bidding and to individual projects; project overruns and rework of individual projects is also generated endogenously. For the purposes of this paper many elements of the real system have been excluded. These excluded elements are in particular: hiring and firing, staff attrition, corner cutting in project execution resulting in inferior quality of the finished project, the effect of staff working on several projects in parallel, the dependence of project or bidding performance on external events.

Staffing

In modelling staffing (for an overview see figure 4) we made some simplifying assumptions. While a “real firm” will certainly have a certain amount of staff turnover, the stylised company we investigate here does neither hire staff nor loose staff. We made this choice in order to keep – at least for the discussion in this article - the phenomenon studied here separate from issues of company growth. A discussion of the effect of different types of hiring (and firing) policies on workload deserves a separate and extensive treatment elsewhere.

In the model we distinguished only between inexperienced and experienced staff, but not between staff with different areas of expertise. To model staff allocation in a project-based organisation we assumed that there are separate stocks of inexperienced and experienced staff not assigned to projects. Experience is only gained while working on a project, but does not decay for unassigned staff. Staff (fractions of full time equivalents) are assigned at the start of each project and subsequently during execution – reflecting the perceived resource requirements needed to meet project deadlines – from the pool of inexperienced and experienced currently unassigned staff in the company. Staff are later released back to this pool and become available for other projects.

Project-based enterprises vary in terms of how they allocate staff time to project acquisition (i.e. the bidding strategy). While some organisations have dedicated teams that bid for projects, in others, project acquisition is the responsibility of the staff who will also be engaged in project execution. The staffing section of the model can be parameterised both to represent the case that there is a separate project acquisition team and the case that some of the experienced staff can be involved in acquisition whenever they are not assigned to the execution of a specific project. The bidding policy section in the model determines which proportion of experienced staff time not currently allocated to projects will be spent on project acquisition. Thus, being involved in bidding does not preclude staff from being assigned in the next time period to a project. This absolute priority of execution is of course a simplification. The model can also represent a combination of these approaches to staff allocation for acquisition.

Figure 4 about here

Acquisition/bidding policy

This section of the model allows us to define a variety of different acquisition policies and to initialise the model. In our model, the fundamental management choice pertains to the amount of time spent on bidding/acquisition, which will then influence the number of bids which can be completed in each time period. This is clearly a significant simplification from the real world where a variety of project and client characteristics would inform the decision to bid or not to bid.

The time spent on acquisition is expressed as a (positive) fraction of the total – in our model constant - staff time. This fraction is the smaller of both by the fraction of staff which can bid in principle (drawn from dedicated bidding staff and non-assigned experienced staff) and the share of staff time desired for bidding.

The share of staff time desired for bidding is given as a fixed parameter (target share) and a correction depending on current workload and the bid pipeline (successful but not yet started bids and not yet decided bids).

> *target share + weight active projects *number of projects active + weight non-decided bids *number of bids waiting for decision + weight successful bids* number of successful bids not yet started*

The weights can be negative. The correction is additive and not multiplicative as more usual in system dynamics since the resource requirements of upcoming projects are also additive.

Which members of staff are available to bid depends on the bidding policy. They might be dedicated bidding staff and/or experienced staff not currently engaged with project execution work; for experienced staff, project execution always takes priority. There is a parameter for the number of dedicated bid staff and a switch variable that determines whether non-assigned experienced staff can bid.

The model is designed to be flexible with different parameter specifications representing different bidding policies after and during the initialisation phase. If the target share is fixed at the value one, bidding depends only on staff availability. In this way the effect of constant effort on bidding (a fixed bid team) or maximum bidding through non-assigned experienced staff (with or without a fixed bid team) can be modelled.

Acquisition/bidding

A way to link time spent on bidding with the number of bids started/completed has to be found. There are several possible methods of conceptualising the relationship, for example the duration of bid preparation and the number of bids prepared in parallel may be fixed or variable. While the reality in a particular organisation might be quite complex, for simplicity we assume here that the number of bids prepared in parallel remains constant (set to 5), that the amount of work required for a bid is fixed, that productivity of staff in bid preparation remains constant and that the total staff time for bidding is distributed equally among these bids. We further assume that waiting times for decision and start after the completion of a bid are fixed. As the bid preparation process is easier to plan than project execution it is not necessary to model the bid preparation process in more detail; considering bid preparation to be a project with a rework cycle would make the model inappropriately complex. We regard the likelihood of bid success to be similar to a lottery, more bids linearly increasing the number of expected successes within a specific period of time in the same way as the purchase of more lottery tickets increases the likely number of wins in a draw. While this is, of course, a considerable simplification of the processes of project acquisition in professional service organisations, for the purposes of this paper we deem it to be appropriate to simplify the 'messiness' of project acquisition and not to consider the role of informal relationships, joint bids and partnering or bid efforts which materialise after long and variable times.

These abstractions allow us to arrive at a relatively simple model. Work on each bid is represented by a different subscripted instance of the array variable effort on bid. While work is carried out on a number of project bids in parallel the growth rate of the array variable 'effort on bid' is for each active bid dependent on a constant fraction of the time spent on bidding activities. A new bid will be started when the number of active bids falls below the set number of bids to be carried out in parallel. After a delay a percentage of completed bids will be successful and lead to projects which will start after a further delay.

Project execution (i.e. the project model)

Project execution is modelled using a slightly modified version of the project model suggested by Lyneis (2004). At the core of this model, as in other project models, is the rework cycle discussed above (see figure 5). The model includes several feedback effects on the productivity and quality of project execution. Productivity (i.e. the number of tasks completed per week and member of staff) is reduced compared to its normal value by less experienced (or less able) staff, and increased by schedule pressure as project deadlines are approached and exceeded. Quality is reduced by schedule pressures, errors in prior work and inexperienced staff. A large number of subscripted models represent the portfolio of projects undertaken by the firm. As we use the same subscripts as for the bidding process, there are many subscripted instances of the project model which are not used, i.e. the project models corresponding to unsuccessful bids. Each of the individual models of project execution can be invoked with varying start times and project sizes. In the execution phase the different projects are only connected in that they recruit from a common pool of staff.

Figure 5 about here

Portfolio issues

The model contains some structure which allows the performance in terms of project completions and excess work and project overruns of the portfolio to be aggregated up from that of the individual projects. This structure also calculates numbers of active bids and projects etc. which are not explicit as stocks in the model but are implicit in the array structure. As the number of staff is kept constant (and therefore costs remain constant as well) and all project are of the same initial size, the number of project completions can be seen as a proxy for financial performance.

A rolling average of overruns relative to the project length for projects finished during the last three months is also calculated. This quantity smoothed (time constant 1 year) is interpreted as perceived relative overruns (which in the last set of experiments will influence bid success rate).

5. Model experiments and analysis

Initialisation

It is necessary to initialise the professional services organisation with projects and a project pipeline, as it would be misleading to start our enquiry into bidding policies from a situation where the company has neither. The behaviour of the system and in particular any fluctuations of workload might under these circumstances be just an artefact created by the highly unusual situation. To initialise the company in equilibrium is not possible due to the probabilistic formulation of bid success and the discreteness in project initiation and completion. In order to initialise the company we ran the simulation for 200 weeks starting with an ‘empty’ company with a fixed bid team of 6.5 staff. We chose this particular initialisation as by week 200 it brings the company to a relatively stable state with few fluctuations in project load.

Figure 7 about here

We conducted our experiments with different bidding strategies for the subsequent 200 weeks starting with the company in a relatively balanced position with a healthy project portfolio and pipeline.

Base run

In the base run we assume that there is no dedicated bidding staff and that experienced staff will engage in bidding whenever they are not engaged in project execution. We choose this policy because of its *prima facie* appeal of minimising non-productive time.

In this run, fluctuation of the workload can be observed (see figures 7 and 8). Bidding activity peaks shortly after week 265 and then again around week 360. This type of bidding policy creates large fluctuations in workload and a cyclical behaviour.

