How to Measure Impacts of Work Environment Changes on Knowledge Work Productivity – Validation and Improvement of the SmartWoW Tool

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Abstract

Purpose – Measuring productivity in changing environment is a challenging task for most of the organizations. However, it is very important for managers to measure how the changes in work environment impact on knowledge work productivity. SmartWoW is proving to be a useful tool for this type of productivity measurement, and organizations are using it to make changes in the work environment. As organisations become more interested in its uses, studies with more accurate results are needed. The purpose of this paper is to validate and improve the use of the SmartWoW tool.

Method – The SmartWoW tool was used in nine organizations, which formulate the research data. Convergent validity, divergent validity and reliability are tested with SPSS and AMOS. Both exploratory and confirmatory factor analyses are applied.

Findings – The SmartWoW tool structure was found to be valid. It follows the structure described in previous literature, with slight changes in two dimensions. Four variables were added to increase tool consistency, and their wording was harmonized.

Practical implications – SmartWoW is useful for evaluating an organization's current work environment and practices, as well as for measuring the effects of work environment changes. This study's results also suggest SmartWoW would be useful for research by, for example, evaluating how dimensions affect each other.

Originality – This study provides a better understanding of the unique features and uses of SmartWoW. The findings not only validate through statistical analysis the tool's structure, but also improve it and offer a broader scope of its uses.

Keywords – Knowledge work, measurement, validation, productivity, work environment

Paper type – Research paper

1 Introduction

Increasing competition and a constant need to increase productivity are concerns for organizations, government and media. Recently, knowledge work productivity has improved by using the New Ways of Working (NewWoW) concept and changing work environments (Gorgievski et al., 2010; Van Meel, 2011). The idea involves giving the knowledge worker more responsibility for how work is done, while management focuses on results; thus, the knowledge worker has more autonomy and flexibility to choose how, when and where the results are created (Van der Voordt, 2004; Van Meel, 2011). This solution is fairly topical as the level of information and communications technology has reached certain heights in many organizations. Flexible working requires that all workers have mobile tools that easily facilitate access to their organization's information systems, regardless of location (Ruostela et al., 2014; Van der Voordt, 2004). Use of NewWoW could make massive changes in organizations, covering the entire work environment (physical spaces, technology and management practices). Organisations are willing to start these changes as they get direct benefits in decreased occupancy costs (Ruostela et al., 2014) and, at least in theory, more satisfied and productive workers (Kattenbach et al., 2010). Assessing the last, however, is still somewhat unclear because the measurement of the effects of work environment changes against knowledge work productivity is challenging (Drucker, 1999; Laihonen et al., 2012).

Drucker (1999) has even announced that knowledge worker productivity is the biggest challenge for the modern work life. Other researchers have also discovered that the productivity of an individual knowledge worker is the most important factor for good organizational performance (e.g. Miles, 2005; Groen et al., 2012). Thus, knowledge work productivity is one essential element of work performance, including also the elements of work environment and personal work practices and well-being (e.g. Bosch-Sijtsema et al., 2009; Ruostela & Lönnqvist, 2013; Palvalin et al., 2015). To manage this important resource, it must first be accurately measured (Drucker, 1999). Knowledge work productivity measurement is not a very well-studied topic in the literature (Takala et al., 2006), but some models exist (e.g. Ramirez & Nembhard, 2004; Laihonen et al., 2012; Takala et al., 2006). Most of the existing measures are based on knowledge worker subjective evaluations which, while having limitations, have proved to be useful in the knowledge work context due to various intangible aspects which are difficult to measure otherwise (Jääskeläinen & Laihonen, 2013; Koopmans et al., 2013; Palvalin et al., 2013). Palvalin et al. (2015) have presented one solution for this challenge: the SmartWoW tool seems to be a promising method for measuring knowledge work performance within a changing work environment. Construct is introduced in section 2.1 and more precisely in Palvalin et al. (2015). The purpose of this study is to test the tool and to improve it. SmartWoW was easily accepted in organisations planning work environment changes, and currently nine organizations have used it to measure the current state of knowledge work performance and assess the potential areas for change. Most of the organizations have already committed to use SmartWoW again within a year after they have made changes in work environment and practices.

Palvalin et al. (2015) have already found that the tool has practical value, and current interest seems to confirm that. The study conducted by Palvalin et al. (2015) is limited in a couple of ways. First, the sample is quite small, and second, the construct is not statistically validated. To address these limitations, this study intends to gather a larger sample and statistically validate the SmartWoW tool. Validation is important for two reasons. First, it confirms the sound structure of the tool; second, validation reveals if the tool measures what it is supposed to measure. Validation also enables improvements to the tool based on the results. After validation, it is also possible to create sum variables based on the construct categories, which will increase the scientific and practical value of the tool. Finally, validation opens up possibilities for the use of SmartWoW in future research with different types of data analyses.

