Team resource management decisions in software development projects

Abstract

Purpose: This paper examines to what extent resource managers are likely to make normatively correct decisions in complex, but realistic, software development team resource management situations.

Research design: Three scenarios were designed, all of them with a software development project consisting of a higher and a lower productivity team. The resource managers were asked to decide which team to increase (or decrease) the productivity by 10% in order to minimize the total effort or the total duration of the software project. Ninety-nine software professionals, most of them with substantial resource management experience, were randomly allocated one of the scenarios.

Findings: Most of the resource managers perceived their scenario as realistic and occurring in practice. The decisions tended, however, to be different from the normatively correct ones. In particular, when the scenario structure resembled that used to document a time-saving bias, the great majority of the managers made non-normative decisions. The findings suggest that the resource managers made decisions based on simple heuristics, often leading to non-normative decisions. When asked about the decisions they would make in practice, more of the resource managers gave normatively correct responses. Our findings suggest a cost-saving potential from more awareness of how to make team resource management decisions.

Originality: The study may be the first to document non-normative team resource decisions, including those related to the time-saving bias, in the context of project management.

Keyword: Resource management, project management, time-saving bias

1. Introduction

Good management decisions on the allocation of people and tasks to development teams are essential to achieve success in completing software projects (Purna Sudhakar, Farooq et al. 2011, Simão Filho, Pinheiro et al. 2015). Some of these resource management decisions are
related to an increase or decrease of one or more of the teams’ productivities (Dingsøyr, Fægri et al. 2016), which is the topic of the study reported in this paper.

For the purpose of the reported study, software professionals with experience in resource management were recruited, introduced to one out of three software development project scenarios and asked to make two team resource management decisions. The team resource management context in common for all three scenarios was one with two teams, where one team had a higher productivity than the other. The software professionals were asked to decide between increasing (or decreasing) the productivity of the most or the least productive team, with the goal of minimizing the total project effort or duration. To derive the correct decisions, the resource managers would have to conduct quite complex formal analyses. It was therefore expected that the managers would tend to rely on simpler, non-optimal decision strategies (heuristics), potentially resulting in decision biases (Tversky and Kahneman 1974, Kulik and Perry 1994, Svenson, Gonzalez et al. 2018). The present study aims at better understanding of the frequency of the usage of two such heuristics, i.e., a heuristic based on the assumption that a higher absolute change in productivity will have the larger impact on the total effort and duration, and a heuristic based on the assumption that a higher relative change in productivity will have the larger impact on the total effort or duration. These two heuristics were the focus of our analyses, because they have been argued to be present in what we assume are structurally similar scenario to several of our scenarios, see for example (Peer 2010, Svenson and Treurniet 2017).

The structurally similar situations are in particular those documenting the so-called *time-saving bias* (Svenson 2008, Svenson 2011). The time-saving bias has mainly been documented in car-driving scenarios (Svenson 2008, Peer 2010), but has also been documented in industry production (Svenson, Gonzalez et al. 2014), health care (Svenson 2008) and consumer choice (Peer 2014) scenarios. The time-saving bias predicts that the time (or related constructs such as effort or cost) saved when increasing speed (or related constructs such as productivity) from a higher speed is overestimated compared to the time saved when increasing the speed from a lower speed. Correspondingly, it predicts that the time added when decreasing the speed from a lower speed is underestimated, compared to the time added when decreasing the speed from a higher speed.

An example of a car-driving scenario used to document the time-saving bias is the following (Decision problem 5 in (Svenson 2008)): You can either (Option A) improve road A so that the mean speed of the cars using the road goes from 30 to 40 km/h, or (Option B) improve road B so that the mean speed goes from 70 to 110 km/h. Roads A and B have the
same length. Which option would lead to the largest time saving per car? In this example, both the percentage increase (57% vs. 33%) and the absolute increase (40 km/h vs. 10 km/h) in speed are higher for Option B than for Option A, and the majority (79.8%) responded with that Option B would lead to the largest time saving. The correct answer is, however, that the time saving is larger for Option A\(^1\), which was the answer given by only 16.5% of the respondents. Replacing cars with software development teams and speed of cars with productivity of teams, while keeping the structure of the decision problem the same, it is possible to derive scenarios potentially displaying time-saving biases in a team resource management decision context.

A potential reason for the use of simple heuristics, leading to incorrect answers, is, as noted earlier, that the correct analysis may be quite complex. In the above car-driving context, the correct formula for the time saving is: \(\text{Time saving} = D\left(1/v_1 + 1/v_2\right)\), where \(v_1\) is the original speed, \(v_2\) is the increased speed, and \(D\) is the distance. Instead of trying to derive the correct formula, which involves an inverse relationship with the initial speed values, people may choose to use simpler heuristic, such as judging that the car with the largest increase in absolute or relative speed would be the one saving more time. For example, the study reported in (Svenson, Gonzalez et al. 2018) found that 47.2% had responses consistent with an emphasis of the largest absolute increase in speed and 30.5% with an emphasis on the largest relative increase in speed. Similar results are reported in (Peer and Gamliel 2012). We will in our study examine to what extent a similar distribution of use of heuristics is present in a team resource management situation.

The work described in this paper extends, to our knowledge, prior work by: 1) Examining team resource management decisions in a novel context where, due to similarity in problem structure, we may expect the presence of a time-saving bias and decisions in accordance with the same two, non-normative, heuristics as in the car-driving context, 2) Increasing the ecological validity by using professional software managers with experience from resource management as participants, 3) Using a request format that supports the separation of decisions based on comparison of the absolute and of the relative change in productivity, i.e., the two decision heuristics believed to be essential in similar contexts.

The remaining part of this paper describes the research design and the scenarios, (Section 2), presents the results (Section 3), and discusses the results and their limitations (Section 4). Appendix 1 provides the full scenario descriptions, while Appendix 2 gives the proofs of the normatively correct decisions of the scenarios.

\(^1\) The time saving for Option A is 5 h 50 min, while that of Option B is only 2 h 20 min.
2. Research design

2.1 Participants and process

The participants of the study were recruited at an industry seminar on the topic on how to achieve an effective software development team in Oslo, Norway, September 2019. Of the around 120 seminar participants, 101 took part in our study.

First, the participants provided information about their company role and experience. Then, they were randomly allocated one of the three team management scenarios (described in Section 2.2) and asked to make team resource management decisions minimizing the total effort and the total duration of a software project. Finally, they were asked about what they would normally do in similar resource management situations, when aiming at minimizing the total work-effort, and how realistic they found the scenarios to be.