Figure 7 about here

Figure 8 about here

Comparison between the time spent bidding and the number of projects active suggests a simple relationship between the two. A peak in bidding leads, with some delay, to a peak in workload (and consequently – given the bidding policy of the base run – a trough in bidding) leading to a drop in workload which frees up time for further bidding. A look at project overruns over time reveals that total overruns in the portfolio rise because the average overrun per project is rising. Workload is increasing more than can be justified by the number of projects alone. This is explained by the rework cycle – under-resourced projects create more rework. increasing workload and overruns.

Figure 9 about here

The fluctuating behaviour can be understood in terms of major feedback loops (figure 10). The first balancing feedback loop reduces the backlog of work to do while the second increases – with significant delay - the backlog through new project starts. The fluctuations are acerbated by the effect of the rework cycle. While the rework cycle is active on the project level (and needs to be studied on that level) its overall effect can be captured as a reinforcing loop in this high-level causal loop diagram: the increased workload reduces the resource availability per work task which results in more rework, increasing work to do. The third balancing loop cannot counteract the effects of the reinforcing loop as the staff time dedicated to execution does not rise enough to ensure adequate resourcing for the tasks.

Figure 10 about here

In order to test whether this pattern of a fluctuating workload depends on the random nature of bid success we have repeated the simulation with different noise seeds. The basic pattern remains the same with only very minor variations. Similarly, small variations of the parameters setting the number of bids in parallel, the bid success rate and delays before project starts do not change the basic patterns.

Alternative bidding strategies

The bidding policy in the base case is not ideal as it results in under-resourcing of projects and a consequent deterioration in performance across the portfolio.

This policy of allocating all spare capacity of experienced unassigned staff to bidding is inappropriate for two reasons: first no bidding is undertaken when project workload is high and second too much bidding work is undertaken when project workload is low. To address the first issue, a bid team of staff which will never be assigned to projects can be created. To address the second issue, bidding activities can be limited depending on current workload and project pipeline (projects not yet started and bids not yet decided). This course of action would however require a cultural change in many project-based organisations: foregoing the opportunity to bid requires courage. In the following we consider the four generic bidding strategies arising from combining these choices (table1).

Table 1 about here

We conducted model experiments to compare four generic bidding policies. The two types of bidding policies which take the project pipeline into account make the maximum bidding time, expressed as a percentage of the (constant) number of overall staff, linearly dependent on the number of projects currently being undertaken, the number of projects yet to be started and the number of bids awaiting decision. The bid effort is also constrained by staff availability: depending on the policy, the size of the bid team or the number of experienced staff not engaged in project execution.

We first compare the 'best' implementations of these four generic strategies, i.e. the parameterisations leading to the highest number of project completions.

Simple bidding policies – no regard for pipeline

We investigated the effects of two classes of simple bidding policies taking no account of the project pipeline. In the 'fixed bidding staff' policy, bidding is continuously done by a fixed number of staff not engaged in project execution. In the ‘target share policy’, experienced staff bid (up to a fixed time limit) when not engaged in project execution.

In each of these two cases we explored the effects of different choices of the key parameter. The graphs below illustrate our experiments for one particular initialisation of the random generator governing bid success; graphs for other initialisations of the random generator would differ slightly but the relationships would not fundamentally change. As the size of the bid team grows, the number of project completions increases (figure 11). If the bid team becomes large, more projects are won than can be completed and the workload rises massively. The projects that are now no longer adequately resourced overrun substantially. Overruns are exacerbated by the effects of the rework cycle: more rework is required in order to complete under-resourced projects. In reality this would be further compounded by the fact that the constant overruns would impact on the bid success rate for future projects; this feedback is omitted here.

Figure 11 about here

As the parameter target share increases, i.e. the amount of time spent on acquisition by experienced staff not engaged in project execution expressed as the share of bidding time in overall staff time, project completions increase and reach a peak for a target share of about 8% (figure 12). For higher values, project completions are lower as projects take longer to complete due to understaffing and increased rework. A target share of 25% or more implies in practice that all available time not assigned to project execution is devoted to bidding as in the base run.

Figure 12 about here

Comparing the four generic bidding policies

The bidding policies determine the fraction of time allocated to bidding in the following way (see figure 13).

Figure 13 about here

The ‘target share and pipeline policy’ results in a smaller number of projects underway at each moment in time than under the ‘bid team policy’ (figure 14) and generally also the base run of maximum bidding , but more project completions (figure 15). The better performance of the ‘target share and pipeline policy’ is due to the underlying dynamics of project execution. Because staffing shortages are avoided, total excess effort and rework are lower throughout the portfolio.

Figure 14 about here

Figure 15 about here

Marked fluctuations in workload appear in both the worst and the best bidding strategy in terms of project completions. These fluctuations are therefore not problematic per se. They are generated internally by these bidding strategies and occur in a stable environment as a result of the base run (maximum bidding in spare time) and under the strategy of bidding being undertaken by project staff, but with account being taken of the pipeline.

The Gantt chart (figure 16) compares projects undertaken following the best and the worst performing bidding strategies. For each strategy and for a number of projects the time for bidding and – if the bid was successful - for execution are shown as small bars. Under the worst performing strategy (the base run) projects take far longer to complete than under the best performing strategy even though the initial size of the projects (measured in number of tasks) is the same. Having experienced staff spend all their available time not allocated to projects on bidding activities (the base run) is not to be recommended as under-resourced projects overrun seriously. This holds even though project execution has priority over bidding.

Figure 16 about here

Bidding policies where time spent on bidding is dependent on the number of active projects, the number of successful bids awaiting start and the number of bids not yet decided are superior to the other options. Having bidding done by project staff is superior to having a dedicated bidding team in terms of project completions (table 2) and rework generation (table 3).

Table 2 about here

Table 3 about here

We have so far chosen the best possible implementation of these generic strategies for a particular set of random numbers describing bid success. Clearly, this could not be achieved by a real world decision maker without perfect foresight.

We therefore extensively examined how these strategies (with the specific parameterisations chosen above) would perform if the random outcomes of bid success were different, but the bid success rate remained the same. We ran 200 experiments for each strategy and found that, as would be expected, the strategies perform worse than in the situation for which the best parameters were chosen (see table 4). The basic pattern was remarkably stable: the strategies that take no account of the pipeline result in much higher rework and far fewer completed projects. The strategy under which experienced staff bid when not engaged in projects, but where bidding is limited according to a rule based on projects in the pipeline, performs best even though the level of rework is slightly higher than in the bid team and pipeline policy. This is because more staff are available for project execution as there is no dedicated bid team which is idle when not engaged in bidding. The ‘best possible’ bidding strategy for a particular situation remains acceptable in the more generic case.

Table 4 about here

In a further set of experiments we checked whether the particular pipeline policies are superior even in a more realistic changing business environment. In these experiments we use the parameters found through optimisation for the static environment. The changing business environment is represented in the model by a changing bid success rate from 0.375 to 0.625 implemented as a sine wave with a period of 80 weeks.

The fluctuations of workload observed in the static environment were modified in a dynamic environment (figure 17). The environment, however, is not the only driver of the workload dynamic of the project-based professional services firm.

Figure 17 about here

In a last set of experiments we added feedback from the perceived overruns of the portfolio on the bid success rate: the bid success rate reduces as potential clients perceive the company to have problems with timely delivery. With this balancing feedback loop the workload of the company is lower. Even with this balancing feedback, workload still fluctuates considerably (figure 18). Project completions, rework and workload (table 5) are in most cases markedly reduced.

Figure 18 about here

Table 5 about here

6. Conclusions

The research described in this paper develops and analyses a generic model which allowed us to explore the interaction between project level and organisation (business) level processes and their influence on workload fluctuations. We have therefore operationalised the insight stated in the literature on project-based firms in the importance of this interaction.

