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Quantification and Evaluation Issues in Group Model Building

An Application to Human Resource Management Transition

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Abstract

Telecommunications providers increasingly compete on Human Resource Management (HRM). KPN, the Dutch incumbent telecom provider, found that for its research department human resource policies needed to be adapted to remain competitive. KPN's Business Modelling department facilitated a group model building project on human resource management transition. Participants in the project were nine KPN employees involved in HRM. In three sessions a quantified although not fully validated model was built. We feel there are three major contributions of this project to the system dynamics literature. First, in the process of modelling we used and adapted a technique on parameter estimation. This technique clarified several complex relationships. Second, the content of the model and its emphasis on soft variables connects to the discussion on the merits of qualitative versus quantitative models. Third, the project was extensively evaluated, in particular with regard to its effects on participants' learning, evaluation change and implementation of project conclusions.

1 Introduction

HRM policies form a substantial factor of a company's strategy. Since HRM is by definition a sociological and cultural concept, the effect of a particular HRM policy is difficult to assess, let alone to quantify. Because of this reason HRM has been the subject of many qualitative system dynamic studies. However, sometimes it is not sufficient to elicit, describe and map the factors that play a role in the HRM field. In some cases quantification is needed to determine the behavior resulting from the interaction of the many variables that play a role in HRM.

Such was the case for the research department of the Netherlands' largest telecommunications firm, KPN Royal Dutch Telecom. KPN Research's HRM department needed to increase its understanding of the effects of a proposed HRM policy. Business Modelling, a group of SD experts within the department, collaborated with Nijmegen University to form a modelling team that set up a number of sessions to model the HRM issues. In traditional quantification, the modelling team is largely responsible for building the quantified model from a qualitative diagram constructed by a group of expert participants. It was felt that this approach would not be sufficient in order to model such an important and complex issue. To overcome the difficulties and shortcomings of this traditional method, a group quantification procedure described by Ford and Sterman (1998) was adapted slightly and used in one of the group sessions.

The results of the quantification procedure yielded valuable insights. In this paper, we will describe how the quantification of relationships between variables was set up in three different ways. The results of using this method can be classified in two categories: results that contribute to the group participation process, and results that have a more direct link with the way of quantification itself. These results will be elaborately described. In addition, the experiences of the group members were extensively evaluated.

The structure of this paper is as follows. In section 2, we will describe the project background and the situation faced by KPN's HRM department. In section 3, the outline of the process and applied methods are described. Then, in section 4, the three quantification approaches are illustrated. Section 5 will elaborate on the two categories of results that were obtained. In section 6, the evaluation of the process is discussed. Finally, section 7 will summarize the conclusions.

2 Project background

The client in this case is the head of the human resource department of KPN Research. KPN is the Dutch telecommunications incumbent. After the market for mobile telecommunications was opened up in 1995 and for fixed lines in 1997, competition on the Dutch telecommunication market has been increasing rapidly. At the moment KPN is the largest Dutch telecommunications provider, both on the fixed and the mobile market, concentrating its operations on the national and European market. An increasingly important element of this competition is hiring and management of employees. KPN Research realized that human resource policies needed to be adapted in order to remain competitive. In addition, the fast pace in the telecommunications sector calls for a constant evaluation and evolution of HRM policies.

2.1 Problem contingencies

In order to bring about the desired changes in HRM policies, the HRM department planned to implement a new structure of personnel profiles. KPN Research's HRM department is primarily responsible for policies in this field, of which consequences extend to over 400 employees. KPN Research operates as a network organization, with employees in research positions reporting to their unit manager as well as to the managers of different accounts they are working for. Implementation of new HRM profiles will affect unit managers, account managers as well as researchers. To hire new employees KPN Research largely draws on the pool of graduates of relevant (mostly technical) universities in the Netherlands. In this they face competition of other telecommunication research centers, universities, consultancies and technology-based companies.

Although demand on the labor market had exceeded supply for some years already, KPN Research had not faced major problems in recruiting newcomers on the job market. KPN's position as the largest provider and reputation for innovation were thought to be largely responsible for this. However, in *retaining* researchers, competition was increasingly felt. KPN, like any other company, needed to adapt HRM policies to the increasing demands posed by a tightening labor market. In addition, the number of juniors and seniors in the workforce needed to be balanced carefully. For juniors to be able to learn, an adequate number of seniors was needed. However, too many seniors relative to juniors would mean that positions would be taken up by seniors, limiting the chance for juniors to gain experience. The HRM instruments included training, salaries, and working conditions. However, the HRM department needed to further understand the effect of these instruments and how to employ their combination to the best benefit. With group model building, system dynamics and quantitative modelling, the HRM department of KPN Research wanted to increase their knowledge and understanding of the dynamics of the Human Resource processes in their company in order to increase their decisiveness.
In sum, the project addresses a highly complex issue. In order to describe the complexity of a problem situation Hickson et al (1986) introduced the terms analytical and social complexity. Analytical complexity refers to the number of variables, their relationships, and the interests involved. Social complexity reflects the degree to which the parties involved had divergent interests, i.e. tried to influence the issue in

opposing directions. In this case, all elements of analytical complexity can be found. Since all participants work within KPN, and the majority within KPN Research, there is no large divergence between the goals of the participants. Social complexity is therefore estimated as 'medium'. Thus we can safely conclude that human resource developments present KPN with a 'messy problem', for which it is difficult to reach a conclusion accepted by all stakeholders. In the following we will describe how system dynamics was used as an intervention tool in this situation.

2.2 Intervention characteristics

The goal of the modelling project included a methodological, an evaluation and a content aspect. KPN Research Business Modelling had experience in building system dynamics models for some years. In most of these projects the client demanded both content and modelling expertise, and model construction proceeded largely in an expert mode. The model builders wanted to increase their ability to build models in a participative fashion. For this reason the modellers took part in a two days workshop on facilitation organized by Nijmegen University. In order to test the approach, it was decided to take on an internal project and have a facilitator of Nijmegen University present as a coach. A second expected benefit of this cooperation was the development of a standard for evaluating the impact of this type of interventions. Apart from developing expertise in participative modelling, Business Modelling also wanted to be able to better measure the benefits of modelling so as to prove its value to clients. A suitable testbed for participative modelling was found in the important internal transition issue. KPN Research's HRM manager acted as the principal client in this project, while a project team consisting of five members of Business Modelling was responsible for facilitation and model construction. Although for KPN the project presented a test of the participative approach, the description of the problem in the previous section clarifies that the issue was quite urgent and complex.

Below we will describe the steps in the modelling process. Since we feel the involvement of participants in the quantification process constitutes the most interesting part of the process, we will focus on this part in more detail in the following section.

3 Process Outline

In this section we will discuss the main phases of the modelling project. The following steps are described: the agenda discussion, the preparatory interviews, a description of the group sessions and project conclusions.

3.1 Agenda discussion

The most important element of the HRM transition consisted of implementing new personnel profiles, that were to replace the large number of competences used traditionally. In a series of meetings with the client, the central problem was formulated as ‘Which variables influence input, throughput and output of employees between each of the KPN Research HRM profiles?’ The model would include the effects of changes in junior/senior ratios on the number of people in each profile, and show how manipulation of the HRM instruments could create the desired composition of human resources. The project team expected to be able to develop a small, quantified model about the problem, simulating developments over the years 2000 to 2005. Since data were largely limited to migration of the KPN Research population as a whole (not detailed for specific personnel profiles or categories), difficulties were expected in finding historical data. The fact that the large number of traditional competencies were not easily translated into the new profiles further complicated data finding. The participant group (hereafter called ‘the group’) was expected to be the primary source of data, and the client and facilitators were both responsible for participant selection. The group members could be regarded as HRM ‘experts’ from their own frame of reference. The group consisted of nine people: HRM advisors, unit managers, account managers and employees working within KPN Research. Two HRM managers from departments outside of Research were present as well. Before and during the project, the composition of the group changed several times as participants were no longer able to invest enough time. In a series of meetings between the project team and a facilitator from Nijmegen University the schedule for the sessions was discussed. It was decided to use a preliminary stock and flows model as this was thought to visualize the migration between HRM profiles and provide a focus for the discussion.