The self-reported experience gave that most of the participants had extensive experience as software professionals. Of the participants, 76% had more than 10 years, 16% 5–10 years and 18% less than 5 years of experience. Their responses on experience level in resource management gave that 24% made team resource management decisions “very often”, 39% “often”, 19% “sometimes”, 15% “seldom” and 3% “never”. The participants’ roles in the organization were manager (28%), team leader (23%), project leader (22%), and “other roles” (27%).

2.2 Scenarios

All three scenarios used in the study assumed a software development project with two teams, where one team had a higher productivity than the other. The decision to be made concerned the effect on the total project effort and duration when changing the productivity of either the higher or lower productivity team. When developing the scenarios, we aimed at the following:

- The scenarios should resemble realistic software development project resource management decisions and scenarios. To ensure this realism of the scenarios, we discussed and piloted the scenarios with experienced resource managers.
- The scenarios should reflect both productivity-increasing and productivity-decreasing situations. The scenarios should, in addition, include scenarios where activities could and could not be transferred between teams and scenarios where activities could be transferred between teams. These scenario variations were included to see to what extent they affected the decisions made.
• The resource management decisions, at least some of them, should be possible to be separated into: i) Normatively correct decision, ii) Decisions in accordance with the use of a heuristic assuming that the team with the higher percentage change in productivity will have the largest effect on the total effort or duration, and iii) Decisions in accordance with the use of a heuristic assuming that the team with the higher absolute change in productivity will have the largest effect on the total effort or duration.

For the purpose of being able to separate the resource management decision heuristic, we created scenarios where the percentage increase or decrease in productivities were the same for both teams. As an illustration of how this may enable a separation of the decision heuristics, consider a project consisting of two teams with different productivity. The decision to be made is whether to increase the productivity of the lower or the higher productivity team with 10%, when the goal is to minimize the total project effort. A resource manager using a heuristic based on comparing the relative (percentage) increase in productivity of the two teams will respond that it does not matter which team to improve, since both teams increase their productivity with 10%. A resource manager using a heuristic based on comparing the absolute increase in productivity of the two teams will, on the other hand, respond that improving the team with the higher productivity is better, since the absolute increase in productivity of that team is higher. The normatively correct response, assuming that tasks are not possible to transfer between the teams, is that the total effort is minimized when increasing the productivity of the team with the lower productivity (see proof of Scenario 1 in Appendix 1). The decision in such a scenario may consequently be used to identify the correct response and, at the same time, separate decision heuristics in accordance with an emphasis put on relative and on absolute change in productivity. Notice that the ability to separate all three decisions is only possible for two of the decisions in our study. For the other decisions, there will be some overlap between the correct decisions and a decision in accordance with one of the heuristics.

Table 1 displays excerpts of the three scenarios and presents the two questions asked. The full scenario descriptions (translated from Norwegian) is included as Appendix 1.

Table 1: Scenario excerpts

<table>
<thead>
<tr>
<th>Project and team context common for all scenarios</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assume that you are responsible for managing the resources of a software development project with two teams. One team has higher productivity, where productivity is measured as “story points”¹ (output) per work-week (effort), than the other. The least productive team has</td>
</tr>
</tbody>
</table>

¹ story points: A common metric for estimating the effort required to complete a feature or task in software development projects. It is typically based on the story point system, where a story point is a unit of measurement that represents the amount of work the developers estimate a feature or task would require. This can be a subjective measure, as it is based on the experience and judgment of the team members.
more members, and the initial delivery speed, measured as number of “story points” per calendar week, is the same for the teams. The two teams are required to deliver the same total amount of output, measured in “story points”, to the project.2

<table>
<thead>
<tr>
<th>Scenario 1</th>
<th>Scenario 2a</th>
<th>Scenario 2b</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decide between increasing the total productivity of the most productive team with 10%, or the least productive team with 10%. The expected productivity increase is achieved by supporting one of the teams with a highly skilled and productive person. Project work cannot be transferred between the teams.</td>
<td>Decide between decreasing the total productivity of the most productive team with 10%, or the least productive team with 10%. This is done by giving one of the teams additional, productivity-decreasing work. Project work cannot be transferred between the teams.</td>
<td>Same as in Scenario 2a, except that project work can be transferred between the teams.</td>
</tr>
</tbody>
</table>

**Questions**

What would you do to minimize:
- the total effort (sum of work-weeks of both teams)?
- the total duration (sum of calendar weeks of both teams)?

**Response options**

- Increase (Scenario 1)/decrease (Scenarios 2a and 2b) the productivity of the team with the lower productivity
- Increase (Scenario 1)/decrease (Scenarios 2a and 2b) the productivity of the team with the higher productivity
- It does not make any difference
- Don’t know

**Other questions** (displayed after finalizing the scenario decisions)

- In a real-life situation, when the goal is to minimizing the total effort, what do you think you typically would do (or what have you typically decided, if you have actual experience from similar situations)?
  [Answer options were the same as those in the scenarios, with the addition of the option]
“Would never emphasize productivity difference” and a change from the response option “It does not make any difference” to “Equally often”.

- How realistic do you perceive the scenario to be? To what extent is this something that could be/has been a decision situation in real-life software development team contexts? [Answer options were: Very realistic (occurs often), Realistic (occurs sometimes), Not very realistic (occurs seldom), Very unrealistic (occurs never), Don’t know.]

1: “Story point” is a frequently used measure of the size of the software functionality to be produced (Cohn 2006).

2: The scenarios and decisions were illustrated with an example, to make them easier to understand, see Appendix 1.

Table 2 displays the normatively correct decision and provides an expression comparing the effect on the total effort and duration when changing (increasing with 10% in Scenario 1 and decreasing with 10% in Scenarios 2a and 2b) the productivity of the least or the most productive team. The expressions are derived as Appendix 2.

Table 2 uses the following abbreviations: E = effort, P = productivity (story points per work-week), D = delivery speed (story points per calendar week), T = project duration, A = team with lower productivity, and B = team with higher productivity. Values with the subscript “initial” are those before, while values with the subscript “changed” are those after the change in productivity. As described in Table 1, the percentage change in productivity (10%), is the same for both teams of a scenario. The examples in Table 2 are based on the productivity values used as example in the full Scenario descriptions (see Appendix 1).

