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GOAL COMMITMENT AND COMPETITION AS DRIVERS FOR GROUP PRODUCTIVITY IN BUSINESS PROCESS MODELING

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Abstract

Many studies have looked at the factors that control the productivity of collaborative work. We claim that goal commitment and competition have a strong impact on group productivity in collaborative modelling. To substantiate this claim we first take a look at existing factor models to identify the factors that potentially mediate the effect on group productivity. We then investigate the relation between the factors with the help of controlled field experiments in five different organisations. We confirm the theoretical results with the help of structured equation modelling.

Keywords: Business process modelling, goal commitment, motivation, participation, competition.

1 INTRODUCTION

Computer support for collaborative modelling (or group modelling) has been an issue of research for two decades now. Early studies include (Dean et al., 1994) and they found that a collaborative tool (basically a text editor) for the IDEF0 activity modelling language was able to reduce modelling time substantially by splitting large groups of more than 20 people into smaller teams each of which would work on a computer to elaborate a different chunk of a large model.

So far computer support of modelling groups has not gone very far. In practice it is restricted to the facilitator and modelling sessions are still mostly supported by brown paper and sticky notes. More sophisticated tools exist but they are often limited to collaborative drawing. From a theoretical perspective such tools are unsatisfactory as collaborative work is not structured in any way. The professional facilitators refrain from using them as they fear that such tools will only increase the cognitive overhead of modelling sessions.

In such a situation it seems hopeless to introduce yet another tool-based approach. But the aim of this paper is not to advocate a tool but to study the methodological features that a sophisticated tool allows for. In particular, our hypothesis is that goal commitment and competition have a positive impact on group productivity mediated by motivation, participation, and individual effort.

To leverage participation and competition we employ a computer-based tool. On the one hand it allows group members to make direct contributions to the model, thereby facilitating participation. On the other hand it can also bring about a competitive situation, in our case the mutual scoring of models created by group members. Although such a competition is in principle possible with brown paper and sticky notes, too, computer support greatly facilitates it.

The remainder of the paper is structured as follows. We first take a look at related research in the area of collaborative work. We then describe the research methodology, followed by an analysis of measuring instruments for group productivity in modelling. After that we introduce some factors that control productivity in group modelling and also discuss measurements for them. We continue with an explanation of the set-up of the field experiments and the analysis of the data collected in these experiments.

We derive a factor model that is validated with Structured Equation Modelling (SEM) and discuss the implications and limitations of this model.

2 RELATED RESEARCH

Group modelling has been studied intensively in the literature concerning all major aspects such as the structure of the process itself, its organisational environment and the supporting tools and techniques.

The basic roles and activities in modelling were studied in (Bommel et al., 2006; Frederiks & Weide, 2006; Hoppenbrouwers et al., 2006) who argue for a separation of knowledge elicitation and model creation. (Hoppenbrouwers et al., 2005) adds that modelling is also knowledge creation and dissemination in the form of a structured conversation. We basically agree with the latter, more inclusive view on modelling but question the separation as discussed in the next section.

(Frederiks & Weide, 2006) identifies natural language as the primary instrument and calls for face-to-face meetings supported by a simple, easy-to-use medium. The computer as a medium has been studied by (Fjermestad & Hiltz, 2001; Reinig & Shin, 2002) for general meetings and in (Dean et al., 1994; Dean et al., 2000) for modelling sessions. The conclusion is that tool support has a moderating impact on the group process, which in turn controls the meeting outcome. It is therefore necessary to look at the process itself to identify effects of different media. We do so by including parameters of the process in our study such as team factors.

In more general terms the rich work on brainstorming methods is also relevant for us. Brainstorming is useful for structuring an unstructured problem (see e.g. (Belton et al., 1997), (Conklin et al., 2003)) but it can also be used to structure existing business process knowledge in the face of different views on the process, i.e. different versions of knowledge.

Beyond the modelling process itself, (Araujo & Borges, 2007; Persson, 2001) look at the environment in which this process is embedded. They study situational factors with the aim of creating better support for software engineering or collaborative modelling in enterprise, respectively.

