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# eCOLLABORATION AND PRODUCTIVITY

Katarina Stanoevska-Slabeva<sup>1</sup>

## **Abstract**

*Companies are increasingly employing various forms of eCollaboration. Despite its growing importance, there is little research on the impact of eCollaboration. This paper presents the results of an empirical survey of the usage of eCollaboration tools and their impact on productivity. Findings indicate that usage of eCollaboration has positive impact on productivity. No correlation was discovered however among eCollaboration and travelling.*

## **1. Introduction and Motivation**

Since the beginning of the 21<sup>st</sup> century, eCollaboration has become an increasingly common phenomenon in our global economy. In general, eCollaboration refers to any kind of collaboration situation, where collaboration is partly or fully enabled or supported by specific information and communication technologies. Driven by market globalization, networked organizations, and employee mobility, eCollaboration is rapidly gaining importance in companies worldwide. A variety of different eCollaboration forms can be observed, ranging from loose collaboration initiated in an ad-hoc manner, to well structured and targeted virtual teams that collaborate on a global scale. Despite its growing importance, there is little research on the impact of eCollaboration. The research presented in this paper provides a contribution in this context by pursuing the following research question: "*What is the impact of eCollaboration technology on productivity of employees involved in eCollaboration?*"

Quantitative research was applied to answer the research question. An online survey was applied to assess the felt productivity of participants in international research projects. 112 participants completed the questionnaire. The results revealed that usage of eCollaboration has positive impact on productivity by decreasing time to reach decisions in virtual settings, by diminishing of asymmetries among project participants, and by reducing unproductive time. No correlation was discovered among usage of eCollaboration tools and travelling.

The content of the paper is structured as follows: Section 2 provides an overview of the state-of-the-art; section 3 contains a description of the research approach, section 4 describes the survey results; section 5 summarizes the results from hypotheses testing, and section 6 provides a conclusion.

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## 2. Overview State-of-the-art

The increased importance of eCollaboration has driven much research from a technical perspective regarding the development of various kinds of collaboration tools (see for example [20]). There is, furthermore, a considerable body of research related to the implementation of eCollaboration in organizations and the impact of eCollaboration on organizational structures [17]. In addition, the factors affecting the acceptance of eCollaboration technology have been investigated as well [20].

The usage of eCollaboration technology in organizations has a long tradition and can be considered as a mature technology that according to Gartner [9] is entering the "plateau of productivity". However, less is known about its impact. The goal of the research presented in this paper is to provide a contribution regarding the impact of eCollaboration technology by analyzing the impact of eCollaboration on productivity of virtual teams involved in international European projects.

Some body of research is available on the impact of eCollaboration based on case studies. Several published case studies show that collaboration technology might have positive effects on productivity (see for example [4]), [21], [13], [14] and [3]). However, it is difficult to generalize the findings from the case studies as they were conducted independent of each other with different focus (see also [7]). Only few studies have analyzed the impact of eCollaboration based on quantitative research. For example [11], [12] have analyzed the impact of eCollaboration on productivity within supply chains. A basic finding of their research is that the level of efficiency is higher for eCollaboration tools that support operational rather than strategic activities. Lefebvre et al. [12] furthermore found out that the overall impact of eCollaboration is positive but not strongly related to cost reduction.

Other research that is relevant to the research question in this paper is of more general nature and considers the impact of information and communication technology on productivity. An important aspect related to impact of ICT on productivity is the so called "IT productivity paradox". This term is attributed to the economist Robert Solow [15]. Solow observed earlier, "...*that computers are everywhere except in the productivity data*" [15]. During the 80s and 90s many studies showed that investments in ICT had negative or zero impact on productivity growth. An analysis of the reason for this paradox revealed three explanations [15]: 1) Some benefits of ICT in particular in the service sector have not been recorded at that time; 2) Benefits of ICT take considerable time to emerge due to long adoption cycles and need for business process redesign; 3) Many early studies were based on a relatively small sample of companies.