This paper is organized in the following structure: Previous literature and the SmartWoW tool are presented in Section 2. Section 3 describes the methods, including a more detailed description of the sample. Section 4 presents the results of the study, which are then discussed in Section 5. The paper closes with a short conclusion about the study's contribution to this field of knowledge.

2 Theoretical background

2.1 SmartWoW construct

The SmartWoW tool (Palvalin et al., 2015) consists of 53 items, where 4 are open-ended and 49 use the five-point Likert scale (Appendix 1), ranging from 1 (disagree) to 5 (agree). The SmartWoW tool covers six dimensions of knowledge work performance divided into drivers and results & outcomes (see Figure 1). On the other hand, the construct can be also divided into the knowledge worker itself who is doing the work and the work environment where the work is done. According to Palvalin et al. (2015) the purpose was to keep tool as light as possible that respondents would be more willing to respond so all the dimensions have only seven to ten items. The following briefly explains the construct.

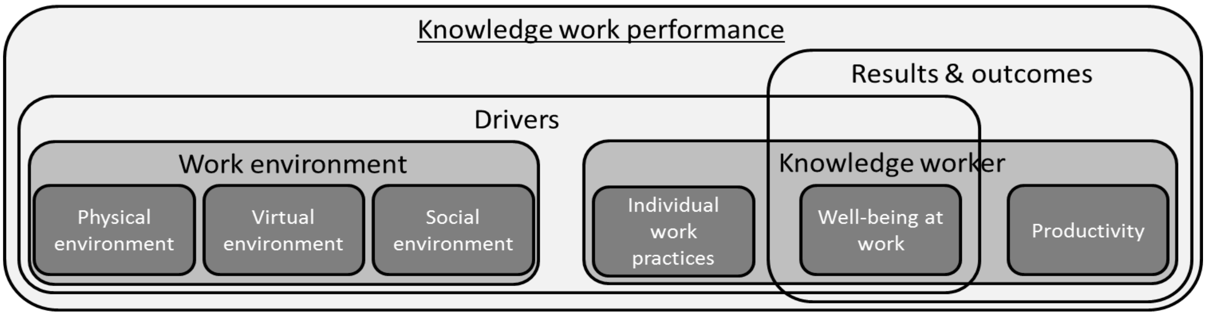
Work environment is divided into three dimensions, according to Bosch-Sijtsema et al. (2009) and Vartiainen (2007): the physical environment, the virtual environment and the social environment. *Physical environment* includes organization facilities and work spaces and should support work by offering the best facilities for different tasks, for instance, collaboration and concentration (e.g. Heerwagen et al., 2004; Halpern, 2005). It is important to have enough spaces for meetings and informal discussion that can be used based on activity (Maarleveld et al., 2009). *Virtual environment* includes computers, smartphones and software that a knowledge worker needs to be able to work efficiently (Vartiainen & Hyrkkänen, 2010). Technology plays a major role in increasing knowledge workers' mobility and flexibility; it allows them to be connected with customers and co-workers from distant locations (O'Neil, 2010). *Social environment* includes everything from the management to organization atmosphere (Bosch-Sijtsema et al., 2009). An effective knowledge worker needs to have clear goals and the ability to perform the work flexibly in time and space (Drucker, 1999; Origo & Pagini, 2008; Kelly et al., 2011). Organization transparency, good information flow, clear policies conveyed through meetings, and an innovative climate are also an important part of the social environment (Drucker, 1999; Wännström et al., 2009).

While the work environment defines the frame for working, the fourth dimension, *individual work practices,* shows whether the worker takes advantage of the frame provided (Ruostela & Lönnqvist, 2013; Koopmans et al., 2013). Quiet spaces and virtual negotiation is not a benefit unless the worker utilizes them to support the work. Individual work practices, which include self-management, setting personal goals, prioritizing important tasks and planning, impact work outcomes (Claessens et al., 2004; Kearns and Gardiner, 2007).