(Lind & Seigerroth, 2010) look at the way a whole modelling project needs to be organized in the context of a process change effort. They argue for the need of different types of process models at different stages in the project.

Success factors of process modelling have been studied thoroughly in (Bandara et al., 2005). But the focus of this work is on management factors that are related to the whole modelling project whereas we concentrate on the factors for a particular modelling session.

The present research is also closely related to our earlier work on success factors as documented in (Rittgen, 2010a, 2010b), which it extends and refines by considering more factors. Self-organization of modelling teams has been studied in (Rittgen, 2009) where we looked at the roles and team structures that evolve when a group is allowed to model on its own.

In particular (Rittgen, 2010b) already introduced the variables competition, individual effort, degree of participation and motivation for modelling which are pivotal in this study.

Tool support and techniques for collaborative modelling are suggested in e.g. (Kemsley, 2010; vom Brocke & Thomas, 2006).

3 RESEARCH METHODOLOGY

We conducted 15 field experiments, 3 at each of 5 organisations. The organisations were:

- ME: a large manufacturer of electronics
- PH: a large psychiatric hospital
- IC: a large insurance company
- BL: A medium-sized bio-engineering laboratory
- PA: a large public (city) administration

We used *competition* as the exogenous variable assuming two states, competition or no competition. Each experiment consisted of two business process modelling sessions, one for either state, and lasted for approximately four hours. The unit of analysis was the session. *Competition* was controlled by either making use of the competition module of the group modelling tool or not (see below). The endogenous variables were *goal commitment*, *motivation for modelling*, *degree of participation*, *individual effort* and *group productivity*. Their measurements are explained in sections 4 and 5.

Both the competitive and non-competitive sessions were conducted in the same way, i.e. using the same method, the same tool and the same modelling assignment (a business process). The only factors that changed were the use of the competition module (yes/no), and the group that did the modelling. The latter is motivated as follows.

Using the same group twice for the same assignment makes no sense. Giving the group a different assignment for the other session introduces too much uncontrolled variation as different modelling exercises can vary substantially in complexity. Using two different groups with the same assignment also introduces some variation but it is easier to control. We took care to select members with the same background and domain knowledge in both cases. The selection was performed by a senior process manager who knew all individuals thoroughly.

4 GROUP PRODUCTIVITY IN MODELLING

Determining group productivity in modelling is a challenging task. Conventionally group performance is measured with respect to the level of achievement regarding a specific task. This task is often designed in such a way that productivity measurement is simple: e.g. the relation of completed steps and the maximum possible steps (Rosenbaum et al., 1980), or economic efficiency or effectiveness in terms of a monetary valuation of inputs vs. outputs or outputs vs. goals, respectively (Goodman & Leyden, 1991; Pritchard, 1995).

Most of these measures assume that the task is summative, i.e. that the group productivity is the sum of the individual productivities. This assumption is not true in modelling. Many measurements also presume that a benchmark exists against which performance can be evaluated. As there is no such thing as the “perfect model”, such measures have likewise to be discarded.

Non-summative measures have been developed in the context of artificial tasks (Crown & Rosse, 1995) but they require relative comparability of one group to another. A model is an artifact that is unique and that is not only developed **by** a group but usually also **for** the group. Only the group itself can therefore assess its quality in their own context and in an inter-subjective manner. In other words: group performance in modelling is the extent to which group members agree with the model and with each other regarding its correctness and completeness w.r.t. to individual cognition.

Social model quality (SMQ) embodies this idea by measuring the extent to which interpretations of different users agree with each other. As both the process of arriving at a model and its use are collaborative endeavors social quality is an important factor of overall model quality. A measure for social quality was introduced in (Krogstie, 1995). It is called Relative Agreement in Interpretation (RAI) and determined as the average mutual agreement among pairs of users w.r.t. their interpretation of the model.

$$RAI = 1 - \frac{\left|\left\{ s \middle| \exists i, j, i \neq j : s \in \Im_i \wedge s \notin \Im_j \right\}\right|}{\left| M_E \right|}$$

In the formula, s stands for a statement of the model. In a process model that could be “There is an activity called Enter PIN code” or “Activity B has to be carried out after activity A”. This means that a statement refers to a node or an arc in the process model. $\Im i$ is the interpretation that modeller i associates with the model. It is a set containing all statements that the modeller considers to be true. M_E is the set of all explicit statements of the model. In words, a statement is seen as controversial if at least two people have a differing opinion on it. If we divide the number of controversial statements by the overall number of statements, we arrive at the relative disagreement in interpretation. Subtracting this from one yields the RAI.