New studies show that, the use of ICT is positively linked to performance of companies [15]. However not all companies benefit equally from investments in ICT. Powell & Dent-Micallef [18] have analyzed the reasons why ICT investments in some companies result in productivity improvement and in some they do not provide the expected results. They proved that there is significant interdependence of ICT and the existing human, business and technology resources of a company. ICT investments result in productivity increase only if they are aligned to the company strategy as well as integrated with complementary human and business resources of a company.

To summarize, there is indication by previous research that usage eCollaboration has a positive effect on productivity, but it has not been assessed broadly yet [8], [19].

### 3. Research Approach

Given the goal of the research presented here, the following research approach has been applied: 1) definition of terms, 2) identification and selection of units of observation; 3) operationalization of the construct, survey design and hypothesis building; and 4) analysis of the results. In the remaining part of this section first the major phenomena under consideration are defined and operationalized for the empirical research. The results of the survey are presented in section 4.

*Definition of Terms:* The main phenomena considered in the research presented in this paper that need to be defined are: eCollaboration, eCollaboration tools and productivity.

- *Definition of eCollaboration:* eCollaboration is defined with different scope by different authors. While [9] for example states that "*Collaboration is about people working together.*" [1] provides an overview of definitions that are indifferent whether the parties who work together are people, groups or organizations or even machines. In this paper the focus lies on eCollaboration among human participants. Given this eCollaboration will be defined in accordance to [10], as "*...collaboration among individuals engaged in a common task using electronic technologies.*". The collaborating individuals considered in this research are at different locations.
- *Definition of eCollaboration Tools:* There are various different terms for denoting collaboration technologies in literature. For example group support systems (GSS) [6], collaborative computing [1], E-Collaboration [2]. According to [2] typical functionalities of collaboration systems are:
  - Communication functionalities: bulletin boards, discussion, e-mail, online paging/messaging, chat, whiteboard and audio/video conferencing.
  - Coordination or process structuring (see also [22]) functionalities: task lists, project management, contact management, meeting scheduling tools, meeting minutes/records, support for specific workflow and similar.
  - Collaboration functionalities: screen and application sharing, surveys/pooling, files and document sharing, document and knowledge management.

In this study the term eCollaboration tools will be used to denote tools that support communication, coordination and collaboration of individuals in specific collaboration settings. In accordance with [2] and [16] the available tool for support of eCollaboration can be divided in three groups: 1) Communication tools that basically support the communication as part of collaboration; 2) Coordination tools that provide support mainly for coordination activities within collaboration; 3) Collaboration tools that support extensive support for complex collaboration activities.

- *Definition of Productivity:* "Productivity" describes in general the relation between an effort ("input") and the benefit resulting from this effort ("output"):

$$\text{Productivity} = \frac{\text{Output}}{\text{Input}}$$

The output and input are task and process specific. As a consequence also the measurement of productivity is task specific and is defined by task or process specific definition of the categories "Output" and "Input". In general research questions regarding the impact of eCollaboration on productivity can be operationalized as follows:

- Does eCollaboration result in increased output per involved employee?
- Does eCollaboration decrease the necessary input (for example, time or other resources) to achieve a defined result?

- *Units of Observation:* In order to be able to analyze the impact of the usage of eCollaboration tools on productivity, a fairly large population of employees involved in intensive eCollaboration was necessary. Such a population was identified in the participants of international European research projects. The European commission is funding in so called "Research Frameworks" international cooperative research projects that are carried out by international consortia of cooperating companies and universities. International cooperative research projects have a minimum duration of one year and involve intensive eCollaboration among the consortium partners scattered around different locations in Europe. European cooperation projects and participants in European projects are considered suitable units of observation because of the following characteristics:
  - European projects are international cooperation projects. According to the rules companies from at least two European countries need to be involved in a project, in order to have a valid consortium. The resulting collaboration settings are dispersed over several locations, involve several European nationalities and disciplines and eCollaboration is an important part of projects.
  - The goal of the European projects is collaborative research and development. Productivity is therefore an important goal of eCollaboration as well.