Organisation-level business policy can influence both portfolio and firm performance as a consequence of under-resourcing of individual projects. Because of the effects of the rework cycle, under-resourced projects require more work than adequately-resourced projects. The workload is therefore further increased with repercussions for the portfolio and for the performance of the organisation. Thus, any fluctuations in the number of projects won and started can lead to even greater fluctuations in workload and project completions. A change in bidding strategy at the organisational level that avoids or reduces bidding for projects which cannot be resourced properly reduces these effects.

Workload fluctuations are influenced by firm internal processes via two mechanisms: the direct consequence of a fluctuating project start rate and the further amplification due to rework cycle effects. The fact that the dynamics of project execution, i.e. project overruns caused by understaffing and their effects on productivity and quality, have dramatic consequences for organisational performance indicates the value of the combination of a project model and a bidding model in this case: the rework (and consequent overruns) generated in individual projects bind the resources required for the successful and timely completion of other projects.

The modelling work offers some insights for managing project-based professional service organisations:

- as rework and overruns in individual projects have consequences throughout the portfolio, measures to reduce and detect rework are beneficial;
- undertaking fewer projects at the same time, but completing them more quickly and (due to less rework) with less effort, could increase the number of projects completed over time;
- avoiding extreme workload fluctuations (resulting in under-resourcing) could have beneficial effects on the execution of individual projects and the performance of the portfolio in terms of the number of projects a firm can complete (with a given amount of resources).

The model experiments suggest that future workloads could to some extent be smoothed by care over timing of marketing efforts or different allocations of time to bidding and project execution depending on current and projected workload. While some degree of fluctuation is unavoidable due to the uncertain nature of the market and the ‘lumpy’ nature of individual projects (i.e. the substantial difference to workload if a single big project is won or not), such fluctuations can be reduced. However, as workload fluctuations are not the only factor influencing firm success, the most successful strategies might not necessarily be those with a completely even workload, but might involve some short periods of somewhat lower utilisation.

Because of the dynamics of project execution, a bidding policy that takes into account the bidding pipeline and avoids overbidding is financially beneficial as more projects can be completed. Sometimes, it might be better to do nothing, than to win additional business. Clearly in practice there are constraints to how often firms should ‘say no’ to projects and the degree of autonomy of project managers and “barons” as well as the culture of these organisations will affect attempts to achieve more centralised coordination.

Although the time delay between project bid and project start may appear to have some similarities with manufacturing supply chains, the uncertainty of bidding success, the organisational form and particularly the dependence of project performance on resource availability make it more difficult to manage the ‘ordering process’ in this case. Inherent in professional service organisation projects is the phenomenon of error amplification caused by the rework cycle: overruns in projects lead to further overruns in other therefore not properly resourced projects.

Our model has to some extent opened the black box of the project within the professional service organisation allowing us to take account both of why projects can and do overrun and the consequences of this. A more aggregated model, without explicit modelling of the dynamics of projects would have missed this insight. Now that this understanding of the dynamics has been gained, explanations – be they formal models or appreciative theories – concentrating on the essence of what has been learned using this more complicated model, would be desirable. Future research should also relax the simplifying assumptions in this model and investigate in particular the inclusion of staff with different areas of expertise; include hiring/firing, outsourcing, project phases, external environment (including reputation due to past performance). The approach taken here lends itself to the exploration of other linkages between the project and the organisation levels in project-based firms, especially in relation to innovation in such firms as this requires also to analyse the link between project and business processes.(Gann and Salter, 1998). Empirical work which further substantiates the model findings by collecting data on the effect of different strategies on workload would also be extremely interesting and useful.

Acknowledgements

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Notes:

1. We determined the available work time in each month taking into account holidays, public holidays and sickness. While administrative work (including promotion, training etc.) was explicitly captured in the data, time allocated to individual project codes had in the past not been recorded separately for bidding and project execution. However, from the sales records we could infer which proportion of time was allocated to unsuccessful bids. We estimated the time spent on all bidding from this number and

the bid success rate for the two types of services of the practice (architecture and project management). We have confidence that this estimation process does not cause the fluctuations as the number of ultimately unsuccessful bids underway under in the practice is quite large (average: 47, minimum 19).

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Figures

<u>Figure 1: Time allocation in architectural practice</u>

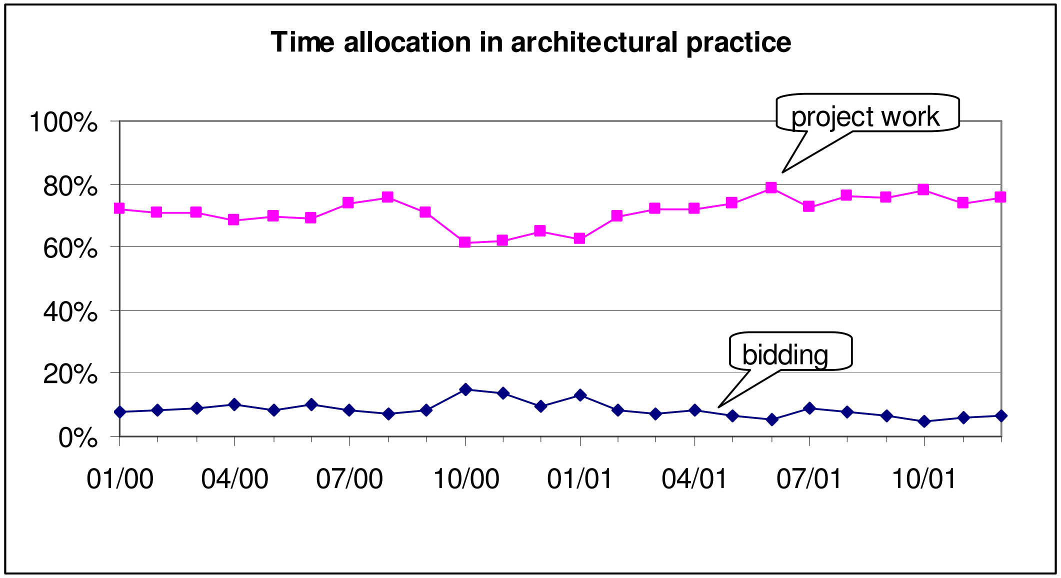
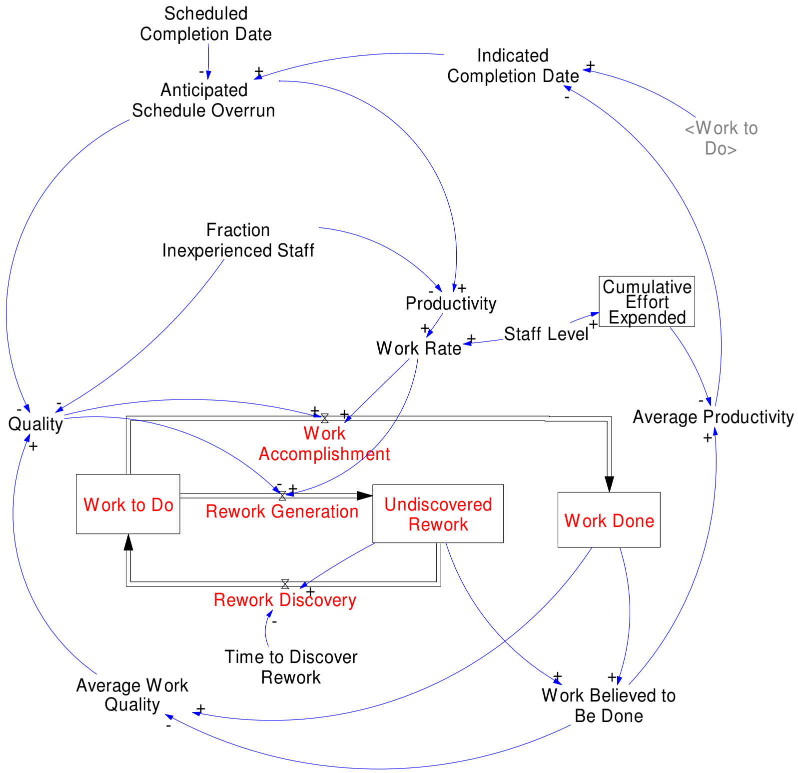


Figure 2: The rework cycle



Note: Polarity on an arrow: "+" ("-") indicates that an increase in the variable at its origin leads to an increase (decrease) in the variable at its end.