To operationalize this measure we have developed a social quality questionnaire. For this we first labelled all the nodes and arcs of the final model with numbers and gave the participants a printout of the model including these numbers. We also gave them a piece of paper with a table. The first column contained the numbers from 1 to 50 (max. expected node and arc count) in ascending order. The second column was empty. Participants were asked to put a cross in this column for each number of a node or arc that they considered to imply a wrong statement. If a node was in a wrong swim lane they put a p for position instead. They also had to put a circle around the number that represented the total number of nodes and arcs.

Putting the filled-in questionnaires of all group members side by side we counted the number of rows that only showed identical markings, i.e. eight empty fields, eight crosses or eight *p*’s. This was then divided by the circled number to yield the RAI. The resulting RAI value is already a group value that relates to a single model. The questionnaire for the RAI is administered directly after each session to make sure that the social context is still vivid.

5 FACTORS OF PRODUCTIVITY IN GROUP MODELLING

This section introduces measurements for the 4 factors that we consider to be relevant. The primary and exogenous factor is that of competition. It is a categorical variable with two values: 0 for no competition and 1 for competition. It is controlled by using the competition module of the group modelling tool or not. The endogenous variables are motivation for modelling, degree of participation, and individual effort.

All factors are derived from Focus Theory (Briggs, 1994) and from earlier theory development as described in (Rittgen, 2010b). These works also exhibit the factor interactions that can be expected and that we have taken into account when devising the experiments of the current study.

While the list of considered factors is not exhaustive the two sources mentioned comprise, as far as we know, the most comprehensive set of cognitive factors determining collaborative work in general and in modelling in particular, respectively.

5.1 Competition

The impact of competition and cooperation on group productivity was comprehensively addressed for the first time in the Theory of Cooperation and Competition (Deutsch, 1949). Deutsch found that groups perform better when their members cooperate instead of competing. But interestingly his so-called cooperative mode, where members are equally rewarded for group success, also bears distinct elements of competition: the group had to beat other groups to be successful.

(Hammond & Goldman, 1961) discovered that it is precisely the combination of intra-group cooperation and inter-group competition that leads to highest group productivity. The competition with other groups raises the group members' desire for achieving the group goal, and the cooperation with other group members helps them achieve it.

We have reproduced this condition in some of our field experiments by dividing a group into modelling teams. Each team would cooperate on the creation of a model proposal but only one team's model will eventually win and be selected for further development.

Out hypothesis is that the competitive-cooperative modelling sessions will outperform the cooperative groups in terms of group productivity as measured by social quality of the model.

In the competitive-cooperative modelling scenario we introduce a scoring of each model proposal by the other participants. After the complete scoring round the facilitator shows the whole group the average scores of all proposals as bars of different sizes and numbers. This is an exciting moment for the participants as they get to know their own scores and how they relate to the others.

Being judged by their own peers (often colleagues) is a strong incentive to put as much effort into the modelling as possible and that is precisely what we want to achieve: the best possible effort by all group members. Nobody can hide behind more active group members. Competition thereby introduces a group-centric individual goal beyond the group goal of creating the overall model, which facilitates group productivity (Crown & Rosse, 1995).

The result of the scoring round, which usually takes ten minutes, is not only a winner but also a winning model. This is the basis for all further development as the highest overall score clearly indicates that this model has the strongest support and therefore the best chance of creating consensus. It cannot be taken as the final version, though, as some details might still be missing or misrepresented, in particular views represented in the discarded models. This needs to be settled in a consolidation step.

In the non-competitive case there was no mutual scoring. Instead the model to proceed with was selected by the facilitator. Group members were neither informed of the criteria for selection nor of the winner to avoid a competitive spirit. According to theory competition is expected to increase motivation (see section 5.3).