The fifth dimension, *well-being at work*, includes all the topics that are typically measured in work satisfaction surveys, but in a compact form. Job satisfaction, work engagement, appreciation, work-life balance and atmosphere are all important for the knowledge worker's well-being (Bakker &

Demerouti, 2008). Well-being at work has a dual role in this model: it operates as a result of work environment drivers (e.g. Kelly et al., 2011; Halpern, 2005), but at the same time, it is itself a driver for productivity (e.g. Wright & Cropanzano, 2000; Schaufeli & Salanova, 2007). The sixth dimension, *Productivity,* is the only complete result dimension in this model. It includes items from two dimensions of productivity, quantity and quality, e.g. work efficiency and effectiveness, achieving goals, customer satisfaction and quality of work are important indicators for knowledge worker productivity (e.g. Ramirez & Nembhard, 2004; Ramirez & Steudel, 2008; Palvalin et al., 2013). Figure 1 summarizes the theoretical framework for knowledge work performance, presented by Palvalin et al. (2015).

Figure 1. SmartWoW framework for knowledge work performance.



2.2 Statistical validation, starting point for improvement

A typical step for construct development is statistical validation. The purpose of this is to prove that the tool is able to measure what it is supposed to and, more specifically, that the different dimensions do not measure the same things. Such validations are called convergent and divergent validity (Hair et al., 2006). Reliability is used to measure the internal consistency of the dimensions and illustrate the organization's current state (Bland and Altman, 1997). These approaches for construct validation and reliability are presented more precisely below.

Convergent validity refers to the degree of positive relationships among the components that make up the construct. If the construct has convergent validity, then there should be a strong correlation between the components. (Narver and Slater, 1990). Convergent validity can be determined in different ways, according to Ahire et al. (1996). The two extremes employ completely different instruments to determine convergent validity, or each item in the same instrument is viewed as different approaches in defining convergent validity. Hair et al. (2006) has a more practical approach to convergent validity. According to them, convergent validity is a condition that concerns what items are needed in a construct to fully represent the dimension in question. They suggest that factor loadings, composite reliability (CR) and average variance extracted (AVE) should be used to assess convergent validity. According to Fornell and Larcker (1981), construct convergent validity requires CR to be greater than AVE and AVE to be at least 0.50.

Discriminant validity of a construct is the difference between the items that are not theoretically similar (Sureshchandar et al., 2002). Different components in a construct need to measure different things, and this can be tested by using maximum shared variance (MSV), average shared variance (ASV) and average variance extracted (AVE). According to Chau (1997), the average variance extracted reflects the amount of variance that is captured by the construct, in relation to the amount of variance due to measurement error. Discriminant validity is achieved when the square root of the AVE is greater than its correlations with other constructs (Fornell and Larcker, 1981). According to Hair et al. (2006), differentiation of items is achieved when MSV and ASV are less than AVE.

Reliability is the measure of consistency of the construct, meaning that the instrument is capable of producing consistent results when the survey is used in two homogenous groups of respondents. Internal consistency can be used to evaluate the consistency of the responses for each item in the instrument. Bland and Altman (1997) suggest the Cronbach alpha analysis be used for the construct reliability test. Cronbach alpha is the same as CR and, according to Bland and Altman (1997), the alpha value over 0.8 is considered good for social science research.

3 Methods

3.1 Predevelopment

At the beginning of this study, the SmartWoW tool and the results of the construction of SmartWoW (Palvalin et al., 2015) research paper were analyzed in collaboration with one organization that was interested in using the tool. Palvalin et al. (2015) had reported Cronbach alphas for each dimension and feedback from organization representatives, which are presented in section 4.1. The results of the predevelopment caused slight changes in the SmartWoW tool, and those are presented in section 4.1. The rest of the research was conducted using the updated version of the SmartWoW tool.

3.2 Data

The data was collected in Finland in 2015 with nine organizations and 998 participants. Organizations were mainly from public or third sectors, but there were also some departments in private organizations. Data was collected using an online survey for the organization's own use and for scientific purposes. Almost all of these organizations were planning work environment changes, so they needed an overview of how their employees were experiencing the work environment, and their individual work practices, well-being and productivity. Organizations are also going to use their own results for measuring impacts of the upcoming changes. Participants were informed that the data will also be used for scientific purposes. Questionnaires were sent to participants in emails, and they typically had about two weeks' time to respond. Response rates varied from 33 % to 89 %.

Table 1. Respondents.