3.2 Preparatory interviews

The project started with individual interviews with all participants. The interviews served both to introduce the project and as a pretest of ideas and evaluations of the subject matter, to be used in the evaluation of the project. The outline of the project included a short preface of the methodology, introduction of the participant group, a time schedule for the sessions and expected contributions of participants. Since the HRM profiles were new to most participants, each interview devoted some time to their definition and relation to the current personnel categories. Seven profiles were identified as the major categories for the new HRM policy. Young academics would first flow into a starter profile. From there on three routes were possible: innovator, integrator and project leader. Each of the routes contained a junior and a senior group. A diagram of the situation is shown in Figure 1.

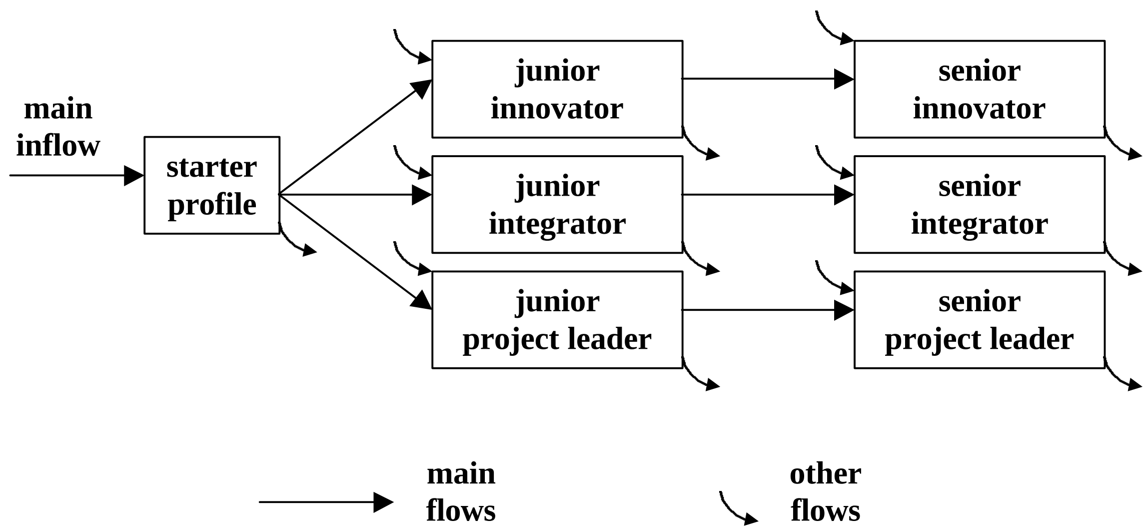

Figure 1 - Personnel flows & profiles within KPN Research

3.3 The group sessions

Session 1

The first meeting started with a round of introductions by the project team and the eight participants present. The Business Modelling team included two modellers, a facilitator and an observer. A preliminary model was presented and used to identify the relevant transitions in the HRM chain. This model consisted of a single stream of employees migrating through the innovator profiles: starter, junior innovator and senior innovator. Starters could promote to junior innovators, who in turn could proceed to the senior innovator profile. In addition, each profile had an inflow and outflow. The terminology was not expected to lead to problems, as the definition of each profile was addressed in the preliminary interviews. Participants were then asked to identify relevant variables connected to the various transitions using Nominal Group Technique. The focus in this session was on the inflow of academics. A small model of less than 20 variables was developed that included three feedback loops. All of the loops were positive and included the variable 'attractiveness of KPN Research as employer'. Results were reported back to participants in a workbook.

Session 2

In the second session, one month after the first, the flow from junior to senior innovators was focussed on. The flow of junior to senior profiles was assumed to operate along similar lines for the other profiles. The session was attended by five participants, two modellers and one facilitator. Two observers, one person from Business Modelling and one from Nijmegen University, took notes during the meeting. After an introduction of new participants, the model constructed in the first session was explained. Participants were given a list of variables mentioned in the first session but not yet included in the model. The discussion on what influenced promotion from junior to senior innovator yielded a new model substructure, largely unconnected to the factors influencing recruitment. A total of five loops were identified. In contrast to the first session, two of these were balancing loops. Both involved the number of seniors limiting promotion opportunities, either because they limit the opportunities for juniors to participate in innovative projects or all available senior positions are occupied. A positive loop was created by the effect of limiting undesired outflow on employee motivation. The two other reinforcing loops involved seniors. Firstly, senior coaching increases junior learning and thereby promotions to the senior profile. Secondly, seniors are needed in the acquisition process of innovative projects, which increase learning opportunities and thereby number of promotions. Results of the session were again reported back in a workbook.

Session 3

In the three weeks to the third session, the model structure developed so far was translated into a quantitative model. A number of relations in the model turned out to be particularly difficult to describe. As was expected, data on migration between HRM groups (traditional competencies as profiles were not yet implemented) were not abundant. Data that were identified included recruitments and job terminations for KPN Research as a whole. These data consisted of aggregate numbers and in some cases qualitative information included in e.g. application and exit interviews. The Business Modelling team was responsible for quantification, and the plan for the third session was discussed together with the Nijmegen University facilitators. Various alternative agendas were discussed, including Warren's (2000) ideas on data gathering, various scripts described by Andersen and Richardson (1997) and Ford and Sterman's (1998) graph estimation procedure. Model development, data gathering and discussions on the session agenda proceeded more or less simultaneously. After much effort was put into equation formulation, debugging and behavior validation, confidence in the model was judged adequate for presenting runs in the third session. However, a number of equations involved rather intangible variables, resulting in very preliminary estimates of relations. It was decided to use model output to demonstrate the quantitative model to participants, but to devote the major part of the third session to joint specification of relationships in the model.

Seven participants attended the last session and were facilitated by the same team as in session 1. The meeting started off with an explanation of the assumptions behind the model developed so far, and the areas where further improvement was necessary, e.g. motivation of employees. The presentation of the equilibrium run of the model met with approval of the participants, who prompted for testing out effects of parameter changes in the model. This was planned beforehand as the last item on the agenda. After the presentation, participants worked on parameter estimation. The knowledge elicitation procedure described by Ford and Sterman (1998), which consists of a positioning phase, a description phase and a discussion phase, was adapted slightly for this purpose. To introduce this method, the facilitator asked the plenary group for an example of two variables that had nothing to do with HRM, one having a nonlinear effect on the other. Petrol prices and number of kilometers travelled were suggested by the group. The facilitator then proceeded to draw the axes, measurement units and a number of data points. The participants were invited to think on whether there were any abrupt changes in the graph connecting the data points. How expensive should petrol be before a person limits his travel kilometers significantly? Participants entered into a lively discussion and seemed to pick up the procedure easily. Another plenary example focussed on the effect of the proportion of senior to junior employees on the level of support for juniors. The estimation of this graph proceeded smoothly as well. After these two plenary exercises, the group was split into two subgroups each modelling two nonlinear relationships. The following relations were addressed:

- The effect of attractiveness of KPN Research as an employer on the number of job applicants;
- The effect of the strictness of recruitment criteria on the quality of people hired;
- The effect of the proportion of senior to junior employees on growth opportunities for juniors;
- The combined effect of quality of juniors and proportion of senior to junior employees on the migration of junior to senior profiles.

The various relationships that were addressed are depicted in Figure 2.