Given the above characteristics of European projects and their participants, they can be considered as suitable units of analysis for empirical investigation of the impact of eCollaboration tools on productivity. Such projects are listed in the online CORDIS database ([www.cordis.org](http://www.cordis.org)). 150 project teams of the projects listed there were randomly selected and invited to participate in the survey.

*Survey Design:* In order to design the survey questionnaire the general terms defined in section 2.1 to 2.4 needed to be operationalized for the specific settings of European research projects.

- *Operationalisation of the Construct "Usage of eCollaboration Tools":* Based on the definition for eCollaboration tools provided above, the identified eCollaboration tools have been classified in three categories: communication, coordination, collaboration. For denoting the usage intensity of collaboration tools during collaboration five different stages were chosen: 0-20%, 20-40%, 40-60%, 60-80%. 80-100%.
- *Operationalization of the Construct "Impact on Productivity":* As mentioned above, productivity can be improved either by increasing the output per time unit or decreasing the cost for producing it. Given the fact that international European research projects have different goals, it was not possible to operationalize the impact on productivity by operationalizing the category "Output". Thus, the impact on productivity was basically measured based on the impact on the category "Input". A positive impact on productivity is present, if fewer resources need to be involved in order to achieve the same result. Based on this and in accordance of the empirical studies of [12] the following constructs were defined:
  - The quality of the decisions and technical discussion with your colleagues were better when supported by eCollaboration tools.
  - The information asymmetry (deficit of information) in the team regarding available knowledge and persons was reduced by using eCollaboration tools.
  - The time to reach decisions decreased in eCollaboration settings.
  - Less travel was required due to usage of eCollaboration technology.
  - eCollaboration technology providing support for document and knowledge management reduces unproductive time as for example searching for persons and information.

*Hypotheses Building:* Based on the findings of the state-of-the-art in section 2 and the specific operationalization of the constructs under consideration of the specific setting of international European projects the following general hypotheses were defined:

- *H1:* There is positive correlation among usage of eCollaboration tools and the quality of the decisions and technical discussions.
- *H2:* Usage of eCollaboration tools is positive correlated with productivity of eCollaboration by diminishing information asymmetries.
- *H3:* Usage of eCollaboration tools is positive correlated with productivity of eCollaboration by decreasing time to reach decisions.
- *H4:* Usage of eCollaboration tools is positively correlated with productivity of eCollaboration by diminishing cost for travelling.
- *H5:* Usage of eCollaboration tools is positively correlated with the productivity of eCollaborating individuals due to reducing unproductive time.

#### **4. Survey Results**

*Demography of Survey Participants:* The questionnaire was sent to participants of 150 randomly selected projects from the online CORDIS project database. Participants from 33 projects participated in the survey. In total 227 participants accessed the online questionnaire and 112 filled in the questionnaire completely. The participants in the survey were between 23 and 63 years old. They were located in 20 different European countries. 66.1% of the participants had more than 5 years of experience in eCollaboration.

*Results Related to Usage of Communication Tools:* The usage of various eCommunication tools for collaboration was surprisingly low. The most applied tool is e-mail. No one of the participants has declared to be a non user of e-mail. The remaining communication tools are used by a lower number of respondents:

- 40.6% of users do not use instant messaging, only about 15 participants use it more than 60%
- 74.7% do not use electronic whiteboard, only 6 participant use it between 40 and 60%.
- 73.5% do not use electronic bulletin boards; only 3 participants use it between 40- 60%.
- 42.3% do not use forums, 34% use it up to 20% of the time, while only 7 participants use it more than 60% of the time
- 71.4% do not use video conferencing at all, and 3 persons use it more than 60% of the time
- 14.7% do not use teleconferencing at all
- 44.6% do not use Skype at all.