### Table 2: Normatively correct decisions

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Decision criterion</th>
<th>Normatively correct decision</th>
<th>Comparison of effects on total effort and total duration when changing the productivity of the lower (A) or higher productivity team (B)</th>
</tr>
</thead>
</table>
| **Scenario 1** (Increase productivity with 10%) | Minimize total effort (sum of work-weeks of both teams) | Increase the productivity of the lower productive team with 10% | \[
\frac{E_{\text{initial}A}-E_{\text{changed}A}}{E_{\text{initial}B}-E_{\text{changed}B}} = \frac{P_{\text{initial}B}}{P_{\text{initial}A}} \geq 1,
\]

i.e., with the same productivity increase the effort reduction is always higher for A than for B. |
Minimize total duration (sum of calendar weeks of both teams) | Increase the productivity of the higher productive team with 10% | \((D_{initial_A} - D_{changed_A}) - (D_{initial_B} - D_{changed_B}) = 1.1 \cdot (P_{initial_A} - P_{initial_B}) < 0\), i.e., with the same productivity increase there is a larger reduction in delivery speed, and consequently total duration, when increasing productivity of B. (The larger reduction in duration comes only from the extra person added, which explains why only the productivity is left in the final expression.)

**Scenario 2a** (Decrease productivity with 10%. Not possible to transfer tasks between teams) | Minimize total effort | Decrease the productivity of the lower productive team with 10% | \(E_{initial_A} - E_{changed_A} = \frac{P_{initial_B}}{P_{initial_A}} > 1\), i.e., analogous to that for Scenario 1.

Minimize total duration | It does not make any difference | \((D_{initial_A} - D_{changed_A}) - (D_{initial_B} - D_{changed_B}) = 0\), i.e., given same initial work speed there is no difference in total duration.

**Scenario 2b** (Decrease productivity with 10%. Possible to transfer tasks between teams) | Minimize total effort | It does not make any difference | \(T_{Disturb_B} = \frac{D_{initial_A} 0.9 + D_{initial_B}}{D_{initial_B} 0.9 + D_{initial_A}} = 1\), i.e., given the same initial delivery speed there is no difference in total time usage. \(T_{Disturb_A}\) and \(T_{Disturb_B}\) are the duration of the project when giving the extra (disturbing) tasks to A or B, respectively. Since both teams finish at the same time (tasks are possible to transfer between the teams), there will be no difference in the effect of total effort and total duration.
The responses that correspond with the use of the two decision heuristics examined in this paper are as follows:

- The response “It does not make any difference” corresponds with a decision heuristic based on emphasizing *relative (percentage) difference* (which is 10% for both teams) in productivity change for all three scenarios and all decisions.
- The response to improve the productivity of the most productive team for Scenario 1 and the responses to reduce the productivity of the least productive team for Scenarios 2a and 2b correspond with a heuristic based on emphasizing *absolute difference* (which is larger for the most productive team) in productivity change.

### 3. Results

#### 3.1 Perceived realism of the scenarios

Table 3 displays the, as assessed by the participants, perceived realism of the scenarios. To examine the connection between level of experience and perceived realism of the scenarios, those who claimed to have made team resource allocation decisions more than 20 times were categorized as having “higher” level of experience, and the others as having “lower” level of experience.

Table 3 suggests that the majority of the resource managers found the scenarios very realistic (occurs often) or realistic (occurs sometimes). It also suggests that there are no large differences in perceived scenario realism between managers with higher and with lower level of resource management experience.
Table 3: Perceived realism of scenarios

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Experience level</th>
<th>Very realistic (occurs often)</th>
<th>Realistic (occurs sometimes)</th>
<th>Not very realistic (occurs seldom)</th>
<th>Very unrealistic (occurs never)</th>
<th>Don’t know</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>All (n=32)</td>
<td>9%</td>
<td>50%</td>
<td>22%</td>
<td>9%</td>
<td>9%</td>
</tr>
<tr>
<td></td>
<td>Higher (n=18)</td>
<td>6%</td>
<td>56%</td>
<td>28%</td>
<td>11%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Lower (n=14)</td>
<td>14%</td>
<td>43%</td>
<td>14%</td>
<td>7%</td>
<td>21%</td>
</tr>
<tr>
<td>2a</td>
<td>All (n=35)</td>
<td>34%</td>
<td>46%</td>
<td>17%</td>
<td>3%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Higher (n=23)</td>
<td>17%</td>
<td>57%</td>
<td>22%</td>
<td>4%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Lower (n=12)</td>
<td>67%</td>
<td>25%</td>
<td>8%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>2b</td>
<td>All (n=34)</td>
<td>12%</td>
<td>62%</td>
<td>24%</td>
<td>0%</td>
<td>3%</td>
</tr>
<tr>
<td></td>
<td>Higher (n=22)</td>
<td>5%</td>
<td>68%</td>
<td>27%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Lower (n=12)</td>
<td>25%</td>
<td>50%</td>
<td>17%</td>
<td>0%</td>
<td>8%</td>
</tr>
</tbody>
</table>

3.3 Decisions

Table 4 summarizes the resource managers’ resource management decisions when minimizing total effort (total number of work-weeks) and total duration (total number of calendar weeks) for the three scenarios. The responses of those with higher and lower degree of resource management experience were very similar and, for this reason, joined. The normatively correct decisions, see Table 2, are in bold.

Table 4: Resource management decisions

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Decision</th>
<th>Least productive team</th>
<th>Most productive team</th>
<th>No difference</th>
<th>Don’t know</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Minimize total effort</td>
<td>9%</td>
<td>48%</td>
<td>33%</td>
<td>9%</td>
</tr>
<tr>
<td></td>
<td>Minimize total duration</td>
<td>21%</td>
<td>58%</td>
<td>15%</td>
<td>6%</td>
</tr>
<tr>
<td>2a</td>
<td>Minimize total effort</td>
<td>46%</td>
<td>34%</td>
<td>14%</td>
<td>6%</td>
</tr>
<tr>
<td></td>
<td>Minimize total duration</td>
<td>29%</td>
<td>43%</td>
<td>26%</td>
<td>3%</td>
</tr>
<tr>
<td>2b</td>
<td>Minimize total effort</td>
<td>47%</td>
<td>32%</td>
<td>21%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Minimize total duration</td>
<td>35%</td>
<td>29%</td>
<td>35%</td>
<td>3%</td>
</tr>
</tbody>
</table>
As can be seen in Table 4, the resource managers did frequently not make the normatively correct decisions. The proportion of normatively correct decisions varies from only 9% (Scenario 1, minimize total effort) to 58% (Scenario 1, minimize total duration).