Sex	**n**	**%**
Female	602	60.3
Male	384	38.5
Missing	12	1.2
Age	**n**	**%**
<35	150	15.0
35-44	241	24.1
45-54	332	33.3
>54	265	26.6
Missing	10	1.0
Work space	**n**	**%**
Personal room	369	37.0

2-person room	147	14.7
3-6 person room	94	9.4
Open-plan office	205	20.5
Multiuse office	179	17.9
Missing	4	0.4

3.3 Exploratory factor analysis

Exploratory factor analysis (EFA) is a commonly used statistical analysis for exploring factor structure. The construct is based on previous literature, so it would have been possible to just see how it fits in CFA, but in this research EFA was used for the preliminary validation for the factorial structure. Using EFA without any limitations (factors with eigenvalues above 1.0) creates a base structure for the CFA. EFA is not limited by the theory, so it could reveal if there were some hidden connections between the items (Fabrigar et al., 1999). In EFA, the maximum likelihood was used with promax rotation in SPSS. Items with factor loadings less than 0.3 are considered dropped from the model. The accuracy of the EFA is evaluated using Kaiser-Meyer-Olkin test and Bartletss's test. EFA has some limitations; for example, items could load on more than one factor and items might correlate with each other even if it could be theoretically explained (Ahire et al., 1996). These limitations can be negated by using confirmatory factor analysis.

3.4 Confirmatory factor analysis

Confirmatory factor analysis (CFA) is reckoned as the best statistical analysis for testing a hypothesized factor structure (Byrne, 2001; Schumacker and Lomax, 1996). A total of 998 responses were analyzed using AMOS 20.0. Analysis was conducted by using Maximum Likelihood (ML) estimation method. The ML method makes a couple of assumptions for the data. First, the sample size needs to be at least 200 cases (West et al., 1995). This is easily fulfilled with our 998 respondents. Second, the scale of the observed variables needs to be continuous. Likert scale is not technically considered continuous, but according to Lubke and Muthen (2004), it can be used in CFA if other assumptions are met. Third, the distribution of the observed variables is a multivariate normal (West et al., 1995). Skewness and kurtosis were used to test normality; according to West et al. (1995), univariate skewness should be less than 2 and univariate kurtosis less than 7. According to Sposito et al. (1983), a good rule of thumb for kurtosis is that it should be below 2,200. Skewness and Kurtosis for each variable is listed in Appendix 1 and shows that the above conditions are met. This means that the data is distributed normally; therefore, all the assumptions of ML estimation are fulfilled.

3.5 Construct validity and reliability evaluation

In CFA, the following measures and critical values are considered for establishing validity and reliability. Composite reliability (CR), average variance extracted (AVE), maximum shared squared variance (MSV), and average shared squared variance (ASV). According to Fornell and Larcker (1981), the construct *convergent validity* requires CR to be greater than AVE and AVE to be at least 0.50. For the construct *discriminant validity,* or differentiation of items between, MSV and ASV should be less than AVE (Hair, 2006). *Reliability* of the measurement items could be tested using Cronbach alpha, which is the same as CR. According to Bland and Altman (1997), the alpha value over 0.8 is considered good for social science research.

4 Results

4.1 Predevelopment results

Palvalin et al. (2015) results point to a couple of issues in SmartWoW; the Cronbach alphas were not excellent on each of the dimensions (physical environment 0.77, virtual environment 0.69, social environment 0.86, individual work practices 0.73, well-being at work 0.88 and productivity 0.84). Some of the variables seemed to be too specific and needed generalization to work for different organisations. Some other variables were also quite difficult to understand and/or evaluate. To counter these issues, four new variables were added (6PE, 7PE, 14VE and 23SE), too specific variables were generalized (1IWP, 4IWP, 6IWP and 8IWP) and all the statements were reread, style was harmonized and more examples were added. Based on the results, changes were successful as Cronbach alphas increased (see Table 2, CR) and the collaborating organizations' representatives felt that the variables were good, with no negative feedback after the questionnaire was run in their organizations.

4.2 Data screening

Analysis started with data screening. First, respondents with missing values higher than 10%, i.e. more than 5 were deleted (7 respondents). Second, unengaged responses, i.e. responses with no variance were deleted (1 respondent). Confirmatory factor analysis with AMOS requires that there are no missing values; therefore, due to this all the missing values were replaced with a median. Variables and basic information is described in Appendix 1.

4.3 Exploratory factor analysis

EFA is tested before CFA to see how factors would naturally construct, and it can be used as a starting point for CFA. During EFA, seven variables (1IWP, 2IWP, 4IWP, 4WB, 6WB, 4P, 7P) were dropped because they did not suit theoretically to any factors, and loadings were low. Appendix 2 presents a pattern matrix for EFA. The results were very close to the framework. As a result of EFA, and based on eigenvalue, there are a total of 10 factors, which is four more than in the Figure 1 framework, but these four are formed because some framework dimensions were split into two different factors. This is the first important result for EFA, and is taken into account in CFA. Three variables (3PE, 10VE, 16SE) did not load into any factor over the limit of 0.3 thresholds. Those were still kept in as they are important theoretically. These need extra attention in CFA as they might cause problems in the model fit.