5.2 Goal commitment

While competition can be assumed to increase motivation a participant's basic motivation is driven by the desire to achieve the group goal. This desire for goal (or goal commitment) is considered highly relevant in many studies of group performance (Klein & Mulvey, 1995; O'Leary-Kelly et al., 1994; Weingart, 2006) and is also present in cognitive theories such as Focus Theory (see section 5.5). We have therefore decided to include it in our study.

Goal commitment is measured according to (Hollenbeck et al., 1989) with the 4-indicator measure. The indicators are (all items are reverse-coded):
1. It is hard to take this goal seriously.
2. It is unrealistic for me to expect to reach this goal.
3. It is quite likely that this goal may need to be revised, depending on how things go.
4. Quite frankly, I do not care if I achieve this goal or not.

All items are measured on a 7-point Likert scale ranging from *strongly disagree* to *strongly agree*.

5.3 Motivation for Modelling

Much has been said about the elusiveness of motivational gains in group work (see (Karau et al., 2000) for an overview and (Hertel et al., 2003) for a discussion on computer support) and the Collective Effort Model has often been used to explain such gains (Karau & Williams, 1993). According to this model individual motivation will be high if group members perceive their own contribution to the group work as instrumental in reaching the group goal.

A fundamental problem with collaborative modelling is the fact that participants of such an exercise have no intrinsic motivation for the result itself. Most people are not interested in the model and do not see a need for it. But extrinsic motivation implies the risk of shirking (i.e. underperforming when not noticed). Consequently intrinsic motivation seems more promising, but instead of on the model we have to focus on the modelling process. **Motivation for modelling** is therefore a key factor.

The measurement of intrinsic motivation is a difficult issue. In principle there are two ways in which this can be done, behavioural and self-reported.

The behavioural measure requires actual observation of motivated behaviour. The usual instrument is free-choice persistence (Deci, 1981) where the observant is instructed to perform a task while being knowingly observed. The experimenter then leaves the observant "alone", i.e. he observes him unknowingly. The time that the observant continues with the task while being "unobserved" is the behavioural measure of intrinsic motivation.

As this measure cannot be readily extended to group work it could not be applied in our study. The self-reported measure consists of a questionnaire that is administered immediately after the task has been performed. It is the most wide-spread instrument as it can be applied in all situations. It has been shown in meta-studies that self-reported measures deliver results similar to behavioural ones (Patall et al., 2008).

The self-reported measures use a combination of task enjoyment, interest and liking as a proxy for intrinsic motivation (Puca & Schmalt, 1999). They come in single and multi-item versions.

We use the interest/enjoyment sub-scale of the Intrinsic Motivation Inventory (IMI) measure that was introduced in (Deci & Ryan, 1985). It is based on Self-Determination Theory (Ryan & Deci, 2000) and has been validated in (McAuley et al., 1989).

The items are scored on a 7-point Likert scale ranging from *not at all true* (1) via *somewhat true* (4) to *very true* (7) and read as follows (items 3 and 4 need to be reverse-coded):

1. I enjoyed doing this activity very much.
2. This activity was fun to do.
3. I thought this was a boring activity. (R)
4. This activity did not hold my attention at all. (R)
5. I would describe this activity as very interesting.
6. I thought this activity was quite enjoyable.
7. While I was doing this activity, I was thinking about how much I enjoyed it.

5.4 Degree of Participation

Another important factor is the **degree of participation**. It indicates the relative number of group members that are actually active in a session. A higher degree raises model quality by making models richer but lowers consensus by adding views.

The former means that a higher degree of participation yields more proposals which leads to more contributions to the group model and hence a more complete model. This makes it more likely that group members agree with it as they can find their view in the integrated model. As a result group productivity will increase following this line of reasoning.

But on the other hand a higher degree of participation has a negative impact as other proponents might also introduce elements in the model that, in some individuals' opinion, do not make the model more complete but rather obfuscate it. In this case the overall agreement decreases and with it group productivity according to that line of reasoning.

It is therefore unclear whether the overall effect of the degree of participation on group productivity is positive or negative and how significant and strong it is.