When there is no difference in effect from changing the productivity of the least or the most productive team, the decisions “Least productive team”, “Most productive team” and “No difference” give the same result, and it may be argued that all three of them, i.e., close to 100%, are correct. The difference in answers nevertheless shows that many of the resource managers thought there was a difference. Notice also that a correct answer is not necessarily based on a correct analysis or decision strategy. In particular, the 58% correct answers in Scenario 1, when minimizing the total duration, may as well be a consequence of the use of a decision heuristic emphasizing that the absolute increase in productivity will be higher when increasing the productivity of the team with the higher productivity with 10%.

Below we discuss the resource managers’ decisions in relation to:

- The time-saving bias
- The use of decision heuristics corresponding with the resource managers’ responses
- What the resource managers would do in real-life situations, when minimizing the total effort
- Responses to the time-saving bias in a car-driving scenario

The time-saving bias

The decision that closest resembles the majority of the previously reported time-saving bias decisions is the one aiming at minimizing the total effort in Scenario 1. Here, a 10% productivity increase will decrease the effort (total number of work-weeks) more when increasing the productivity of the least productive team. In this scenario, there is a strong time-saving bias, and only 9% of the resource managers gave the normatively correct decision. If we compare this with the results for the decisions of problems 8 and 9 in (Svenson 2008), which is structurally very similar to our Scenario 1 in that the percentage increase of speed is the same for both cars, we see a similarity in results. In (Svenson 2008), the proportions of correct decisions for the two problems were 19% and 17.3%, while in our study it was 9%. The proportions of responses in accordance with a heuristic emphasizing the absolute change in productivity were, for the same two problems in (Svenson 2008), 56.4% and 52.7%, while in our study it was 48%. Finally, the proportions of responses in accordance with a heuristic emphasizing the relative change in productivity were, for the two problems in (Svenson 2008), 24.6% and 30%, while in our study it was 33%. This similarity may suggest that the structural
similarity of the problems in the car driving and the team resource management contexts leads to similarity in response biases and use of decision heuristics.

The other decision resembling the previously reported time-saving bias situation, but now with a decrease rather than an increase in productivity, is the decision on minimizing the effort in Scenario 2a.\footnote{In Scenario 2b, the work can be transferred from one team to another and, consequently, describes a situation different from that where the time-saving bias is examined. The work speed (output per calendar week) is the same for the two teams, and it makes, for this reason, no difference whether we decrease the productivity of the least or most productive team (see the Appendix 2 for proofs).} Here, the total effort will be minimized when decreasing the productivity of the most productive team with 10%. In this scenario, there is a much higher proportion of correct answers than the 9% in Scenario 1. In Scenario 2a, when aiming at minimizing the total effort, 34\% of the respondents gave the normatively correct answer, 46\% had responses in accordance with an emphasis on the increase in absolute productivity, and 14\% had responses in accordance with an emphasis on the relative change. There are no corresponding prior studies on time-saving bias using a format similar to that in the productivity-decreasing scenario in this paper, but the results in (Svenson and Treurniet 2017) suggest that the proportion of correct answers may, similarly to our findings, increase in productivity (speed) decreasing situations. Notice that there may be differences, other than the productivity increasing vs. decreasing difference, which may explain the increase in proportion of correct answers in Scenario 2a.

In total, it seems reasonable to conclude that there is a time-saving bias for team resource management decisions, when resembling a format similar to that traditionally used in car-driving contexts, especially in productivity-increasing, but also for productivity-decreasing scenarios.

\textit{The heuristics underlying the resource managers' (frequently incorrect) decisions}

We argued in Section 2 that the response “It does not make any difference” is in accordance with use of a heuristic emphasizing a comparison of the relative (percentage) increase in productivity. Table 4 shows that, depending on the scenario and decision, 14–35\% of the resource managers gave this response. The proportion of this type of response is only slightly higher when this is the normatively correct answer compared to when it is not the normatively correct answer, with mean proportions of 27\% and 21\%, respectively. This suggests that giving the correct answer, when this actually is “It does not make any difference”, is not necessarily based on a correct,
formal analysis, but rather on the use of a heuristic that is non-optimal, but sometimes nevertheless gives the correct answer.

The decisions to increase the productivity of the most productive team in Scenario 1 and to decrease the productivity of the least productive team in Scenarios 2a and 2b are in accordance with an emphasis on the absolute increase in productivity. Depending on the scenario and decision, 29–58% of the resource managers gave this response.

The mean proportion for this response is about the same when this is the normatively correct (32%), compared to when it is the normatively incorrect answer (31%).

The proportion of responses that are neither in accordance with the two examined heuristics, nor the normatively correct one, varies from 21% to 43%, suggesting that there are other heuristics or types of intuition-based expert judgments in use, as well.

As explained earlier, tasks were not possible to transfer between the teams in Scenario 2a and possible to transfer between the teams in Scenario 2b. Examining the responses in Table 4, we find no large difference in the proportions of the different heuristics or decisions between the two scenarios. This suggests that few of the resource managers, if any at all, were aware of the effect of this difference, which matters for the decision on minimizing the total effort, but not for the decision minimizing the total duration.

What the resource managers would do in real life

Table 5 displays the managers’ responses to the question about what they think they typically would do, or what they typically had done in a similar real-life situation, when minimizing the total effort. The answers corresponding to the normatively correct answer in the previous scenarios are in bold. When responding to this request, we added the response option “Would never emphasize productivity differences” and replaced the option “No difference” with the option that they “Equally often” would have/actually had increased/decreased the productivity of the least and the most productive team.
Table 5. Real-life decisions when minimizing total effort

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Least productive team</th>
<th>Most productive team</th>
<th>Equally often</th>
<th>Never emphasize productivity differences</th>
<th>Don’t know</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>39%</td>
<td>21%</td>
<td>12%</td>
<td>24%</td>
<td>3%</td>
</tr>
<tr>
<td>2a</td>
<td>17%</td>
<td>37%</td>
<td>20%</td>
<td>20%</td>
<td>6%</td>
</tr>
<tr>
<td>2b</td>
<td>27%</td>
<td>21%</td>
<td>12%</td>
<td>32%</td>
<td>9%</td>
</tr>
</tbody>
</table>

As shown in Table 5, the resource managers more often made the normatively correct decisions in real life than in the hypothetical Scenario 1 (39% in real life vs. 9% in Scenario 1), while having about the same proportion of normatively correct decisions for Scenario 2a (37% in real life vs. 34% in Scenario 2a). If we remove those who would never emphasize productivity differences, the proportions of normatively correct decisions in the real-world situation increased to 56% and 46%, which are close to half of the decisions. While this may be good news for the quality of real-life team resource management decisions, the proportion not making the normatively optimal decision is still large.