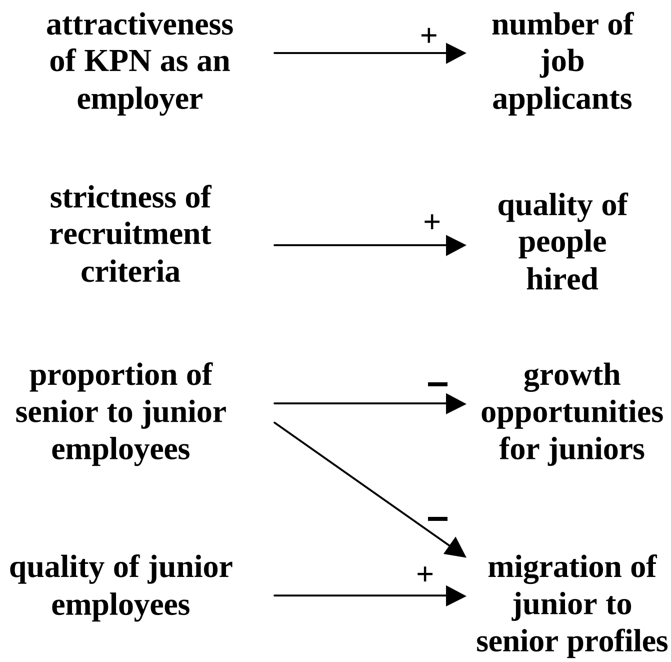

Figure 2 - The relationships that were quantified by the group

In the last part of the session, participants were asked to indicate expected results for changes in a steering variable. This part drew on Andersen and Richardson's (1997) and Richmond's (1997) suggestions for scenario runs. The variable 'strictness of recruitment criteria' was selected for this purpose, and three values were tried out. Participants were asked to 'put a stake in the ground' by sketching graphs for the average quality of KPN Research and migration of junior to senior levels. These graphs were compared to simulation runs of the provisional model. The outcomes turned out to differ from most participants' assumptions but were explainable from the model structure. The session was wrapped up with a short evaluation of the project[1].

3.4 Project results

The project's results were handed over in the form of a short workbook of the last session that was made and sent out to the participants. The suggested changes were not immediately implemented in the model, and participants were cautioned to interpret results as very preliminary. For the participants the project was concluded with evaluation interviews

[1] Three participants had to leave the last session before the discussion on the model outcomes. These participants were later shown the same runs in a short separate session.

The HRM manager that commissioned the project was handed over the model and documentation in a familiarization session. His reaction was very positive. The system dynamics model as well as the quantified model will be used in strategic HRM sessions later this year.

4 Quantification methods used in the project

In the literature, much caution is applied when a model containing soft variables is to be quantified. There are several reasons for this. First, the question of the usefulness of quantification as opposed to the construction of only a qualitative diagram is addressed by Richardson (1996; 1999). Second, difficulties of the quantification of soft variables are discussed by Coyle (2000), who states that ’quantification may be unwise if it is pushed beyond reasonable limits’. Coyle notes several difficulties with this, one of which is the danger of constructing ‘models that are so misleading as to be valueless, or even, when practical decisions are involved, damaging’. He also warns for the construction of measurement scales that have little or no meaning. Third, the fact that historical data are necessary to measure certain variables often obstructs or prevents quantification.

When multiple effects are involved, quantification becomes even more difficult. For example, when three explanatory variables have an effect on one result variable, how does one know whether the effects of these variables are additive, multiplicative or of some other form?

The project described in this paper demonstrates that, even when practical decisions are involved, quantification, though soft and imprecise, may build confidence in the decision makers, yield valuable insights and provide a basis for a quantified model. We have experienced this through the use of three quantification techniques. These are: *quantification via extreme values*, *quantification via exact numbers* and *quantification of multiple effects*. We will describe these methods in the following three sections. The methods do not provide an answer to all quantification questions and issues, but help to involve participant groups in quantification, thereby offering a stepping-stone to discover what the limits of quantification in a specific case really are.

4.1 Quantification via extreme values

In the third session, the group was asked to describe the effect of the strictness of recruitment criteria on the quality of the people hired, both of which are soft variables (see Figure 2). This relationship was suggested by participants in the first session, and included in the diagram. It had already been decided (by the modellers) that variables that indicate a ‘quality’ of some sort should be measured on a scale from 0 to 1. This is what we call a *semi-quantified scale*, 0 meaning 'very bad' (the lowest possible value) and 1 meaning 'very good' (the highest possible value). The advantage of such a scale is that it allows both the group to think in qualitative terms and the modellers to construct formulas with the variable. Another benefit is that any other scale that might be suggested can be changed into a semi-quantified scale easily by a simple transformation. Moreover, variables can be measured in a relative manner: a certain numerical value of the variable can be compared to the extreme cases in which the variable takes on a value of 0 or 1. This is often easier to understand than trying to measure the variable on an absolute scale. The group, faced with the given relatively difficult relationship, decided to redefine the strictness of recruitment criteria as 'the percentage of applicants hired'[2], and figured out the relationship and graph shown in Figure 3. The two points marked by stars are the points that the group could estimate with high confidence[3].

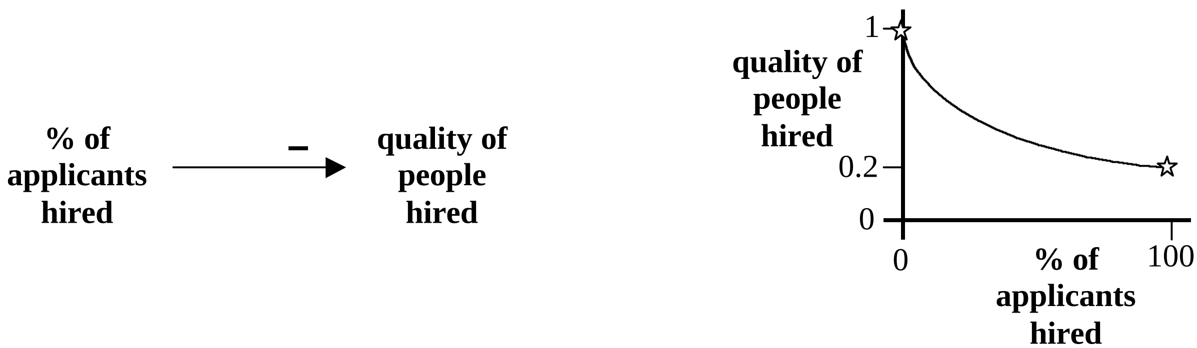

Figure 3 - The relationship between the % of applicants hired and their quality

The idea behind the graph is, that if you hire all people that apply for a research job, quality will generally be poor (but not very bad), while if you hire only the best candidate, this one person will be of very high quality. The exact shape of the graph was not very important to the group in this case.

In this example, only the values of two extreme points and the general direction of the graph were important to the group. All group members felt the relationship was adequately described without defining both variables in great detail, or sketching their exact relationship. In this case, it was the modellers' task to construct a formula that best matches the given graph.

4.2 Quantification via exact numbers

Another relationship that the group was asked to sketch, was the effect of the ratio of seniors to juniors on the (average) growth potential of juniors. In this case, too, the group started by redefining a variable. The

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[2] This re-definition actually causes the corresponding + and - signs to reverse.

ratio seniors / juniors was (trivially) replaced by the percentage of seniors (the percentage is taken to be from the entire employee population). Then, the group tried to identify a way of measuring the variable ‘growth potential of juniors’. The group first figured that a very important way for a junior to grow is to do tasks that need senior expertise. To measure the growth potential for juniors in this way, they came up with 'the percentage of time that a junior spends doing tasks at senior level. Furthermore, they stated that about 25% of the research tasks are typically senior tasks[4]. They realized that, if the percentage of seniors is 25% or higher, all senior tasks will actually be carried out by seniors, and hence the growth potential of juniors will be zero. Also, they contemplated that the percentage of seniors in the current organization was 18%. They furthermore assumed that all seniors were, at that moment, doing senior tasks, hence doing 18% of all tasks available. This implied that 7% of the work was senior work that was done by juniors. Since juniors formed 82% of the population, doing 82% of all the work, they would spend on average 7% / 82% (or about 9%) of their time doing senior work[5]. These results, combined with extrapolation of the relationship, yielded the diagram and linear graph shown in Figure 4. The stars depict the numbers that were established by the group.