In general it can be concluded that there is significant usage of e-mail while the usage of all other communication tools is marginal.

*Usage of Coordination Tools:* Most of the coordination tools show a marginal usage: shared calendar, routing and workflow, user directory and workflow support are not used at all respectively by 53.47 %, 61.62% , 49.00% and 69.00% of the respondents. The only type of coordination tool that showed a higher usage is meeting coordination. There are still 29.41% of non users of coordination tools, but at the same time also 38.83% users that use it up to 40% of their collaboration time. From the different kind of coordination tools, only tools for meeting coordination show a higher usage. All other tools are only insignificantly used by participants.

*Usage of Collaboration Tools:* From the collaboration tools listed in the online survey, the highest usage was reported for:

- Document management systems with 25.0% non users and 23% that use it more than 60% of their time.
- Collaboration portals are used by 66.66% of participants and 12,12% use it from 80-100% of their collaboration time.
- Wikis seems to be increasingly adopted by respondents, as only 36.3% do not use it at all and 19 participants use it even more than 60% of their time.
- Blogs and social bookmarking are less popular for project work, as 76.5% and respectively 85.4 of the participants do not use them at all.
- Co-authoring tools are used by to a certain extent by 81.8% of the participants.

The above findings show that specifically dedicated collaboration tools that provide a more integrated support for collaboration show a higher usage. Emerging tools resulting from Web 2.0 developments are starting to be used. From all Web 2.0 tools, the highest value was reported for Wikis. This reflects also the better suitability of Wikis for project work. Blogs are used less, while all other Web 2.0 tools show marginal usage by a very low number of participants. Interesting is that tools supporting classification as taxonomies or social bookmarking have also marginal usage.

*Summary of Findings Regarding Collaboration Tools:* The above results regarding usage of collaboration tools show that: With respect to *communication tools* the most used tool is still e-mail. Even though some respondents also use other *communication tools*, their usage is marginal. *Coordination tools* are not broadly used as well. Some usage can be observed for shared calendar as well as routing and notification support. The category of collaboration tools comprises tools that offer a more integrated support as for example document management tools, collaboration portals or Wikis. These tools are used by a higher number of users and also with higher intensity than the other tools.

In general, tools that offer integrated support show higher usage and intensity of usage. The more routine activities are handled manually, the less the positive effects of collaboration tools can be experienced. The preferences to integrated tools might also result from the specific nature of European projects. These projects are set up for a certain limited period of time. This means that very soon after the start of the project a common environment has to be set up. In many cases then an environment is chosen that offers most of the needed functionalities and is available to the consortium. Tools that offer single functionality might be preferred less, as at the current stage of technology development, it is not easy possible to link them into a common environment. The results also show that none of the tools for which a certain level of usage was reported, are used 100% of the time. Most of them are used about 20% of the time. This means that participants are switching among collaboration and non-collaboration mode. The non-collaboration mode is probably used for preparing individual contributions to the team. The switch between collaboration and individual time has to be supported in a way that it allows smooth transition between eCollaboration and individual work.

*Summary of Findings Regarding Impact on Productivity:* In general the survey respondents reported to have experienced a positive effect of eCollaboration on productivity. The following percentage of respondents either "Strongly Agree" or "Agree" that: a) eCollaboration diminishes unproductive time: 79%; b) eCollaboration has a positive effect on travelling: 76.23%; c) eCollaboration decisions with better quality are made: 64.65%; d) eCollaboration has positive impact on information asymmetry: 64.36; e) less time is needed for reaching decisions: 47%.