For Scenario 2b, it does not matter whether we decrease the productivity of the most or the least productive team. Decreasing the productivity of the least productive, the most productive team, or equally often would all lead to the same increase in total effort. All these answers may consequently be considered optimal.

In total, we consider the results presented in Table 5 to suggest that real-world decisions are better than those given when presented the more hypothetical Scenarios 1 and 2a. Even here, however, there is a substantial proportion that do not make the decision that, we argue, is likely to minimize the total project effort.

4. Discussion, limitations and conclusion

Given the complexity of the formal calculations, it may not be surprising that the majority of the resource managers are unable to formally derive the normatively correct decisions and instead have to rely on simple heuristics when making complex resource management decisions.

The use of too simple heuristics may explain why the decisions by the resource managers frequently were not the normatively correct ones. Especially for the scenarios
corresponding to the traditional time-saving bias context, e.g., minimizing total effort in Scenario 1, few of the managers made the normatively correct decision. When looking at what the managers would do in real life, the proportion of managers making decisions that would minimize the effort increases, i.e., it is possible that the managers do better “in practice” than “in theory”. Why it is like this is not clear, but a possible reason is that the format of the hypothetical scenarios may have stimulated the use of the too simple decision heuristics, while real-life decisions may be based on more thorough considerations or more experience-based decisions. More research is needed to examine how real-world team resource management decisions of the type examined in this paper are made and how they differ from the ones used in more hypothetical scenario situations.

The main implication of our finding is, we believe, that there may be software projects that spend more effort, and get higher cost, than they need to, due to non-optimal resource management decisions. To be able to improve on this, given the complexity of deriving the normatively correct decisions, there may be a need for better training in how to derive the correct resource management decision. This may be especially important in situations structurally similar to those where the time-saving bias has been observed.

Limitations

When reading and applying the findings of this paper, it is important to be aware that only few scenarios are examined and that there may be many other scenarios where the decisions of resource managers better correspond with the normatively correct ones. The results should consequently not be used as a general evaluation of the resource management skills of the participants.

Most respondents evaluated the presented resource management scenarios as relevant and occurring sometimes or often, but it is not clear what this means in terms of frequency and representativeness in the context of software, or other types of, projects. The results in this paper mainly apply to the situations where a resource manager has to choose between improving/reducing the productivity of one out of two (or more) teams with different productivity, and where the relative change in productivity is about the same for both teams.

Another essential limitation of the study is that the managers did not have much time to make the decisions. Although no explicit limit was put on the resource managers’ time usage, the managers typically spent only 10–15 minutes on making the decisions. This may be much less than they would use in a real-life setting. By spending more time on the decision, more of
them may have been able to come up with better analyses, which is consistent with the improved real-world decisions displayed in Table 5.

**Conclusion**

We conclude that there are resource management situations, especially those with a structure resembling the time-saving bias, where even experienced resource managers frequently make non-optimal decisions. A possible reason for making the non-optimal decision is that the analysis leading to the normatively correct decision may be quite complex, which leads the managers to rely on simple, in some contexts too simple, heuristics. These heuristics in our scenarios may have been based on the assumption that a larger absolute or relative change in productivity will have a larger impact on the total effort or duration of a project. This is, however, sometimes not the case and may cause non-optimal decisions and higher project effort or duration than need be. To avoid this, we recommend that companies increase the awareness of these heuristics that may lead to non-optimal decisions and train managers in how to analyse the effect of changing the productivity of teams with different levels of productivity on the project’s total effort and duration.

**References**


Appendix 1: Scenarios

All scenarios are translated from the original Norwegian text.

Scenario 1: Increase the productivity of the low or high productivity team?
Assume that you are the project leader or resource responsible for an IT project consisting of two teams (Team A and Team B). Both teams use a software development process involving frequent (weekly) deliveries during the project. The teams work on different domains, and it is not possible to transfer tasks from one team to the other. The teams are planned to deliver the same volume of functionality (for example, measured in story points), with about the same complexity, quality requirements and importance for the client.

Team B has substantially higher productivity than Team A, meaning that Team B has more productive team members and on average delivers more functionality per person than Team A does. Team A has, however, more members than Team B, so that Team A and Team B are expected to deliver about the same amount of functionality per calendar week, i.e., the delivery speed of Team A and Team B is the same.

Example: Team A has a productivity of 1 story point per work-week, while Team B has a productivity of 1.5 story points per work-week. Team B has consequently 50% higher productivity than Team A. Team A has, however, 9 members, while Team B has 6 members. In one calendar week, Team A and Team B are consequently delivering the same number of story points (same delivery speed). Team A delivers 9*1 = 9 story points per calendar week, and Team B delivers 6*1.5 = 9 story points per calendar week.

Decision to be made: Increase the productivity of the team with the lower (Team A) or the higher (Team B) productivity?
Assume that you have the budget to employ one — and only one — extra person. You can either employ a person to work in Team A or a person to work in Team B. You have two very skilled candidates: Person X who fits Team A very well; and Person Y who fits Team B very well. You assess the situation to be that Person X’s good skill will increase the productivity of
Team A with ca. 10%. Similarly, Person Y’s good skill will increase the productivity of Team B with ca. 10%.

**Example:** Following up on the above example, this means that the total productivity of Team A will increase with $1.0 \times 0.1 = 0.1$ story points per work-week, and the total productivity of Team B will increase with $1.5 \times 0.1 = 0.15$ story points per work-week.

As described earlier, it is not possible to transfer tasks from one team to the other.

**Question 1 (minimize cost):**
Assume that the goal is to have as low total cost as possible, which corresponds to minimizing the sum of work-weeks (total work effort) spent by Team A and by Team B to complete all deliveries. Would you then hire Person X to work in the team with the lower productivity (Team A) or Person Y to work in the team with the higher productivity (Team B)? Or does it not make any difference?