Figure 3: Model overview

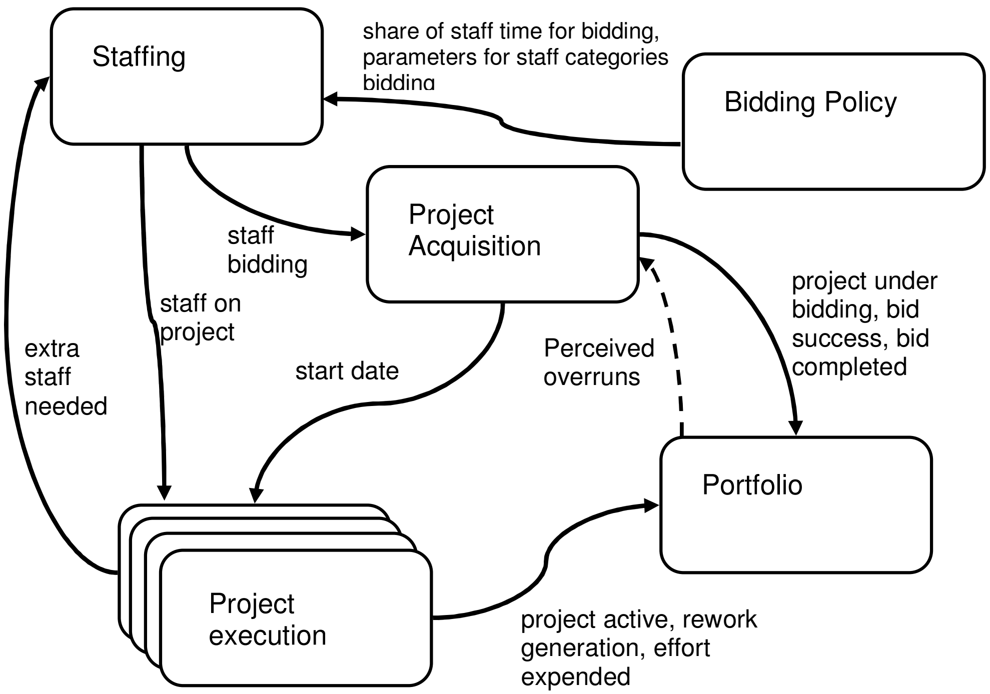


Figure 4: Staffing

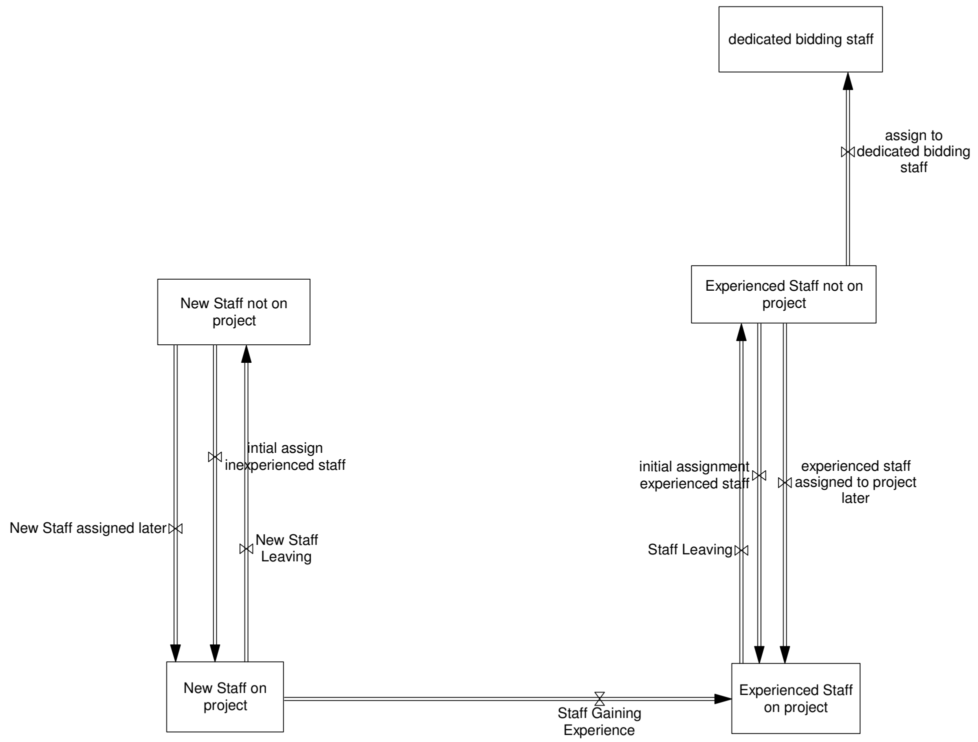


Figure 5: Project Execution

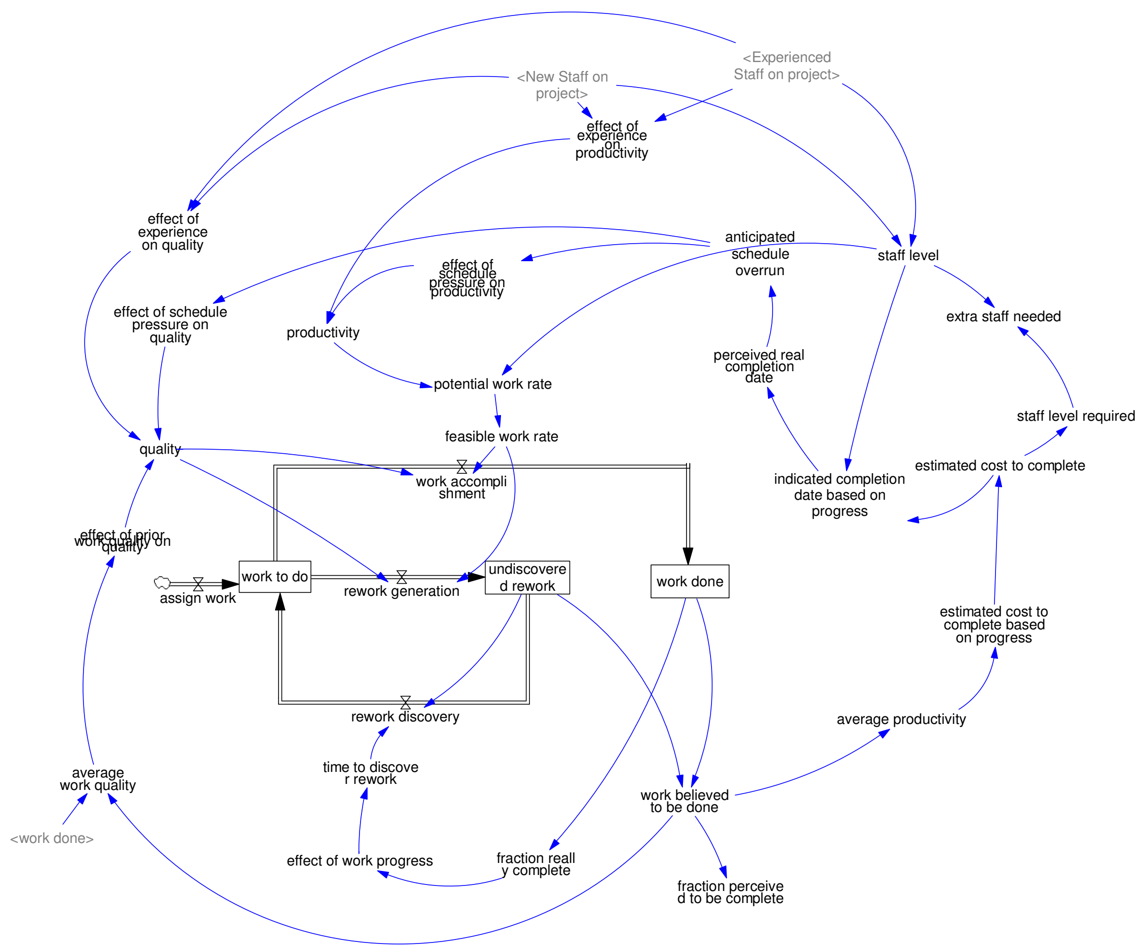


Figure 6: Initialisation run

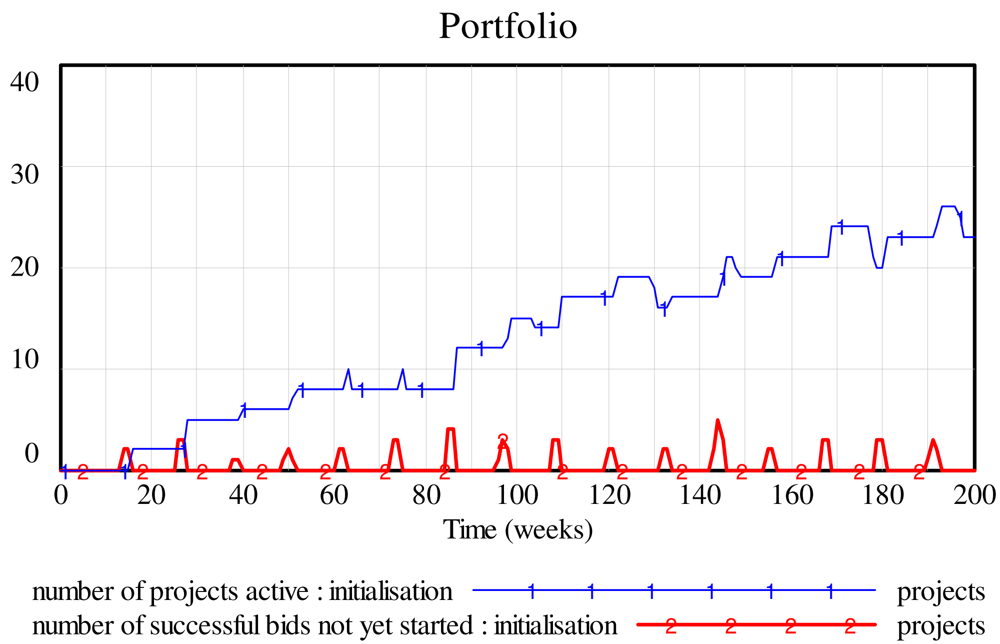


Figure 7: Staff bidding Base Run

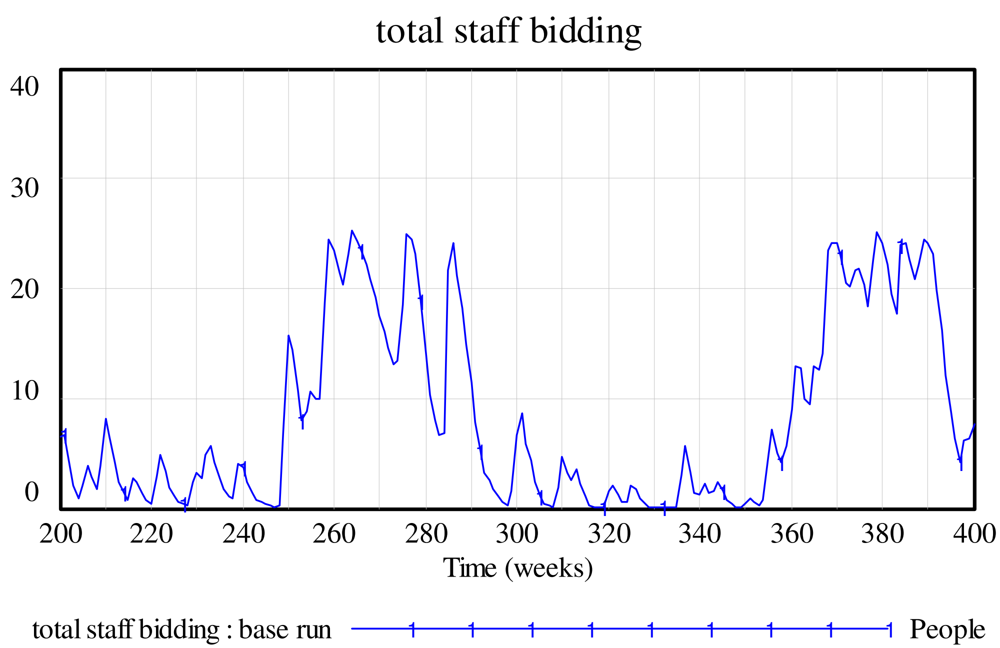


Figure 8: Portfolio Base Run

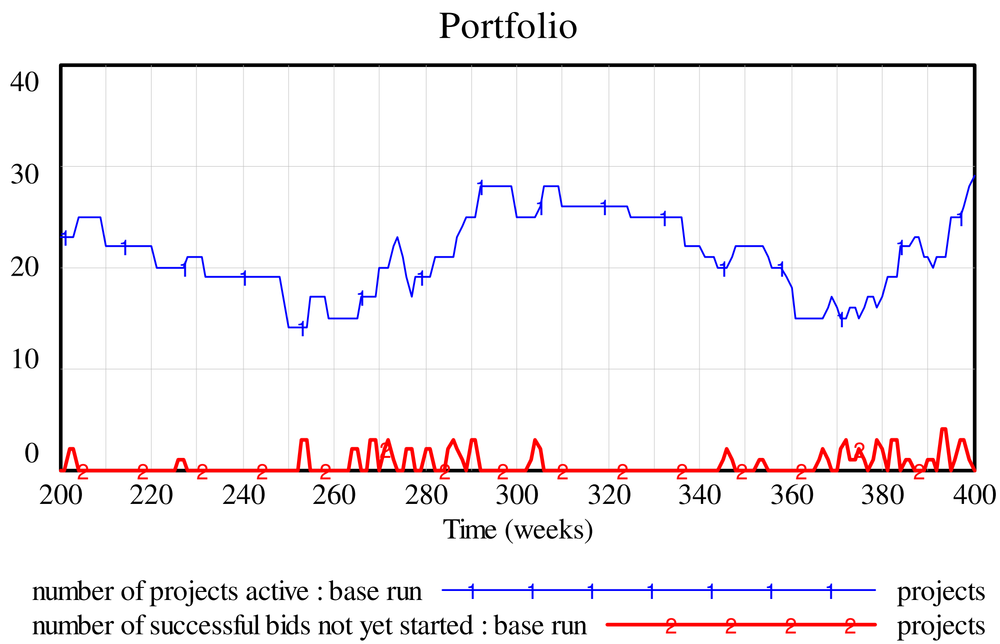


Figure 9: Overruns Base Run

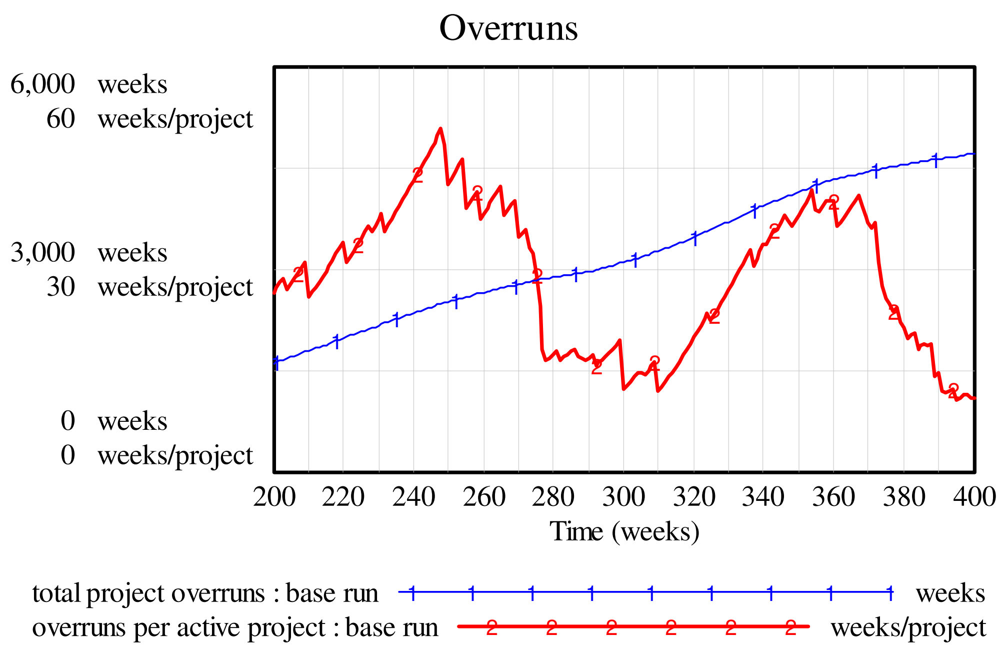


Figure 10: Loops for base run

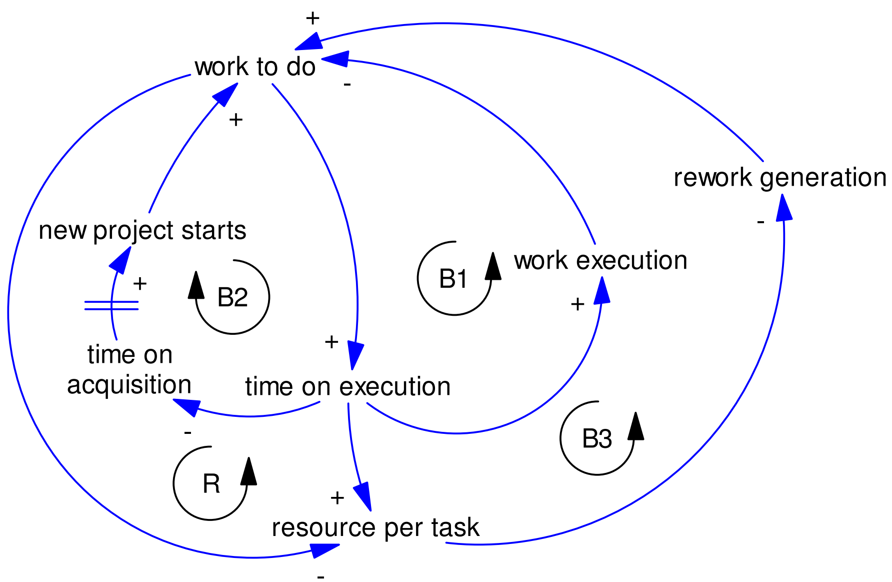


Figure 11: Sensitivity to size bid team

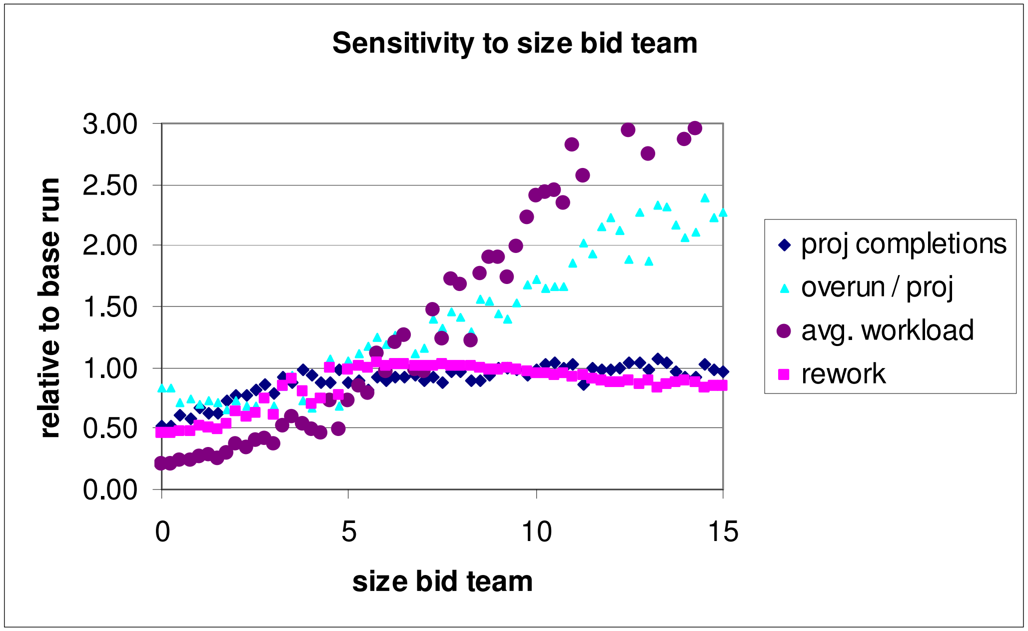