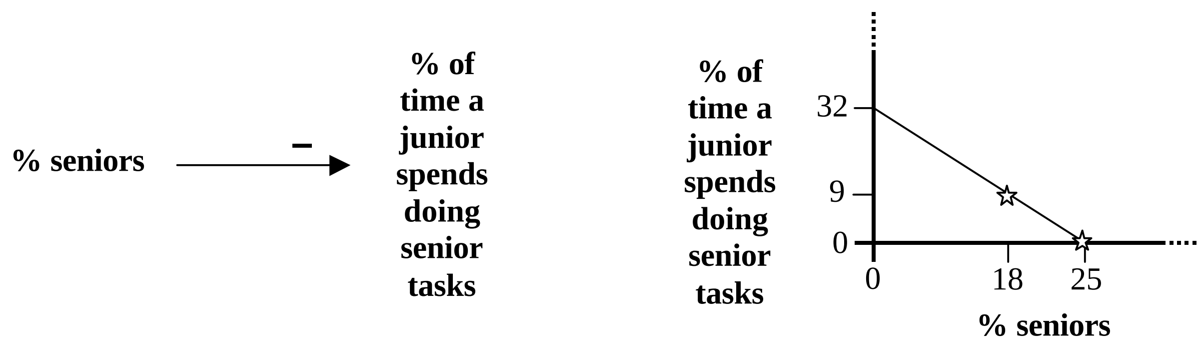

Figure 4 - The relationship between the percentage of seniors and the time a junior spends doing senior tasks

In this case, the shape of the graph was assumed to be linear, due to the nature of the variables defined. The group confidence from this exercise came from the straightforwardness of the calculation. There was no additional work for the modelling team involved.

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[3] The exact values of the variables have been masked in this paper.
[4] Again, exact values of variables have been masked.

4.3 Quantification of multiple effects

A somewhat more difficult relationship was the combined effect of the quality of junior employees and the percentage of seniors on the flow from juniors to seniors.

This effect prompted an interesting adaptation of Ford and Sterman's method. For estimating the combined effect of the two independent variables, a matrix was handed out. The two independent variables were plotted along the horizontal and vertical dimension, and the group was asked to note their combined effect in each cell. The matrix is depicted in Figure 5.

Effect on the flow of juniors to seniors (F)		**Percentage of seniors (S)**				
(as % of the number of juniors)		0 %	25 %	50 %	75 %	100 %
Quality juniors (Q)	very bad					
	poor					
	neutral					
	good					
	very good					

Figure 5 - Two-dimensional matrix to estimate the effect of two combined variables

Again, the variable quality of junior employees is measured along a semi-quantified scale, 'very bad' corresponding to 0 and 'very good' corresponding to 1.

After a bit of explaining, the group was able to fill out the matrix using both their knowledge of the actual situation and by making assumptions about the hypothetical situation of the extreme values (the corners of the matrix). Thus, they combined both approaches of the first two exercises. The group had some discussion on the values that were to be filled out, but grasped the concept fairly easily. With regard to the group process the exercise was useful, as participants seemed to gain a lot of satisfaction and confidence from completing a -in their eyes- relatively difficult exercise. The results were translated into a formula by the modellers.

[5] The additional assumption that juniors and seniors do the same amount of work is made here.

5 Quantification results

We have seen that quantification of relationships can be attained in several ways: either the shape of the graph can be conjured without focussing too much on the absolute values, or the absolute values can be determined without worrying too much about the shape of the graph. Points on the graph can be plotted based on the 'actual' situation, in which case real data is used. Alternatively they can be based on a hypothetical situation of extreme values, in which case the group must come up with assumptions about the values.

There is more to learn here. The general results of the quantification session are twofold. First, a contribution was made to the group participation process. Second, the issue of quantification of soft variables was addressed. These subjects will be discussed below.

5.1 Contribution to the group participation process

It is often difficult to extract knowledge from experts, especially when it concerns their mental models. Ford and Sterman (1998) state that "Descriptions of these relationships are not generally available from traditional data sources but are stored in the mental models of experts. Often the knowledge is not explicit but tacit, so it is difficult to describe, examine, and use". Furthermore, the numerical nature of a quantified relationship makes it hard for experts who are not used to think and report numerically to share their knowledge easily. Therefore, extracting (numerical) knowledge from experts is usually not done in a group setting, but in, as we call it, a 'back-office mode', with the modeller writing out equations.

In the system dynamics literature few guidelines can be found on how to involve clients in the quantitative phases of modelling. Clients are presented with the conceptual model and model output, but are seldom involved in formal modelling. Authors that do discuss involvement of clients in formalization are Richmond (1987; 1997), Morecroft (1992), Andersen and Richardson (1997), Warren (2000) and Ford and Sterman (1998). We will first describe the ideas on client involvement offered by these authors. Second, we will describe the approach we used in developing the HRM model at KPN and discuss similarities and differences to the guidelines offered in the literature.

Guidelines on client involvement in quantification

Richmond’s Strategic Forum (1987; 1997) covers the complete process of group model building, from familiarization with participants, through conceptual modelling to scenario runs and policy design. The heart of his approach consists of a series of pre-designed small-group exercises. Two to three participants work together, using a single PC for model simulations. After exercises are completed, participants report their results back to the plenary group. Exercises comprise three phases: putting a stake in the ground, confronting the stake, and discussion followed by resolving the disparities. Putting a stake in the ground involves estimating key model parameters and their effect on output behavior. Parameters, e.g. average price per unit sold, and output behavior, e.g. sales revenues, are noted down on paper. The stake is confronted by typing in the parameter values and comparing model output to expectations. Differences between actual and expected output prompt a discussion in the subgroups. Since participants agreed to the conceptual map or ‘plumbing’ (the structure of the model, especially the stocks and flows) in an earlier phase and also formulated expectations themselves, differences are a direct reflection of inconsistencies in the subgroup’s understanding of the problem. If expectations do not match model output, then either the map, the estimates of model parameters, or the predictions of model output will need to be altered. Richmond describes how these exercises force discussions to become more structured, which often leads to the discovery of implicit assumptions. Changes in understanding follow from finding inconsistencies between assumptions. Richmond (1987; 1997) primarily uses the conceptual map and model output in his group exercises. Participants interact with the model through a control panel, allowing them to change operating parameters and policy variables and to see results in the form of graphs. He does not mention discussing equations in front of clients.

Morecroft (1992) does mention addressing model equations in front of participants. In principle he wants the model to be fully transparent to clients. To this end he proposes to use *‘friendly algebra’*, e.g. easily comprehensible variable names and explanations of relationships in the model, which makes the formal model easier to understand.

Andersen and Richardson (1997) describe a large set of techniques and interventions in the process of group model building in the form of ‘scripts’. A script is a small-group procedure that supports a specific group task, and usually generates a specific product. For example, a nominal group technique helps to make a broad identification of ideas, which subsequently can be translated into variables to be included in the model. Andersen and Richardson mention that there is rarely enough time for equation writing with the complete client group and usually only few participants are interested in the formal model. They do use two techniques for eliciting ideas on model formulation. The first technique is used for data estimation. Working from a structure diagram, they identify the major stocks, flows and parameters in the model. The participant team is then handed a list of these key variables and asked to provide numerical values for each. The second technique supports model refinement. The flow diagram is depicted in front of the group and handed out on a paper sheet to each participant. The facilitator then takes the group through the model structure, one line or icon at a time. Vennix et al. (1988) use this technique in a mailed questionnaire resembling the Delphi method. Suggestions for changes in variable values or model structure are collected and used in model refinement.

Andersen and Richardson's data estimation technique produces specific parameter values or ranges, and no mention is made of sketching graphs over time in the formulation phase. However, in their model formulation stage they do include an exercise on sketching graphs. This technique starts with a plenary discussion on the time horizon for which problem behavior will be studied. Participants are then given the first third or quarter of the time line and asked to complete the graph.

Warren's (2000) approach uses techniques similar to those described in the foregoing. His approach is different in its emphasis on jointly eliciting model structure and time paths for important variables. In a first exercise, a flow model is built in front of the group, adding time paths for all stocks and flows immediately. After a plenary example participants are asked to follow the same procedure in subgroups, constructing a flow model with time paths for all major variables. Participants are helped in finding relevant variables by the concept of strategic resources: stocks of material, human resources or 'qualities' that are needed to realize desired goals. To get from, for example, desired sales revenues to the number of salespeople needed, estimations of salespeople productivity per hour and average working hours are made. Although Warren provides a very clear integration of problem structure and behavior, he offers few guidelines on the process of estimating graphs. Most attention goes out to determination of strategic resources, that primarily aid in developing model structure.