**Response alternatives:**
- Use Person X in Team A
- Use Person Y in Team B
- Does not make any difference
- Don’t know/not possible to decide

**Question 2 (minimize calendar time):**
Assume the same scenario as in Question 1, but that the goal instead is to minimize the total use of calendar time, measured as the sum of the calendar time (duration in number of weeks) spent by Team A and by Team B to complete all deliveries. Would you then use Person X in

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3 A comment (from a pilot review of the paper) on the scenario was that it is not realistic that adding one person will improve the productivity (and not only the delivery speed) of the whole team with 10% and that the scenario for this reason may have been misunderstood. There are several arguments against this: 1) It is not unusual that one very skilled person has substantial positive impact on the productivity on the whole team in software development, either through her/his own high productivity or through better support other team members. 2) Most of the respondents (59%) evaluated the scenario to be realistic or very realistic. 3) We sent a request to all participants answering this scenario to describe how they had interpreted the scenario. All participants responding to this request (response rate, however, of only 19%) had interpreted the scenario correctly. 4) None of the respondents commented (there was a field for this in the questionnaire) that the scenario was difficult to understand. 5) The example used in the scenario is about the increase in team productivity, not of one individual.
the team with the lower productivity (Team A) or Person Y in the team with the higher productivity (Team B)? Or does it not make any difference?

Response alternatives:
- Use Person X in Team A
- Use Person Y in Team B
- Does not make any difference
- Don’t know/not possible to decide

Question 3 (real-life decision):
In a real-life situation, what do you think you typically would do (what have you typically decided, if you have relevant experience) to minimize the total effort of the project?

Response alternatives:
- Improved the team with lower productivity
- Improved the team with the higher productivity
- Equally often improved the team with lower and higher productivity
- Would never emphasize productivity differences
- Don’t know

Question 4 (realism):
How realistic do you perceive the scenario to be? (To what extent is this something that could be/has been a decision situation in real-life software development team contexts?)

Response alternatives:
- Very realistic (occurs often)
- Realistic (occurs sometimes)
- Not very realistic (occurs seldom)
- Very unrealistic (never happens)
- Don’t know
Scenario 2: Decrease productivity of the low or high productivity team?

Assume that you are the project leader or resource responsible for an IT project consisting of two teams (Team A and Team B). Both teams use a software development process involving frequent (weekly) deliveries during the project. The teams work on different domains, and it is not possible to transfer tasks from one team to the other. The teams are planned to deliver the same volume of functionality (for example measured in story points), with about the same complexity, quality requirements and importance for the client.

Team B has substantially higher productivity than Team A, meaning that Team B has more productive team members and on average delivers more functionality per person than Team A does. Team A has, however, more members than Team B, so that Team A and Team B are expected to deliver about the same amount of functionality per calendar week, i.e., the delivery speed of Team A and Team B is the same.

Example: Team A has a productivity of 1 story point per work-week, while Team B has a productivity of 1.5 story points per work-week. Team B has consequently 50% higher productivity than Team A. Team A has, however, 9 members, while Team B has 6 members. In one calendar week, Team A and Team B are consequently delivering the same number of story points (same delivery speed). Team A delivers $9 \times 1 = 9$ story points per calendar week, and Team B delivers $6 \times 1.5 = 9$ story points per calendar week.

Decision to be made: Decrease the productivity of the team with higher or lower productivity?

Assume that you have to choose between giving Team A or Team B some extra tasks that make the productivity go down (for example, that all the developers in Team A or in Team B have to spend half a day each week to provide user support on the developed software). You assess the situation to be that this would either decrease the productivity of Team A with 10% or decrease the productivity of Team B with 10%.
In the above example, that means that the productivity of Team A will decrease with 1.0*0.1 = 0.1 story points per work-week, and the productivity of Team B will decrease with 1.5*0.1 = 0.15 story points per work-week.

As described earlier, it is not possible to transfer tasks from one team to the other.

**Question 1 (minimize cost):**
Assume that the goal is to have as low total cost as possible, which corresponds to minimizing the sum of work-weeks (total work effort) spent by Team A and by Team B to complete all deliveries. Would you then give the extra tasks to the team with the lower productivity (Team A) or to the team with the higher productivity (Team B)? Or does it not make any difference?

**Response alternatives:**
- Give the extra tasks to Team A
- Give the extra tasks to Team B
- Does not make any difference
- Don’t know/not possible to decide

**Question 2 (minimize calendar time):**
Assume the same scenario as in Question 1, but that the goal instead is to minimize the total use of calendar time, measured as the sum of the calendar time (duration in number of weeks) spent by Team A and by Team B to complete all deliveries. Would you then give the extra tasks to the team with the lower productivity (Team A) or to the team with the higher productivity (Team B)? Or does it not make any difference?

**Response alternatives:**
- Give the extra tasks to Team A
- Give the extra tasks to Team B
- Does not make any difference
- Don’t know/not possible to decide

**Question 3 (real-life decision):**
In a real-life situation, what do you think you typically would do (what have you typically decided, if you have relevant experience) to minimize the total effort of the project?

Response alternatives:

- Give the extra (productivity-decreasing) tasks to the team with lower productivity
- Give the extra (productivity-decreasing) tasks to the team with higher productivity
- Equally often give the extra (productivity-decreasing) tasks to the team with lower and higher productivity
- Would never emphasize productivity differences
- Don’t know

Question 4 (realism):
How realistic do you perceive the scenario to be? (To what extent is this something that could be/has been a decision situation in real-life software development team contexts?)

Response alternatives:

- Very realistic (occurs often)
- Realistic (occurs sometimes)
- Not very realistic (occurs seldom)
- Very unrealistic (never happens)
- Don’t know

Scenario 3: Decrease productivity of the low or high productivity team?
Assume that you are the project leader or resource responsible for an IT project consisting of two teams (Team A and Team B). Both teams use a software development process involving frequent (weekly) deliveries during the project. The teams work on the same domain, and it is possible to transfer tasks between the teams. Tasks will be distributed so that the teams (and consequently also the project) will be finished at the same time.

Team B has substantially higher productivity than Team A, meaning that Team B has more productive team members and on average delivers more functionality per person than Team A does. Team A has, however, more members than Team B, so that Team A and Team B are
expected to deliver about the same amount of functionality per calendar week, i.e., the
delivery speed of Team A and Team B is the same.

**Example:** Team A has a productivity of 1 story point per work-week, while Team B has a
productivity of 1.5 story points per work-week. Team B has consequently 50% higher
productivity than Team A. Team A has, however, 9 members, while Team B has 6 members.
In one calendar, week Team A and Team B are consequently delivering the same number of
story points (same delivery speed). Team A delivers $9 \times 1 = 9$ story points per calendar week,
and Team B delivers $6 \times 1.5 = 9$ story points per calendar week.