## 5. Results from Hypotheses Testing

The process of hypothesis testing followed the following procedure: 1) First the data sets, where any kind of usage of eCollaboration tools was reported, were identified. 2) Then an overall analysis of correlations among eCollaboration tools and impact on productivity was performed. 3) The initial general hypotheses given in section 3 were adjusted for the specific tool, for which a significant correlation to impact of productivity was identified. The hypotheses were then tested. 4) Finally, a complete analysis for the category of integrated tools was performed, because these tools were reported to be used most frequently.

*Testing of Hypothesis 1:* The initial correlation analysis revealed that there is a significant positive correlation among "Usage of shared calendar", "Usage of routing and notification function" and "Usage of workflow support" (see table 1 below). Thus, hypotheses 1 was adjusted towards more specific hypotheses as follows: Shared calendar, usage of routing and notification functionality, and workflow support have a significant positive correlation with the quality of decisions made.

Table 1: Correlation among coordination tools and impact on productivity

				Correlations				
				v_97 Shared Calendar	v_98 Meeting Coordination	v_99 Routing and Notification	v_100 User Directory	v_101 Workflow support
Spearman's rho	v_122 Quality of decisions	Correlation Coefficient		.473*	.024	.490*	.002	.578*
		Sig. (2-tailed)		.030	.884	.033	.991	.049
		N		21	41	19	23	12
v_123 Information asymmetry	v_123 Information asymmetry	Correlation Coefficient		.264	.001	.558*	.226	.371
		Sig. (2-tailed)		.276	.994	.020	.311	.262
		N		19	37	17	22	11
v_124 Time	v_124 Time	Correlation Coefficient		.250	-.059	.549	.221	.247
		Sig. (2-tailed)		.368	.746	.052	.377	.555
		N		15	33	13	18	8
v_125 Less travel	v_125 Less travel	Correlation Coefficient		.175	.189	.255	-.209	.324
		Sig. (2-tailed)		.448	.231	.264	.350	.280
		N		21	42	21	22	13
v_126 Unproductive Time	v_126 Unproductive Time	Correlation Coefficient		.205	-.008	.152	.120	-.050
		Sig. (2-tailed)		.361	.957	.501	.551	.859
		N		22	43	22	27	15

\*. Correlation is significant at the 0.05 level (2-tailed).

All the hypotheses were supported by the data as all rs, that means the observed Spearman's rank correlation were not in the rejection reason. All three types of eCollaboration technologies actually provide support for routine activities and lessen the burden of coordination overhead in eCollaboration. As a result more time is available for discussion and decision making.

*Testing of Hypotheses 2:* With respect to the variable "Diminishing of information asymmetry" positive correlation was observed only for tools providing routing and notification functionality (see table 4). Thus, H2 was tested in the following form: "Usage of routing and notification functionality has a significant positive correlation with the variable "Diminishing of information asymmetries". The hypotheses was supported by the data.

*Testing of Hypotheses 3:* A significant positive correlation was observed among Wikis and "Time necessary to make decisions". The adjusted hypotheses, that "Usage of Wikis is positively correlated with time necessary to make decision" was supported by the data. This finding is in line with the core functionality of Wikis to support convergence of opinions and knowledge.



*Testing of Hypotheses 4:* Interesting is that H4 was not supported by the data for any of the tools. For all tools and for each category of tools separately there was no significant correlation among usage of eCollaboration tools and diminishing of the need and costs for travel. This finding contradicts the expectation that eCollaboration would reduce the need for travel within dispersed teams. However, it conforms the findings from qualitative research and case studies that face-to-face meetings have an important role in eCollaboration [21]. Independent of the usage of eCollaboration and the ICT support for eCollaboration, face-to-face meetings are scheduled on a regular basis. Thus, the productivity gains of eCollaboration need to be achieved in other areas.

*Testing of Hypotheses 5:* The hypothesis 5 was tested for all tools and each tool separately. Strong correlation was observed and the hypothesis was confirmed that there is positive impact of usage of document management tools and impact on diminishing unproductive time.