Figure 12: Sensitivity target share

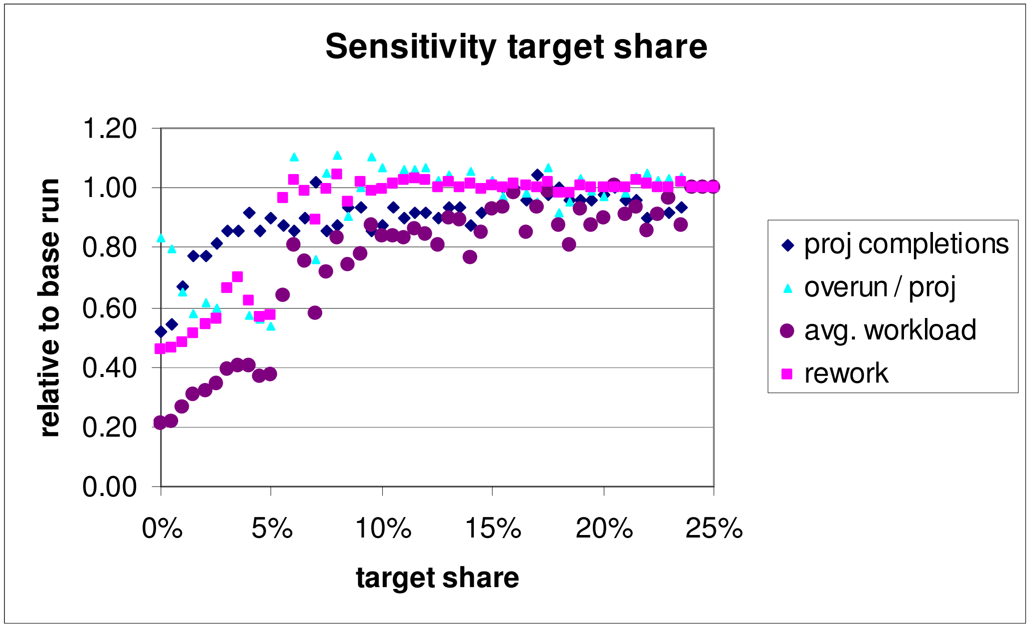


Figure 13: Share of time allocated to bidding

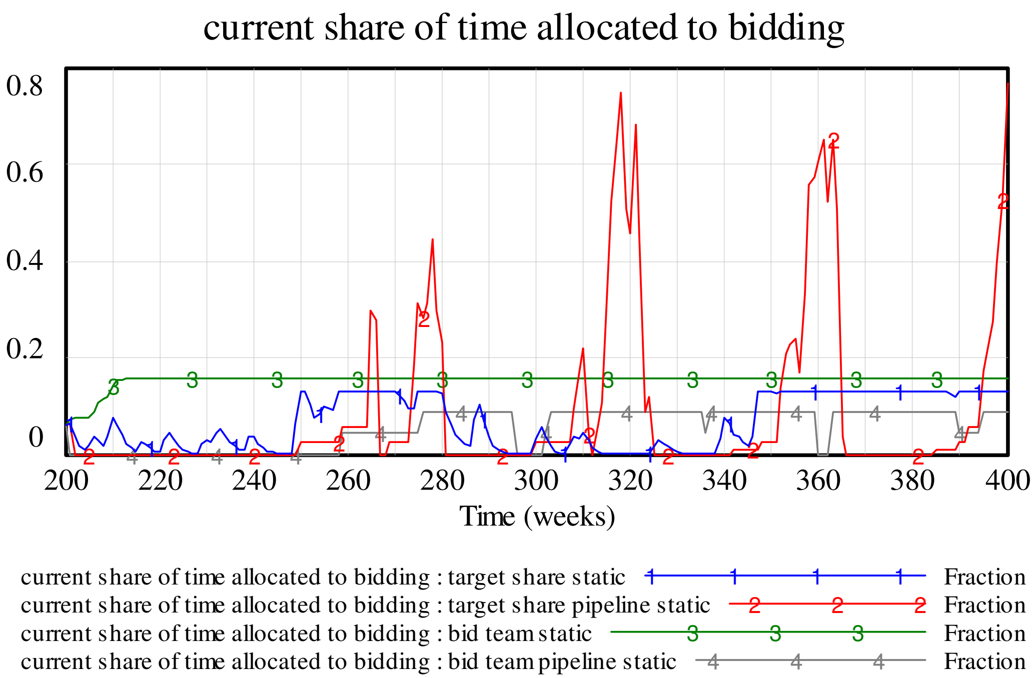


Figure 14: Active projects

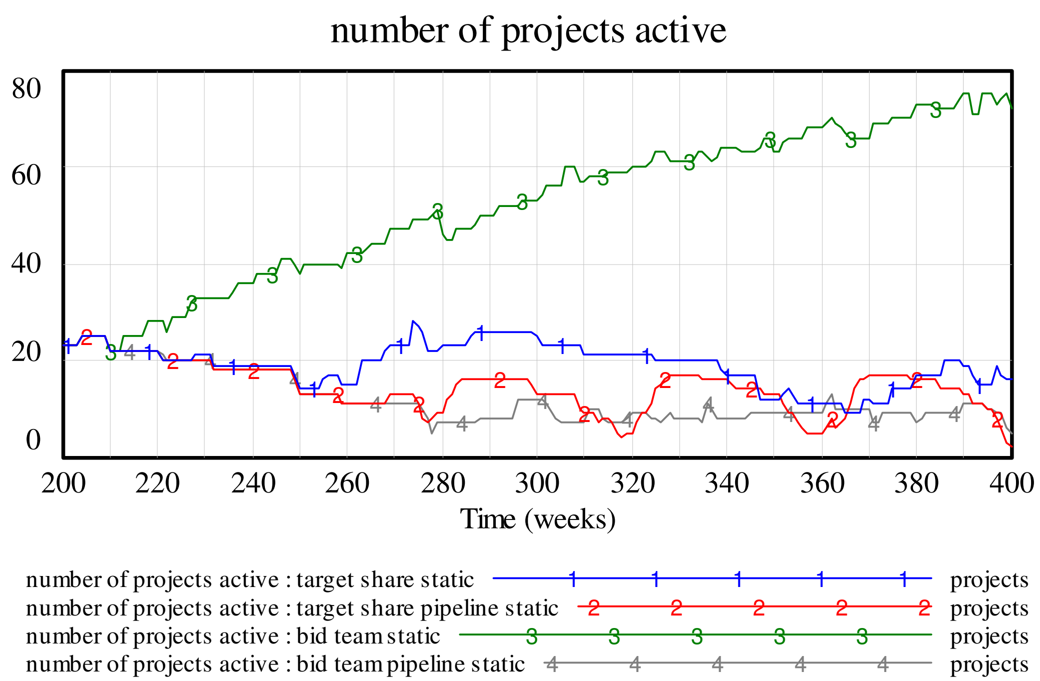


Figure 15: Completed projects

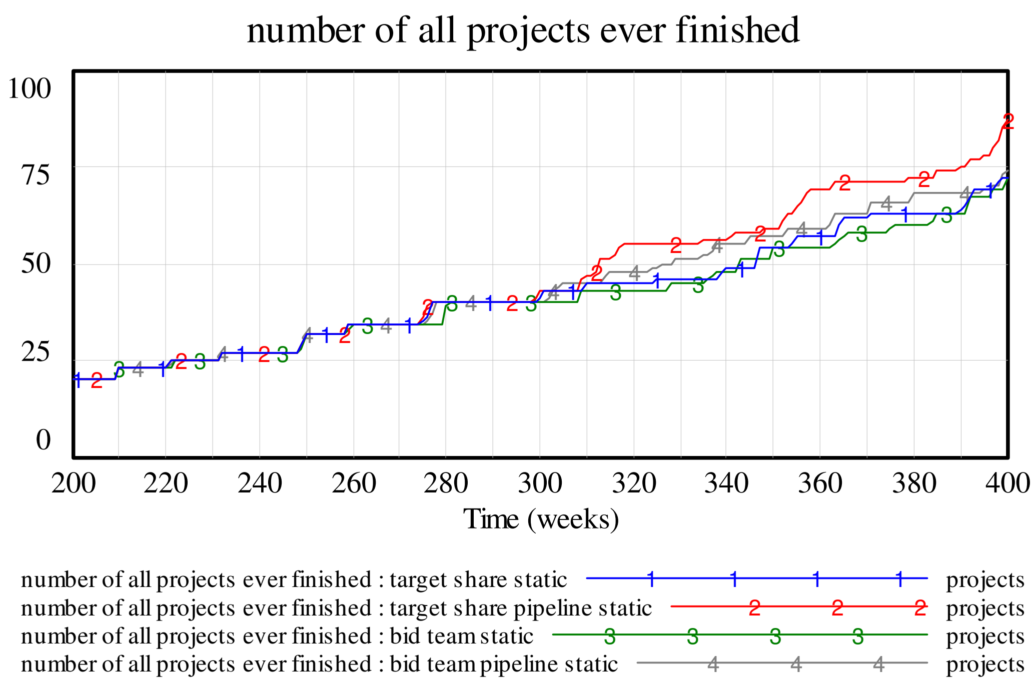


Figure 16: Gant chart

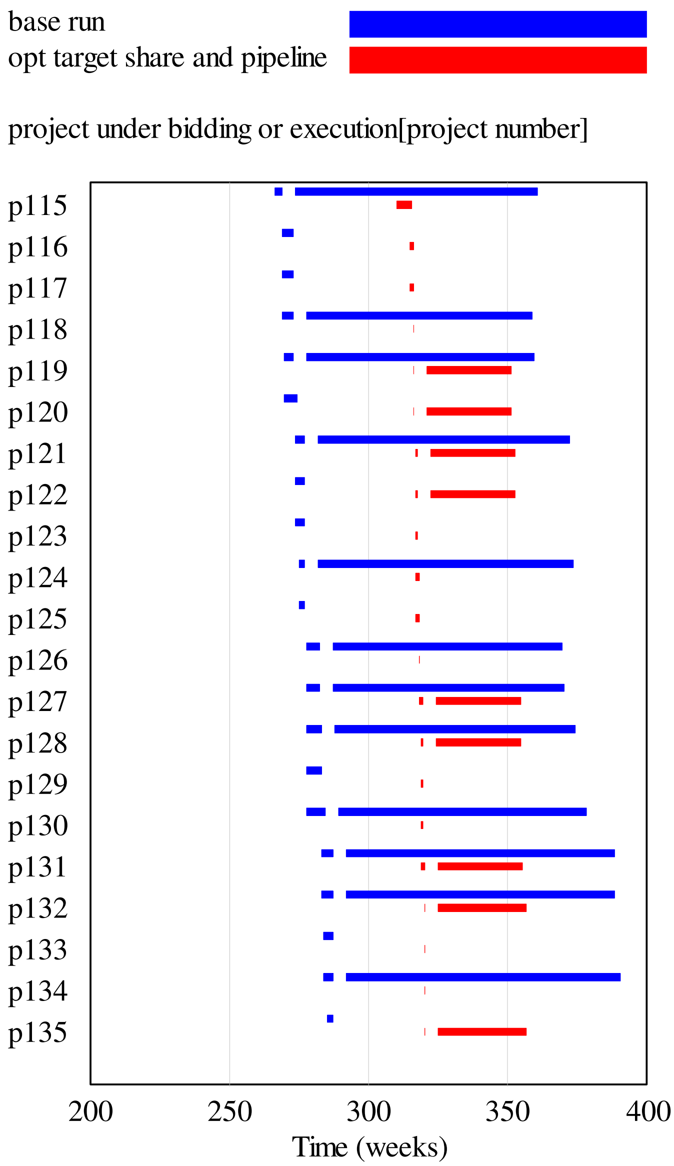


Figure 17: Active Projects in Variable Environment

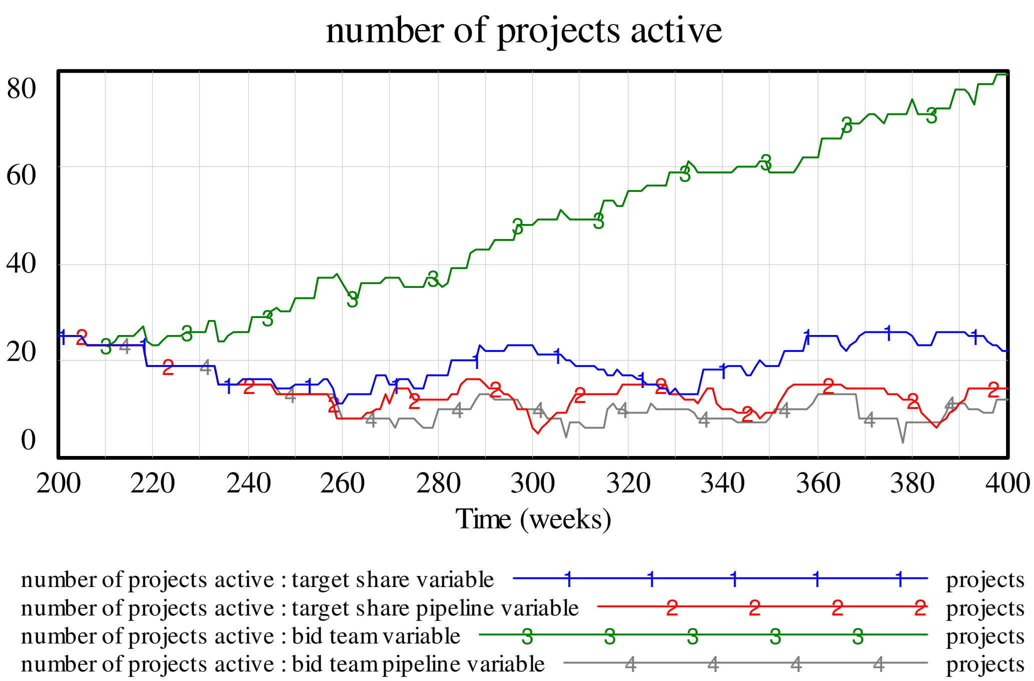
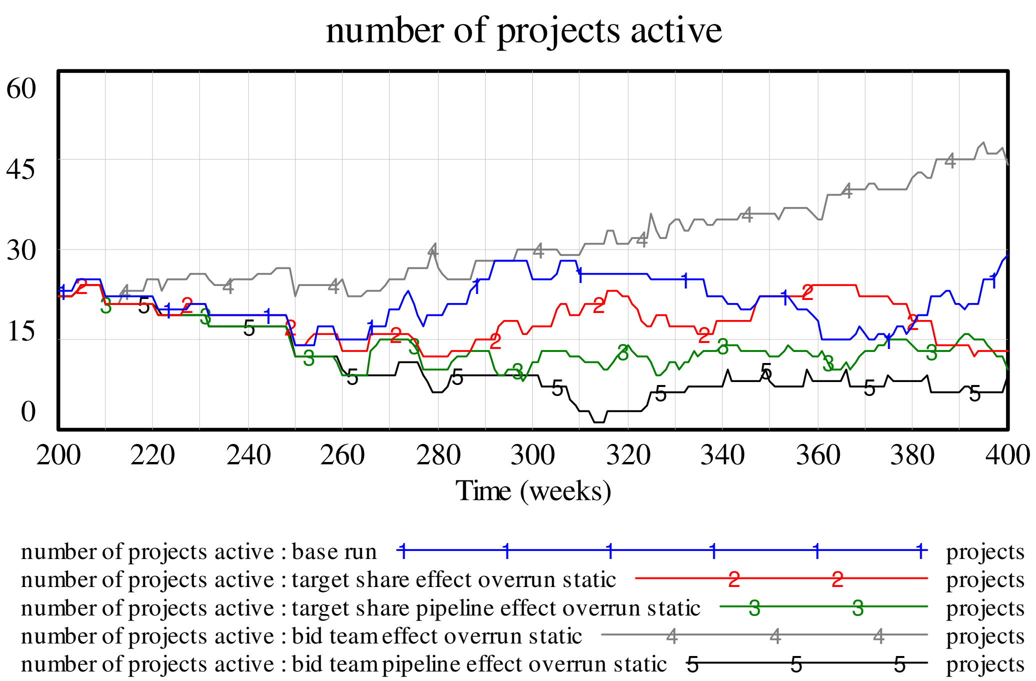


Figure 19: Active projects with balancing feedback from overruns



Tables

<u>Table 1: Bid strategies</u>

	Pipeline not considered	Pipeline considered