Ford and Sterman (1998) described a detailed procedure for parameter estimation. Knowledge of the relationship between two variables is elicited in three phases: positioning, description and discussion. In the positioning phase the model's purpose and sectors are described. A single relationship is selected for the exercise and the method is illustrated using an example. In the description phase four different modes are used to capture a relationship: a visual, verbal, textual and graphic mode. Ford and Sterman provide an example on constructing an office building. In this case participants are asked to form a mental picture of how one floor is constructed on top of the other. They then write down individually how the process described in the relationship proceeds. In the textual description the relationship is made more explicit by capturing important anchor points on paper, e.g. if zero percent of the building is finished ten percent is available for construction (the first floor). Finally the relationship is sketched in a graphical form. The discussion phase includes a comparison and discussion of these individual descriptions.

Client involvement in quantification of the HRM model

In the meetings prior to the third session, the approaches described above were reviewed with regard to their use for quantification of the HRM model. Since this was the last time participants would meet to discuss the model, a threefold goal was formulated for this session: familiarizing participants with the formal model as much as possible, eliciting information on important parameters, and involving participants in scenario runs with the model. We considered sketching time graphs of important variables, as suggested by Warren (2000). These time graphs could then be compared against model runs, providing a check on the data used and fostering participants' understanding of the model. It was decided not to follow this route since a number of variables were difficult to grasp (e.g. attractiveness of KPN Research as an employer) and it was expected that the group did not possess historical data on these parameters. Instead, it was decided that most attention would go out to eliciting information on relations between variables. We decided to address the formal model, parameter estimation and scenario runs in turn, making sure that plenary work, exercises in subgroups and individual tasks were alternated. For each of these goals elements of the approaches above were used, which we will address in turn.

The session was started with a short explanation on changes in the model since the last session. The flow diagram and crucial output graphs were presented (cf. Andersen and Richardson, 1997). It was made clear that data from the HRM department was used for initializing the variables. The flow diagram was an adaptation from the diagrams used in the previous sessions, although variable names and proposed relationships were similar. The facilitator proposed to 'freeze' the model structure for the time being, and focus attention on the four difficult relationships described in the previous sections. Participants did not have any objections and later commented that they were pleased that the model had been taken a step further.

In effect the presentation of the flow diagram constituted the start of the positioning phase (cf. Ford and Sterman, 1998) for parameter estimation. As described in the section on the third group session, parameter estimation took place in subgroups. This format was chosen for four reasons: it provided a more efficient use of time as work was done in parallel, groups could easily present conclusions to one another in the form of graphs, and it provided an alteration of work format compared to the plenary introduction before (cf. Andersen and Richardson, 1997). Finally, even if groups could not come to a decision on the shape of relationships, the modelling team expected it to be valuable to bring these differences of opinions to the fore. Before going into subgroups, the facilitator took participants through the four modes of parameter estimation using two plenary examples. Participants seemed to feel comfortable with the method and to appreciate its use in this stage of model construction. One participant asked which experiences the modelling team had with this method, and whether it was used more broadly. The facilitator and other participants commented that the extreme values were most interesting, while these would hardly ever be found in data sets. In addition, data would reflect the impact of other variables as well, making an effect difficult to interpret. Thus, apart from this inquiry on the experiences with the method, positioning the parameter estimation approach was quite straightforward and its use readily accepted by participants.

Most striking in the description phase was the participants' reformulation of model variables. E.g. participants decided to measure 'attractiveness of KPN research as an employer' as whether (and if so, where) KPN would be in the top 10 of most preferred employers. Another notable result was the ease with which participants used the matrix for estimating a combined effect of two independent variables. In this case, this step proved effective in resolving differences in conceptualization and measurement as described by Andersen and Richardson (1997). In fact this step is an additional check on the model structure laid down in the conceptualization sessions.
The discussion phase did not present any surprises. As each of the subgroups had discussed and resolved most of their differences of opinions in sketching the graphs, presentations did not meet with many comments from the other subgroup.

In the scenario runs we closely followed Richmond's (1987; 1997) approach. For putting a stake in the ground participants were asked to sketch expected model behavior for three runs. Results proved to be both surprising as well as explainable in terms of model structure. Richmond stated that he often meets with three reactions to unexpected model behavior: denial, resignation, and resolve. In this case participants readily accepted the model output, without questioning the facilitator's explanation in great detail. Undoubtedly the fact that it was made clear that results were preliminary (suggested changes in parameters were not yet implemented in the model) contributed to this reaction.

Another important effect came up during the quantification session. Because the participants themselves drew the graphs and filled out the matrices, they developed a considerable responsibility for the mathematical relationship. They felt that it was *their* graph, which increased confidence in the model as a whole. This is a considerable advantage compared to cases where it is the modellers' responsibility to collect data from sources that may not be available to all group members, are distrusted by them, or simply cannot provide sufficient or accurate data.

In sum, the process of constructing the HRM model offered the following insights:

- if its place in model construction is clear, participants easily accept switching the focus to quantification after two sessions on model of conceptualization;
- after proper positioning, the value of parameter estimation is clear to participants;
- parameter description can give rise to reformulation of variables, which can prevent conceptualization and measurement differences and is a check on model structure;
- participants find the use of a two-dimensional matrix for estimating combined effects of parameters fairly easy;

- participants’ confidence in the model is increased due to high involvement in quantification.

5.2 Contribution to the quantification of soft variables

When soft variables are involved, model quantification becomes difficult and uncertain. A lot of discussion has been going on about the use and limits of quantification. Some argue that quantification of soft variables might lead to inaccurate, uncertain and thus misleading results, while others feel that soft variables are inherent to reality and should therefore not be omitted. The question here is, of course, when to quantify and when to stick with a qualitative diagram. In the HRM project, we have explored this boundary, as far as it concerns group quantification.

Coyle (2000) states that “in system dynamics practice the uncertainties are usually justified by the argument that one is concerned with general patterns of behaviour rather than with precise numbers”. To this purpose, Kim (2000) has developed a method called ‘Normal Unit Modeling By Elementary Relationships’ or ‘NUMBER’. He argues that “we need not confine the concept of simulation … to the narrow meaning of quantitative, concrete, operational modeling”. Kim has developed a method that aims to quantify soft variables and relationships by only considering patterns of behavior, as opposed to exact values. He does this by restraining all variables to a scale ranging from 0 to 1 and then constructing ‘safe formulas’ (i.e. formulas that have [0,1]-variables as result) to describe the relationships.

In the project, we elaborated on the NUMBER method by using semi-quantified scales (see section 4.1). Semi-quantified scales have the advantage that the modellers can use the scale to construct formulas, and that the group can attach a meaning to the values of the scale. Even when measuring such a difficult term as 'attractiveness of KPN Research as an employer', the group could attach a meaning to the (qualitative) values quite easily. For example, with a 'very good' attractiveness, they imagined that KPN Research was in the Top-3 of most attractive employers in the relevant line of business in the Netherlands.

The question arose, which form the formulas (whether they are ‘safe’ or not) should have. This is in fact a very important modelling issue. It was partly dealt with by the participants themselves, as demonstrated by the following example:

The effect of two variables (**Q** and **S**) on a third variable (**F**) was facilitated by using a matrix. This allowed the group to discuss the effects of **Q** on **F** while **S** was held constant, and the effect of **S** of **F** while **Q** was held constant, without losing the idea that both variables were actually intertwined. It happened that some experts knew more about the variable **Q**, and other experts were more familiar with the variable **S**. After some discussion, agreement was reached on their combined effect on **F**. This combination of insights proved to be fruitful.

On the basis of the completed matrix, the modellers could construct a formula that produced variable outcomes similar to those in the matrix.