To measure the degree of participation we counted the relative number of individuals per group who provided at least one proposal, i.e. this variable can be measured by directly observing behaviour which should always be preferred if possible.

5.5 Individual effort

Focus Theory by Briggs (Briggs, 1994) assumes that individual effort can be on communication, deliberation, and information access, but not at the same time. Productivity in one area therefore limits the effort that can be spent on the others. The overall productivity of an individual depends on high productivity in all three areas which constitutes a kind of a vicious circle.

In short his model comprises the factors perceived difficulty of task, desired certainty of success, perceived effort required, perceived effort available, self-efficacy, desire for goal, **individual effort** and group productivity. Figure 1 shows Briggs' model.

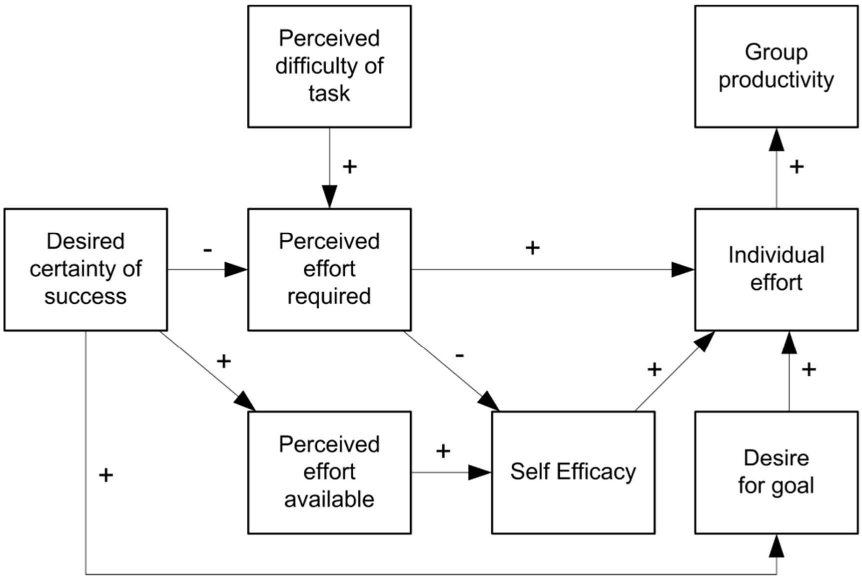

Figure 1. Briggs' model of individual and group effort in e-collaboration

We focus in our study on the direct antecedent of group productivity in Briggs' model, i.e. individual effort.

We measured individual effort in a result-oriented way, i.e. we have not tracked the cognitive efforts themselves but their traces, the number of proposals that were produced by each participant. They were recorded for each participant and averaged for the group. Again this variable can be observed directly providing a more objective measurement.

6 SET-UP OF THE FIELD EXPERIMENTS

For the experiments in the field we selected five organisations: the public administration of a city (PA), an insurance company (IC), a bio-engineering laboratory (BL), a psychiatric hospital (PH) and a manufacturer of electronic components (ME). In each of the organisations we carried out three experiments. An experiment consisted of two parts: a morning session, where we used competition, and an afternoon session where we did not. The sessions included between 5 and 9 participants and lasted 3 to 4 hours. The measurement of a session were pooled so the overall sample size was 30 (5 x 3 x 2).

Participants were domain experts without formal training in modelling. Most of them had been present in conventional chauffeured modelling sessions before but have never created models themselves. The modelled processes varied in size from 32 to 47 activities and were of medium complexity.

To keep the two parts as similar as possible we used the same method and tool for them (for the latter see www.coma.nu). For the non-competitive experiment we just did not perform the scoring and the facilitator chose the model to proceed with by his own judgment, not telling the participants about the reasons for his choice. We also used the same modelling assignment in both cases. The people for the second round were recruited from the same functional units as those of the first round and they were close colleagues of the latter.

After the competitive morning session we handed out a questionnaire to each participant that contained the measurements for intrinsic motivation (7 indicators, IM1 – IM7). We also gave them the model printout and the table for the measurement of social quality. During the experiment we kept track of the number of proposals by each participant for the individual effort measure and the degree of participation. This data was collected with the help of the computer-based modelling tool that each participant was provided with.