**Decision to be made:** Decrease the productivity of the team with higher or lower
productivity?
Assume that you have to choose between giving Team A or Team B some extra tasks that
make the productivity go down (for example, that all the developers in Team A or in Team B
have to spend half a day each week to provide user support on the developed software). You
assess the situation to be that this would either decrease the productivity of Team A with 10%
or the productivity of Team B with 10%.

In the above example, that means that the productivity of Team A will decrease with $1.0 \times 0.1$
$= 0.1$ story points per work-week, and the productivity of Team B will decrease with $1.5 \times 0.1$
$= 0.15$ story points per work-week.

**Question 1 (minimize cost):**
Assume that the goal is to have as low total cost as possible, which corresponds to minimizing
the sum of work-weeks (total work effort) spent by Team A and by Team B to complete all
deliveries. Would you then give the extra tasks to the team with the lower productivity (Team
A) or to the team with the higher productivity (Team B)? Or does it not make any difference?

**Response alternatives:**
- Give the extra tasks to Team A
- Give the extra tasks to Team B
- Does not make any difference
- Don’t know/not possible to decide
Question 2 (minimize calendar time):
Assume the same scenario as in Question 1, but that the goal instead is to minimize the total use of calendar time, measured as the sum of the calendar time (duration in number of weeks) spent by Team A and by Team B to complete all deliveries. Would you then give the extra tasks to the team with the lower productivity (Team A) or to the team with the higher productivity (Team B)? Or does it not make any difference?

Response alternatives:
- Give the extra tasks to Team A
- Give the extra tasks to Team B
- Does not make any difference
- Don’t know/not possible to decide

Question 3 (real-life decision):
In a real-life situation, what do you think you typically would do (what have you typically decided, if you have relevant experience) to minimize the total effort of the project?

Response alternatives:
- Give the extra (productivity-decreasing) tasks to the team with lower productivity
- Give the extra (productivity-decreasing) tasks to the team with higher productivity
- Equally often give the extra (productivity-decreasing) tasks to the team with lower and the higher productivity
- Would never emphasize productivity differences
- Don’t know

Question 4 (realism):
How realistic do you perceive the scenario to be? (To what extent is this something that could be/has been a decision situation in real-life software development team contexts?)

Response alternatives:
- Very realistic (occurs often)
- Realistic (occurs sometimes)
- Not very realistic (occurs seldom)
• Very unrealistic (never happens)
• Don’t know
Appendix 2: Scenario calculations

Terminology:
\[ T = 0 \text{ (initial productivity situation) or 1 (changed productivity situation)} \]
\[ X = A \text{ (the team with the lower productivity, i.e., Team A) or B (the team with the higher productivity, i.e., Team B)} \]
\[ O_{XT} = \text{Total output delivered by Team X in situation T (measured in story points delivered)} \]
\[ I_{XT} = \text{Input by Team X to produce the output in situation T (= work-weeks)} \]
\[ T_{XT} = \text{Time spent by Team X to produce the output in situation T (= calendar weeks)} \]
\[ P_{XT} = \text{Productivity of Team X in situation T (= story points delivered per work-week)} = \frac{O_{XT}}{I_{XT}} \]
\[ D_{XT} = \text{Delivery speed of Team X in situation T (= story points delivered per calendar week)} = \frac{O_{XT}}{T_{XT}} \]
\[ Y_{XT} = \text{Productivity change of Team X in situation T (For example, } Y_{X1} = 1.1 \text{ means 10% increase in productivity from the initial to the changed productivity situation. Notice that the productivity change is identical with the delivery speed change when all other elements are held constant, i.e., a 10% increase in productivity (e.g., story points per work-week) also means a 10% increase in delivery speed (e.g., story points per calendar week). We therefore also use } Y_{XT} \text{ as the increase in delivery speed in the calculations below).} \]

Scenario 1: Add one person to Team A or Team B, who improves the total productivity

Assumptions:
\[ Y = Y_{A1} = Y_{B1} \text{ (The productivity change is the same for Teams A and B)} \]
\[ Y > 1 \text{ (There is a productivity increase)} \]
\[ O_{A1} = O_{A0} = O_{B1} = O_{B0} \text{ (Team A and Team B deliver the same amount of required output, and the required output is the same for the initial and changed situations)} \]
\[ P_{A0} < P_{B0} \text{ (Team B has higher initial productivity than Team A)} \]
\[ D_{A0} = D_{A0} \text{ (Team A and Team B have the same initial delivery speed)} \]
\[ P_{A1} = Y \times P_{A0} \text{ (Team A’s productivity after adding one person)} \]
\[ P_{B1} = Y \times P_{B0} \text{ (Team B’s productivity after adding one person)} \]
\[ D_{A1} = D_{A0} \times Y + P_{A1} = D_{A0} \times Y + P_{A0} \times Y \text{ (Team A’s delivery speed after adding one person)} \]
\[ D_{B1} = D_{B0} \times Y + P_{B1} = D_{B0} \times Y + P_{B0} \times Y \text{ (Team B’s delivery speed after adding one person)} \]
Effect of an increase in productivity on decrease in input (effort measured in work-weeks) required for Team A and Team B

Team A: \( I_{A0} - I_{A1} = O_{A0}/P_{A0} - O_{A1}/P_{A1} = [O_{A0} * P_{A1} - O_{A1} * P_{A0}] / P_{A0} * P_{A1} = [O_{A0} * Y * P_{A0} - O_{A0} * P_{A0}] / P_{A0} * P_{A1} = [O_{A0} * (Y * P_{A0} - P_{A0})] / P_{A0} * Y * P_{A0} = O_{A0} * (Y - 1) / Y * P_{A0}. \)

Similarly, for Team B: \( I_{B0} - I_{B1} = O_{B0} * (Y - 1) / Y * P_{B0}. \)

We know that \( O_{A0} = O_{B0} \) and that \( Y \) is the same for Teams A and B.

We then have that:
\[
[I_{A0} - I_{A1}]/[I_{B0} - I_{B1}] = [O_{A0} * (Y - 1) / Y * P_{A0}]/[O_{B0} * (Y - 1) / Y * P_{B0}] = [O_{A0} * (Y - 1) / Y * P_{A0}]/[O_{A0} * (Y - 1) / Y * P_{B0}] = [1/P_{A0}]/[1/P_{B0}] = P_{B0}/P_{A0}.
\]

Since \( P_{A0} < P_{B0} \), the ratio is \( > 1 \). This means that \( [I_{A0} - I_{A1}] \) is larger than \( [I_{B0} - I_{B1}] \). We consequently reduce the input (reduce the number of work-weeks) more when adding one resource and increasing the productivity of Team A.