When, as in the above example, multiple effects are involved, the quantification of a causal map can be very difficult. We have described cases where there is either a one-to-one or a two-to-one relationship of variables. But what happens when there are more than two explanatory variables present in the causal map? This kind of relationship will become too complex and multi-dimensional for a participant group to understand. Moreover, Coyle (2000) warns us for the effects of cascading several multipliers: "If the uncertainties combine and compound in such ways, it may be hard to believe that the dynamics of the model *and the policy inferences made from it*, are more 'correct' than can be achieved from a qualitative model" (emphasis as in original).
In the project, this problem never came up. However, we propose to combine the multiple variables in pairs. This selection should be done in such a way, that the variables in a pair are 'alike' to some extent. For example, the effect on 'growth potential of juniors' of 'amount of coaching per senior' and 'percentage of seniors' can be combined to 'the effect of seniors'. The effects of 'HRM knowledge of employees' and 'amount of career planning' can be combined into 'the effect of HRM instruments'. Then, the relationship of both new variables on the resulting variable can be modelled. The general idea is depicted in Figure 6.

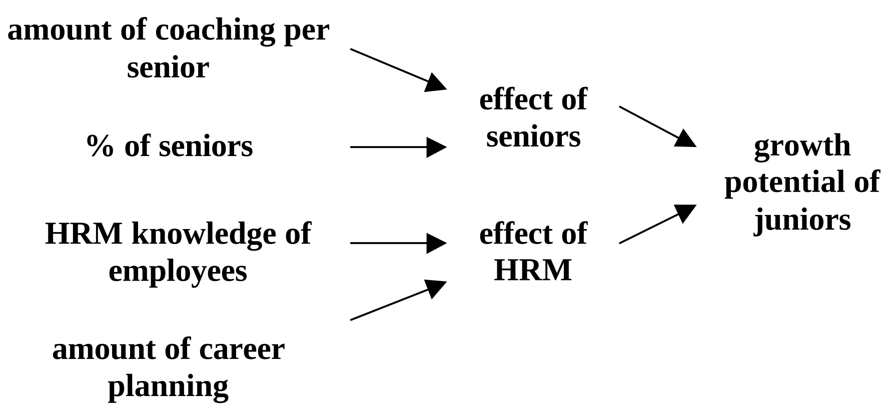

Figure 6 - Cascading the effects of multiple variables on a two-to-one basis

In the case depicted in Figure 6, it must be made sure that the explanatory variables are independent[6], so as to avoid, as Coyle puts it, 'double-counting' of effects.

[6] The concept of independency may, of course, not apply in SD models. In the given case, it may be enough that the explanatory variables do not influence each other *directly*.

We did not need to model such structures into the model yet. The results and patterns of behavior of the combined effects offer a rich subject for further study. We feel that, when such a *cascading tree* is constructed, modellers must make sure that only variables that are meaningful to the participants are used. This must include the new intermediary variables that are constructed. To this purpose, in the above example the effect of seniors may be measured by ‘the general amount of influence the seniors have’, and the effect of HRM by ‘the importance of HRM policies’. These variables may be measured along a semi-quantified scale.

In sum, the following insights were obtained:

- when measuring soft variables, the use of semi-quantified scales is a good alternative to full quantification, provided that the group is able to attach a meaning to the variables;
- a group of participants can be perfectly capable of plotting a relationship pattern between two variables; this action actually increases confidence in quantification and the resulting model;
- cascading multipliers might be an alternative to trying to model them all into one formula.

6 Evaluation

A growing number of authors report on the process and effects of client involvement in modelling. Rouwette et al. (1999) give an overview of effectiveness studies on client involvement, to which we will refer as group model building for simplicity. On the basis of their review of 107 modelling projects, Rouwette et al. conclude that group model building is generally effective in fostering learning and system changes. However, in the majority of these projects outcomes are assessed using a case study design which suffers from a number of methodological shortcomings. Although studies employing formal evaluations show similar results with regard to some outcomes, it is too early to conclude that group model building has proven its effectiveness. More data using rigorous assessments of field applications are needed before the question on effectiveness can be answered satisfactorily.

In addition, the system dynamics literature is relatively silent on how the impacts of modelling, for example learning and system changes, are produced. Only a few authors are explicit on what elements of group model building contribute to these results. Andersen et al. (1994) describe how modelling is expected to lead to ”more elaborate, causally sophisticated and feedback-sensitive cognitive models”. In addition, models can provide strategic insights on the consequences of interventions in the system. These heuristics bypass detailed knowledge on system structure and impact implementation more directly. Vennix (1996; 1999) details how modelling can overcome the limited human information processing capacity. The combination of modelling and facilitation prevents the process losses in traditional decision making teams. An interaction characteristic that limits effectiveness of communication is e.g. the tendency to mix up production and evaluation of ideas, which limits the number of contributions. By separating these two phases, as was originally proposed in group process techniques like brainstorming and Nominal Group Technique, the interaction process in group model building is made more effective..

With this paper we hope to contribute to the literature on group model building evaluation in two ways: a) by using a formal evaluation of the HRM project described and b) by using an explicit conceptual model for identifying relevant variables. For our evaluation we used the following materials:

- Structured pre- and posttest interviews. Participants were interviewed before and after the intervention and presented with a number of closed and open format questions. These questions concerned an evaluation of actions in the problem as well as process elements.
- A post-project analysis of session notes. This was mainly used to describe the intervention process and organizational changes that might influence the impact of the modelling sessions.

6.1 Conceptual Model

The conceptual model we used for our evaluation is described by Vennix, Akkermans and Rouwette (1996). This framework links the impact of group model building on communication, learning and implementation of system changes. It is based on social-psychological theories on attitude change (Chaiken et al., 1989; Petty and Cacioppo, 1986) and the impact of attitudes on behavior (Ajzen, 1991). Its use for evaluation of group model building is its explicit description of effective elements in the intervention and the relations between different goals. Rouwette (2001) provides a more elaborate treatment, but a couple of examples will hopefully clarify the conceptual model's contribution to evaluation. The model specifies that in order to change a participant's beliefs, two conditions need to be satisfied: 1. persuasive arguments for a change of position need to be presented, and 2. the participant needs to be motivated and able to process this information. Participants can be expected to be motivated to process information if the issue is important to them. Group model building increases participants' ability to process information, e.g. by addressing terminology differences and by providing a clear link between ideas by incorporating them into a model.

To establish the impact of changes in beliefs on implementation of system changes (i.e. behavior), we used Ajzen's (1991) theory of planned behavior. In this theory, beliefs form the basis for three central concepts in: attitude toward behavior, subjective norm and perceived behavioral control ('evaluations' for simplicity). The attitude toward behavior reflects the degree to which a person has a favorable or unfavorable appraisal of a behavior. The subjective norm is an assessment of the extent to which important referents approve or disapprove of forming a behavior. A person's perception of the ability of performing a behavior is captured by perceived behavioral control. The three factors jointly determine the intention to engage in a behavior. For example, the intention to implement pollution reduction measures is increased if attitude towards pollution prevention, subjective norms about environmental regulation or perceived control over source reduction activities grows stronger (c.f. Cordano and Frieze, 2000). Intention and perceived control in turn determine actual behavior: the more a person intends to and thinks he is able to perform an action, the greater the likelihood that he will perform the action. The conceptual model is shown in Figure 7.