The same was done for the non-competitive afternoon session.

7 DATA ANALYSIS

In order to understand how the factors are related to each other we investigated the theoretical model with the help of Structured Equation Modelling (SEM). SEM is a statistical technique that allows for the confirmation of a factor model. From the theory presented in section 5 we can conclude that goal commitment and competition influence motivation, which in turn influences individual effort and the degree of participation. The latter two will then determine group productivity.

To confirm these relations we used structural equation modelling with the help of the WarpPLS 1.0 tool. The analysis was done with the help of the Warp3 PLS regression (partial least squares) and the default method of bootstrapping re-sampling. This particular analysis was chosen as it can also deal with non-linear relations and categorical variables (e.g. binary variables).

The result is depicted in Figure 2, which also shows the path coefficients (β values) that indicate the strength of the relations. All correlations are significant on the 1% level.

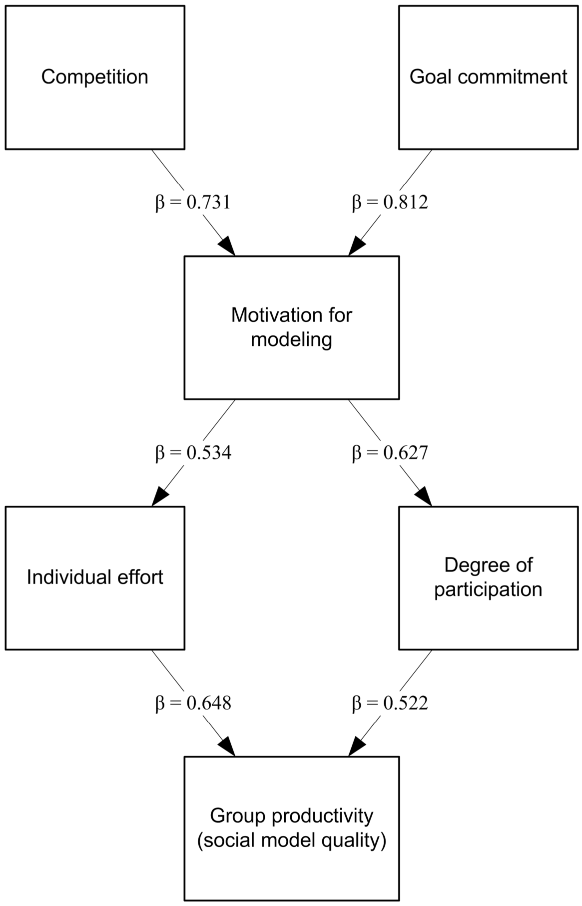

Figure 2. The factor model with SEM results

The average R^2 (coefficient of determination) is 0.824 which represents a good fit. In order to assess the structural fit of the model we have compared it against the base-line model where all variables are considered direct predictors of group productivity (no latent variables), and against another plausible model where competition, goal commitment, motivation and participation are predictors of individual effort, which in turn determines group productivity.

The average R^2 of the base-line model is 0.601, that of the model with individual effort as single latent variable is 0.717.

Hence the model shown in Figure 2 represents the best fit with the data.

8 CONCLUSION

While the study has shown that motivation, participation and competition are important factors that control individual effort and hence the productivity of a group, it is still unclear which other factors control group productivity. The mentioned factors mostly operate on the level of the individual. But it is reasonable to assume that there are also factors that operate on group level.

Such group-level factors could for example be the organisation of the group. Should all members work individually or should they work in smaller units (teams)? How should teams be composed? Should they be matched or complimentary, i.e. should team members come from the same or from different organisational units? An argument for the former is that teams with matched people can work together more effectively as they share a similar background. An argument for the latter is that complimentary teams comprise richer knowledge about the business process and can therefore produce richer proposals.

When we introduce the level of a team between that of the individual and that of the group there are again factors to be considered on this level. Examples of such factors are: the quality of the proposals submitted by a team, their formality, their richness, their understandability and so on.

All the mentioned factors might explain some of the variance that is not yet covered by the factors considered in this study. We therefore suggest to include these factors in further studies or to at least investigate their influence separately.

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