*Testing of the Impact of Document Management Tools:* The eCollaboration tools for which the highest usage was reported are document management tools as document management systems, Wikis, Blogs and eCollaboration portals. The correlation to the variables related to productivity is given in table 2 below.

Table 2: Correlation among document management tools and impact on productivity

				Correlations				
				v_122 Quality of decisions	v_123 Information asymmetry	v_124 Time	v_125 Less travel	v_126 Unproductive Time
Spearman's rho	v_108 Document Management System	Correlation Coefficient		.338**	.122	.067	.176	.281**
		Sig. (2-tailed)		.001	.229	.514	.081	.005
		N		97	99	98	99	98
v_109 Wiki	Correlation Coefficient		.110	.069	.017	-.104	.023	
	Sig. (2-tailed)		.278	.492	.869	.301	.823	
	N		99	101	100	101	100	
v_110 Blog	Correlation Coefficient		.077	-.127	-.003	-.035	.147	
	Sig. (2-tailed)		.460	.214	.978	.736	.153	
	N		95	97	96	97	96	
v_115 Collaboration Portals (i.e. BSCW, Marattech, Google Groups, etc.) comprising	Correlation Coefficient		.192	.007	-.038	.205*	.206*	
	Sig. (2-tailed)		.061	.943	.712	.042	.043	
	N		96	98	97	98	97	

\*. Correlation is significant at the 0.05 level (2-tailed).

\*\*. Correlation is significant at the 0.01 level (2-tailed).

The analysis taking in consideration all tools together, was based on the following hypotheses:

*H6:* The usage of eCollaboration tools providing support for document management (including automatic search, classification and similar) is positively correlated with the productivity on participants in eCollaboration.

First a factor analysis for the most used collaboration tools providing support for document management and for the productivity variables was calculated. The subsequent correlation analysis is presented in table 3 below.

Table 3: Correlation matrix among factors for document management and productivity

		FAC1_3 Document Management Systems	FAC1_4 Productivity
FAC1_3 Document Management Systems	Pearson Correlation Sig. (2-tailed) N		
FAC1_4 Productivity	Pearson Correlation Sig. (2-tailed) N	.319** .002 94	

\*\* . Correlation is significant at the 0.01 level (2-tailed).

The critical value  $r_{p, 0,05}$  is 0.197 and  $r_{p, 0,01}$  is 0.256. The observed  $r_p = 0.319$ , which means that the observed Pear's rank correlation coefficient ( $r_p$ ) is in the rejecting region for the null hypotheses at the significance level 0.01 ( $r_p \geq r_{p,0,01} \rightarrow 0,319 \geq 0,256$ ) and significance level 0.05 ( $r_p \geq r_{p,0,05} \rightarrow 0,319 \geq 0,197$ ).

The null hypothesis that there is no correlation has to be rejected on the 0.01 significance level. Hence, the data supports the hypotheses that collaboration tools providing support for document management have a positive impact on productivity.

## 6. Conclusion

The paper presented the results of an empirical analysis of impact of the usage of eCollaboration tools on the productivity of involved employees. The unit of observation was international European cooperative research projects. The analysis revealed that the usage of document management systems as integrated solutions for collaboration support has a significant correlation with productivity. No correlation was detected in relation to diminishing of travelling time. These results confirm the findings of Lefevbre et al. [12] that no direct correlation among usage of eCollaboration tools to cost can be detected. Participants experience the main value from eCollaboration tools in the support with routine tasks that help to provide more time for the collaboration activities. As a result less time is needed to make decisions and also the quality of decisions improves. The above findings point furthermore out that the focus of the usage of eCollaboration tools has to be on support for routine activities and smooth integration with individual activities and tools. The presented research has several limitations: The evaluation was performed on project level by an anonymous online survey that was sent to project participants. The answers of the participants reflect the felt experiences of individuals with respect to eCollaboration and its impact. This means that only subjective measures are taken in consideration.

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