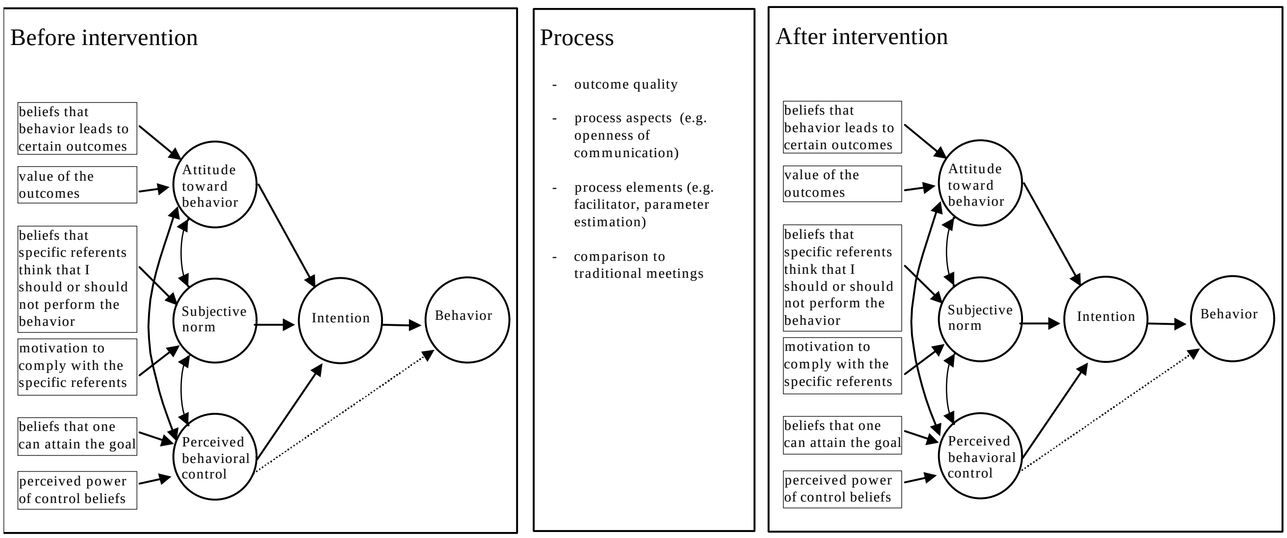

Figure 7 - The conceptual model for evaluation

The concepts in Figure 7 may seem unfamiliar at first sight. However, most concepts bear a strong resemblance to variables that are more common in the strategy or decision making literature. Intention closely resembles commitment to a course of action, while behavior is the counterpart of implementation or system changes on an individual level.

According to the conceptual model, beliefs are strongly related to attitude, norm and control. For example a person's attitude towards increasing recruitment of KPN employees is formed on the basis of two sets of beliefs. The first is the *value* placed on outcomes of this action. The second belief concerns the *expected likelihood* that the action brings about this outcome. A possible outcome of increasing recruitment is for example an increase in innovation potential of KPN. Let us suppose that a HRM advisor positively values this outcome. Considering only this action (increasing recruitment of KPN employees), the chance that the valued outcome will be realized is the expected likelihood that recruitment leads to an increased innovation potential. If either innovation is valued more, or the relation between recruitment and innovation potential grows stronger, we expect the attitude to become more positive. In other words, values and expectancies combine to form evaluations. Fishbein and Ajzen (1975) propose to sum expectancy times value products over all beliefs.

For Ajzen's other concepts, subjective norms and perceived behavioral control, a similar procedure was used.

6.2 Measurement procedure

In the questionnaire employed for this case, we measured the concepts discussed above as follows.

In the pretest interview each respondent was asked to identify two relevant actions with regard to the problem to be modelled. This question prompted actions such as the following:

- recruit people from other research institutions, abroad or in learning trajectories;
- identify who the competent people within KPN Research are;
- promote the right people to the right position: on the basis of HRM instead of content knowledge;
- intensify career development coaching.

Subsequently for both actions the following variables were assessed: intentions, attitude towards action, subjective norm and perceived behavioral control. Each concept was measured using one or two statements in the so-called Likert format, using a five point scale. E.g. the attitude toward actions was assessed by asking 'Implementing action 1 within the coming two years is' *very unfavorable – …– very favorable* and *very good – … – very bad*. Beliefs were measured in three steps. First, respondents were asked to identify two important expectancies (i.e. outcomes, referents and threats or opportunities). Second, the value of the outcomes was assessed, e.g. how important an increased innovation potential would be. This could be scored on a scale from 1 (very unimportant) to 5 (very important). In the third step the strength of each expectancy was measured, e.g. the degree to which recruitment leads to an increased innovation potential. This could be scored from –5 (obstructs realizing outcome) to 5 (contributes very much to outcome).

With regard to process, we formulated two requirements in the above. Participants will change their beliefs in the session if they receive information (persuasive arguments) and are inclined to consider this information (able and motivated to process). If over the course of the sessions persuasive arguments relating to these actions were discovered, we can expect beliefs and evaluations about these actions to change. An example is when a participant received new information on how to retain employees. Before the sessions, he was convinced that researchers' main motivation was to work on innovative projects. During the sessions, several arguments for the importance of adequate coaching were presented and discussed. Since modelling allows this new piece of information to be fitted in with other data, this new and existing knowledge can readily be integrated. In this example, a new positive outcome of coaching has been introduced, leading us to expect a more positive attitude on coaching.

Naturally, the information in the sessions is not the only basis for changes in opinions on HRM strategies. Other developments within KPN Research, its mother company or market position can be expected to impact participants' opinions as well. The project background provides a clear example of the pace of change in the telecommunications business and KPN more specifically. These developments might counteract or strengthen the effect of information received in the sessions in unanticipated ways.

In addition, the modelling project did not result in explicit recommendations for changes in HRM policies. In the section on modelling results we mentioned that outcomes of model runs were regarded as preliminary, since additional data and testing would be needed to validate the model further. The developments impacting KPN and the provisional conclusions of the modelling project do not lead us to expect large changes in participants' intentions or evaluations.

A last remark is on the subjects involved in the evaluation. Since there were several changes in the group of participants, not all people present during the sessions were interviewed at two points in time. Out of the total group of nine participants, seven were interviewed before and after the modelling sessions, whereas two people were interviewed after the intervention only.

In the following section we will address the results of the evaluation. We will not address behavior since the evaluation was completed immediately after the project, which is too early to expect an implementation of conclusions already. We will first go into the variables in Ajzen's theory and discuss intention, evaluations (attitude, subjective norm and perceived control) and beliefs for each evaluation. Subsequently we will address process evaluations.

6.3 Pretest and posttest

On the level of intentions, or commitment to implement system changes, we find few changes between pretest and posttest. Only six out of 14 intentions change. This is not surprising since the project did not result in explicit recommendations for HRM policies. Awaiting further validation and analysis of model outcomes, the last session report provided only preliminary conclusions. Similarly, the scores for attitude towards action, subjective norm and perceived behavioral control did not show large differences between pretest and posttest.

For beliefs, there are changes between pretest and posttest. As we described before, Fishbein and Ajzen (1975) arrive at belief scores by summarizing the sum of expectancies multiplied by values for all beliefs.

Respondents in this case rate the value of each outcome as ‘high’ or ‘very high’, while there is a large variation in the expected contribution of actions to outcomes. We calculated the weighted sum and, since there is little variation in scores for value, mean expectancies. Using both indicators, participants’ beliefs after the HRM modelling project are slightly more positive than before.

6.4 Process

Outcome quality

Outcome quality is measured using 10 Likert items, which could be scored from 1 (strongly disagree) to 5 (strongly agree). An example is ‘In the meetings all relevant risks were discussed’.

The results show that participants in general agree that all goals and consequences have been discussed, and that all information is integrated. They do not feel that all costs, risks and contingencies have been dealt with. Other elements (options, values, information for weighing options, conditions) score around neutral.

In interpreting these answers, we again need to consider the preliminary character of the project’s conclusions. The model does not include financial aspects of HRM decisions, which is a possible explanation for the low score on incorporation of relevant costs. Since the model awaits further validation, risks and contingencies of model interventions need to be considered more carefully, and no attempt has been made to translate interventions to implementable changes in KPN’s HRM policies. The fact that we only had data on the aggregate level (not on specific HRM profiles) is probably one of the causes for this evaluation result.

Process aspects

We assessed ten different aspects of process quality, for example the openness of communication during the group session. One of the questions measuring process quality is for example: “the sessions are characterized by clear, understandable communication”. Answers could be scored from ‘strongly disagree’ to ‘strongly agree’. In general, process aspects score satisfactorily. All participants feel the modelling project was successful, and on average that the approach is efficient.

Process elements

A further question is how the separate elements of the project are evaluated. Table 1 shows the results for the various session elements. Answers could be scored from –5 (obstructed the sessions) to 5 (contributed very much to the sessions).

process element	N	Minimum	Maximum	Mean	St.Dev.
projection of diagrams	9	4.00	5.00	4.56	.53
facilitator	9	3.00	5.00	4.56	.73
open discussion	9	2.00	5.00	4.00	1.00
causal loop diagrams	9	3.00	5.00	4.00	.71
parameter estimation	7	1.00	5.00	3.29	1.38
analysis of model output	5	3.00	5.00	4.20	1.10

Table 1 - Participants' opinion on process elements

From Table 1 it appears that all elements score rather high. The projection of diagrams (the group memory) and facilitator contributed most to the overall effect of the sessions. As expected, parameter estimation contributed positively to the effect of the sessions, although it receives the lowest score.