Effect of an increase in productivity \((Y > 1)\) on reduction in calendar time required for Team A and Team B:

We know that \( D_{A1} - D_{A0} = D_{A0} * Y + P_{A0} * Y - D_{A0} \) and \( D_{B1} - D_{B0} = D_{B0} * Y + P_{B0} * Y - D_{B0} \).

We know that \( D_{A0} = D_{B0} \) and that \( Y \) is the same for Teams A and B.

We then have that:
\[
[D_{A0} - D_{A1}] - [D_{B0} - D_{B1}] = [D_{A0} * Y + P_{A0} * Y - D_{A0}] - [D_{B0} * Y + P_{B0} * Y - D_{B0}] = [D_{A0} * Y + P_{A0} * Y - D_{A0}] - [D_{A0} * Y + P_{B0} * Y - D_{A0}] = P_{A0} * Y - P_{B0} * Y = Y *(P_{A0} - P_{B0}).
\]

Since \( P_{A0} < P_{B0} \), the difference is \( < 0 \). This means that \( [D_{A0} - D_{A1}] \) is less than \( [D_{B0} - D_{B1}] \). We consequently reduce the time (total calendar weeks) more when adding one resource and increasing the productivity of Team B.

**Scenario 2a: Give Team A or Team B extra tasks that decrease the productivity**

Assumptions:
\( Y = Y_{A1} = Y_{B1} \) (The productivity change is the same for Teams A and B)

\( Y < 1 \) (There is a productivity decrease)
\[ O_{A1} = O_{A0} = O_{B1} = O_{B0} \] (Team A and Team B deliver the same amount of required output, and the required output is the same for the initial and changed situation)

\[ P_{A0} < P_{B0} \] (Team B has higher initial productivity than Team A)

\[ D_{A0} = D_{A0} \] (Team A and Team B have the same initial delivery speed)

\[ P_{A1} = Y \cdot P_{A0} \] (Team A’s productivity after given the productivity-decreasing extra tasks)

\[ P_{B1} = Y \cdot P_{B0} \] (Team B’s productivity after given the productivity-decreasing extra tasks)

\[ D_{A1} = D_{A0} \cdot Y \] (Team A’s delivery speed after given the productivity-decreasing extra tasks)

\[ D_{B1} = D_{B0} \cdot Y \] (Team B’s delivery speed after given the productivity-decreasing extra tasks)

Effect of a decrease in productivity \((Y < 1)\) on increase in input required for Team A and Team B:

\[
\frac{I_{A0} - I_{A1}}{I_{B0} - I_{B1}} = \frac{[O_{A0} \cdot (Y - 1) \cdot Y \cdot P_{A0}] / [O_{B0} \cdot (Y - 1) \cdot Y \cdot P_{B0}]}{[O_{A0} \cdot (Y - 1) \cdot Y \cdot P_{A0}] / [O_{A0} \cdot (Y - 1) \cdot Y \cdot P_{B0}]} = \frac{[1 / P_{A0}] / [1 / P_{B0}]}{P_{B0} / P_{A0}} = \frac{P_{B0}}{P_{A0}} \] (same formula as in Scenario 1)

Since \(P_{A0} < P_{B0}\), the ratio is > 1. This means that the \([I_{A0} - I_{A1}]\) is larger than \([I_{B0} - I_{B1}]\) and that we minimize the increase in input (added total work-hours) when giving the extra tasks to Team B.

Effect of a decrease in productivity \((Y < 1)\) on increase in time required for Team A and Team B:

We know that \(D_{A1} - D_{A0} = D_{A0} \cdot Y - D_{A0}\) and \(D_{B1} - D_{B0} = D_{B0} \cdot Y - D_{B0}\).

We know that \(D_{A0} = D_{B0}\) and that \(Y\) is the same for Teams A and B.

We then have that:
\[
[D_{A0} - D_{A1}] - [D_{B0} - D_{B1}] = [D_{A0} \cdot Y - D_{A0}] - [D_{B0} \cdot Y - D_{B0}] = [D_{A0} \cdot Y - D_{A0}] - [D_{A0} \cdot Y - D_{A0}] = 0.
\]

There is consequently no difference in the added time (added calendar weeks) dependent on whether we give the extra tasks to Team A or Team B. [The only difference in the similar productivity increase condition comes from the added person!]
Scenario 2b: Give Team A or Team B extra tasks that decrease the productivity

Changed assumptions compared to Scenario 2a:
\[ O = O_{A0} + O_{B1} = O_{A1} + O_{B0} \] (There is a fixed output (O), but how much output created by Team A and Team B is not fixed and will depend on whom we give the extra tasks to)
\[ T = T_A = T_B \] (The teams will finish at the same time)
\[ O_{A1} = D_{A1} \cdot T = D_{A0} \cdot Y \cdot T \] (The output of Team A after we give the extra tasks to it)
\[ O_{B1} = D_{B1} \cdot T = D_{B0} \cdot Y \cdot T \] (The output of Team B after we give the extra tasks to it)

We want to find out whether the time spent to complete the project (T) is lower, the same or higher when Team A or Team B is given the extra tasks. In this case, an increase in time (since both teams finish at same time) equals an increase in use of effort.

We compare the two situations below:
Reduce Team A’s productivity (using the time \( T_{\text{DisturbA}} \)):
\[ O = (O_{A1} + O_{B0}) = (D_{A0} \cdot Y + D_{B0}) \cdot T_{\text{DisturbA}} \]
Reduce Team B’s productivity (using the time \( T_{\text{DisturbB}} \)):
\[ O = (O_{A0} + O_{B1}) = (D_{A0} + D_{B0} \cdot Y) \cdot T_{\text{DisturbB}} \]

This gives (using the assumption that the total output (O) is fixed) that:
\[ (D_{A0} \cdot Y + D_{B0}) \cdot T_{\text{DisturbA}} = (D_{A0} + D_{B0} \cdot Y) \cdot T_{\text{DisturbB}} \]

which is equivalent with that (for \( D_{A0} = D_{B0} \)):
\[ T_{\text{DisturbB}} / T_{\text{DisturbA}} = (D_{A0} \cdot Y + D_{B0}) / (D_{A0} + D_{B0} \cdot Y) = (D_{A0} \cdot Y + D_{A0}) / (D_{A0} + D_{A0} \cdot Y) = 1 \]

This means that it does not matter whether we disturb (reduce the productivity of) Team A or Team B by giving them extra tasks regarding the use of time. Not impacting the time also means that it does not matter in terms of total input spent.