Bidding (up to time limit) in non-project time	Experienced staff bid (up to a fixed share of staff time) when not engaged in project execution (equals base case when maximum share of staff time =1)	Experienced staff bid when not engaged in projects, bidding limited according to a rule based on projects in pipeline
Bid team	Bid team constantly bidding	Bid team bid, bidding limited according to a rule based on projects in pipeline

Table 2: Completed Projects

Number of completed projects	**Pipeline not considered**	**Pipeline considered**
Bidding (up to time limit) in non-project time	72	87
Bid team	72	79

Table 3: Rework

Amount of rework [tasks]	**Pipeline not considered**	**Pipeline considered**
Bidding (up to time limit) in non-project time	27137	22422
Bid team	24195	20724

Table 4: Comparison of bidding strategies

strategy			environment	project completions		total excess work [tasks]		average workload [tasks]	
name	bidding	pipeline considered		Mean	StDev	Mean	StDev	Mean	StDev
target share	execution staff	no	static	65.0	1.9	28385	354	773	40
target share pipeline	execution staff	yes	static	84.6	3.1	23699	639	535	18
bid team	bid team	no	static	67.1	2.3	24249	267	3923	381
bid team pipeline	bid team	yes	static	70	2.4	20611	653	438	28
target share	execution staff	no	variable	68.0	3.9	29446	985	787	54
target share pipeline	execution staff	yes	variable	80.0	5.0	24276	1227	528	58
bid team	bid team	no	variable	67.9	4.1	26212	896	3213	395
bid team	bid team	yes	variable	74.78	4.1	21511	1305	446	71

Table 5: Effect of project overruns

strategy (static environment)			project completions		total excess work [tasks]		average workload [tasks]	
name	**bidding**	**pipeline considered**	**Mean**	**StDev**	**Mean**	**StDev**	**Mean**	**StDev**
target share	execution staff	no	64.1	2.8	27270	1060	644.6	54.4
target share pipeline	execution staff	yes	76.6	4.2	22955	650	495.8	21.1
bid team	bid team	no	65.1	2.2	25393	371	2415.2	337.7
bid team pipeline	bid team	yes	67.6	3.0	19662	563	387.1	30.3