Comparison to regular meetings

In the last section of the questionnaire, participants were asked to compare the modelling sessions to regular meetings. An example is 'If you compare these sessions, using different techniques, with regular meetings in which you discuss similar matters, would you say the sessions result in more insight?' These questions could again be answered on a scale from 1 (strongly disagree) to 5 (strongly agree). The results are shown in Table 2.

Comparison to regular meetings	N	Minimum	Maximum	Mean	St.Dev.
more insight	9	4.00	5.00	4.11	.33
faster insight	8	2.00	5.00	3.63	.91
better communication	8	3.00	4.00	3.63	.52
faster consensus	9	2.00	5.00	3.33	1.12
more clear consensus	9	3.00	5.00	4.00	.50
faster commitment	8	2.00	5.00	3.63	.92
more commitment	9	2.00	5.00	3.78	.83

Table 2 - Participants' opinion on quality of sessions compared to regular meetings

All average scores are above 3, indicating that modelling sessions indeed are more effective on these aspects than regular meetings. Two outcomes are similar to other modelling cases reported by Vennix and Rouwette (2000). First, the highest scores are obtained for increased insight. Second, the questions on the 'speed' of obtaining an effect on average score lower than the 'size' of the effect (e.g. more commitment scores higher than faster commitment).

6.5 Evaluation conclusion

In sum, participants feel that the sessions were successful with regard to modelling the HRM transition. The large changes in KPN’s environment and the preliminary character of the modelling results prevent a large impact on commitment to system changes (intentions). The main outcome of the sessions was increased insight into the problem. This learning effect is reflected in changes in beliefs from pretest to posttest, as well as the posttest questions on insight and consensus.

Participants also considered the sessions an *efficient* vehicle for fostering insight and consensus. The open communication process, supported by a facilitator and the structuring of ideas in a model, is considered the most important contribution to these outcomes.

This paper presented evaluation results on a single group model project which involved nine participants. If we consider the data presented here in isolation, there is only a very small basis for formulating conclusions. However, results are in line with other cases reported by Vennix and Rouwette (2000) and by Rouwette (2001). Although the value of the social psychological theories for describing group model building effects needs to be researched more thoroughly, it is possible to formulate a set of tentative conclusions. The social psychological theories presented here seem very valuable in organizing the multitude of variables that jointly create the effects of system dynamics interventions. While we would need to increase our database of modelling evaluations, this framework provided the opportunity to integrate diverse settings and findings. In this way an accumulation of evaluation results contributes to identifying the relevant conditions for successful system dynamics interventions.

7 Conclusions

In this paper we reported on a group model building intervention at KPN Telecom. A quantified model on KPN’s human resource policies was built in close interaction with stakeholders involved in the problem. Both the process outcomes and the evaluation of the project offer insights that might be useful to the system dynamics community. In order to enable participants to estimate parameters in the model, we used a technique recently described by Ford and Sterman (1998). We adapted their approach in three ways: by using extreme values as anchor points in the relationship, by judging a relationship using exact numbers and by employing a matrix to assess multiple effects. This procedure yielded results which were meaningful to participants and thereby are an answer to some of the objections to quantitative modelling recently offered in the system dynamics literature. The cascading of multipliers for example, is expected to yield inaccurate or at least uninterpretable results. By separating a cascaded relationship into steps that are meaningful to participants, a check of parameter values is possible. Our evaluation shows that the participative approach inspired confidence in the resulting model. Participants' objective scores and self-assessments indicate that their insight into the problem has increased. Since the model needs to be tested and validated further, at this point only a minor impact on evaluation of and commitment to the conclusions could be established. Although the preliminary character of the conclusions prevented an impact on implementation, several participants noted that after further validation the model should be very useful in assessing alternative HRM policies. With regard to the process of modelling, participants feel the meetings were successful and more effective than traditional meetings.

Acknowledgement

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8 References

Ajzen, I. (1991), The Theory of Planned Behavior, Organizational Behavior and Human Decision Processes no. 50: 179-211.

Andersen, A.F. and G.P. Richardson (1997), Scripts for group model building, System Dynamics Review Vol. 13 No. 2 pp. 107-129.

Andersen , D.F., T.A. Maxwell, G.P. Richardson, T.R. Stewart (1994), Mental models and dynamic decision making in a simulation of welfare reform, Proceedings of the 1994 International System Dynamics Conference: Public Policy Making, Sterling, Scotland: 11-18.

Andersen, D.F., and Richardson, G.P. (1997), Scripts for Group Model Building, System Dynamics Review, 13 (2), 107 – 130.

Cordano, M. and Frieze, I.H. (2000), Pollution reduction preferences of U.S. environmental managers: applying Ajzen's theory of planned behavior, Academy of Management Journal, 43(4), 627 – 641.

Coyle G., (2000), Qualitative and quantitative modelling in system dynamics: some research questions, System Dynamics Review Vol. 16 No. 3 pp. 225-244, 2000.

Fishbein, M., and I. Ajzen (1975), Belief, Attitude, Intention and Behavior: An Introduction to Theory and Research, Reading, MA: Addison-Wesley.

Ford, D.N., and Sterman, J.D (1998), Expert Knowledge Elicitation to Improve Formal and Mental Models, System Dynamics Review, 14 (4), 309 – 340.

Hickson , D.J. R.J. Butler, D. Cray, G.R. Mallory, D.C. Wilson (1986), Top decisions: strategic decision making in organizations, Oxford, UK: Basil Blackwell.

Kim D.-H. (2000), A Method for Direct Conversion of Causal Maps into SD Models: Abstract Simulation with NUMBER, Proceedings of the 2000 International System Dynamics Conference, Bergen, Norway.

Morecroft, J.D.W. (1992), Executive Knowledge, Models and Learning, European Journal of Operations Research, 59, 9-27.

Richardson, G. (1996), Problems for the future of system dynamics, System Dynamics Review 12: 141-157.

Richardson, G. (1999), Reflections for the future of system dynamics, Special issue on system dynamics of Journal of the Operational Research Society 50: 440-449.

Richardson, G.P., and A.L. Pugh (1981), Introduction to System Dynamics Modelling with DYNAMO, MIT Press, Cambridge, Massachusetts.

Richmond, B. (1987), The Strategic Forum: From Vision to Strategy to Operating Policies and Back Again, High Performance Systems, Lyme (NH), The Netherlands.

Richmond, B. (1997), The Strategic Forum: Aligning Objectives, Strategy and Process, System Dynamics Review, 13(2), 131 – 148.

Rouwette, E. (2001, forthcoming), Group model building as mutual persuasion. Ph.D. dissertation, University of Nijmegen, The Netherlands.

Rouwette, E., J.A.M. Vennix and T. van Mullekom. (1999), Group model building. A review of assessment studies, Proceedings of the 1999 International System Dynamics Conference, Wellington.

Vennix, J.A.M. (1996), Group Model Building: Facilitating Team Learning Using System Dynamics, John Wiley & Sons, Chichester.

Vennix, J.A.M., H.A. Akkermans and E. Rouwette (1996), Group Model Building to Facilitate Organisational Change: An Exploratory Study, System Dynamics Review, 12 (1), 39 – 58.

Vennix , J.A.M., J.W. Gubbels, D. Post, and H.J. Poppen (1988), A structured approach to knowledge acquisition in model development, Proceedings of the 1988 International System Dynamics Conference, La Jolla, CA.

Vennix, J.A.M. (1999), Group model-building: tackling messy problems, System Dynamics Review, 15 (4), 379 – 401.

Vennix, J.A.M. and E. Rouwette (2000), Group model building: what does the client think of it now?, Proceedings of the 2000 International System Dynamics Conference, Bergen, Norway.

Warren, K. (2000), Handouts teaching workshop Strategy Dynamics, Bergen, Norway, 10-11 August 2000.