EFA included some exploration with using a fixed number of factors. This revealed that the three variables from well-being at work (5WB, 7WB, 8WB) loaded constantly into the same factor with social environment variables. This makes sense theoretically because those variables are close to social environment variables, which measure organizational atmosphere. This is the second important lesson from EFA that needs to be taken into account in CFA.

4.4 Confirmatory factor analysis

CFA is the main analysis in validation of SmartWoW tool. CFA was used after the EFA, and the results of EFA were a starting point for CFA. The first factor structure was based on the theoretical framework, and it was modified with the results of EFA. CFA processes included several iterations until the acceptable model fit was found. During the CFA, four variables (3PE, 4PE, 10VE, 16SE) were dropped as they did not load into any factor more than threshold 0,5. The final factor structure is presented in Appendix 3.

As a result, CFA variables loaded into factors as they were supposed to load, and 6 factors were found. All six dimension of the Figure 1 framework (physical environment, virtual environment, social environment, individual work practices, well-being at work and productivity) had its own factor. As EFA results indicated, three of the factors were second level, which consists of two, first level factors. First was virtual environment, which has variables divided into more device centric or electronic possibilities centric variables. Social environment also consists of two first level factors, management and atmosphere. Individual work practice was the third, second level factor and its first level factors were proactivity and utilization of electronic possibilities. CFA also confirms that a couple of well-being at work variables loaded more on the social environment atmosphere factor than the well-being at work factor.

Accuracy of CFA is tested with several indicators. Bentler (1990), McDonald (1990) and Mulaik et al., (1989) have suggested the following values for good model fit:

- x^2/df, chi square per degrees of freedom, below 5
- RMSE, root mean square error of approximation, below 0.08
- SRMR, standardized root mean square residual, below 0.08
- CFI, comparative fit index, above 0.90
- NFI, normed fit index, above 0.90
- TLI, Tucker-Lewis index, above 0.90

The model fit of the final CFA structure is presented in Table 2. Our model meets these criteria in x^2/df, RMSE, SRMR, and CFI. NFI (0.877) and TLI (0.898) are just below the threshold.

Table 2. Reliability coefficients, correlations among factors and model fit.

	Reliability coefficients				**Correlations**					
	CR	**AVE**	**MSV**	**ASV**	**PE**	**VE**	**SE**	**IWP**	**WB**	**P**
PE	0.852	0.539	0.291	0.171	0.734*					
VE	0.808	0.678	0.464	0.228	0.539	0.824*				
SE	0.962	0.927	0.533	0.352	0.538	0.681	0.963*			
IWP	0.928	0.866	0.244	0.169	0.290	0.348	0.439	0.931*		
WB	0.909	0.768	0.533	0.255	0.332	0.380	0.730	0.451	0.877*	
P	0.862	0.559	0.285	0.203	0.288	0.348	0.531	0.494	0.534	0.724*

* The square root of a given factor's AVE

x^2/df = 3.512; RMSEA = 0.050; SRMR = 0.0494; CFI = 0.908; NFI = 0.877; TLI = 0.898.

CR, composite reliability; MSV, maximum shared squared variance; ASV, average shared squared variance; AVE, average variance extracted; x^2/df, chi square per degrees of freedom; RMSEA, root mean square error of approximation; SRMR, standardized root mean square residual; CFI, comparative fit index; NFI, normed fit index; TLI, Tucker-Lewis index.

4.5 Validity results

The purpose of the CFA was to measure the construct convergent and divergent validity and reliability requirements. Convergent validity requires that each factor has a CR higher than AVE, which is accomplished and AVE needs to be over 0.5, which it is. The construct is convergent valid. Discriminant validity requires that each factor MSV and ASV are less than AVE, which is easily achieved, and so the construct is discriminant valid. Reliability requires that CR is over 0.8 which is easily achieved on every factor except on VE which is barely over the threshold. Construct reliability is achieved. Convergent validity, discriminant validity and reliability requirements are fulfilled in this factor structure.

5 Discussions

5.1 Structure of SmartWoW tool

The purpose of this study was to improve SmartWoW tool by adding the variables based on pilot test feedback and by performing validation and reliability analyses on updated SmartWoW tool. The purpose of the statistical analysis was to confirm the structure of the tool. With regard to convergent and discriminant validity, the SmartWoW tool has shown a structure of six factors as suggested in previous literature. The analyses indicate that items in each factor are related and there are differences between the factors. This study reasserts the claims of previous literature by recognizing the six dimensions as suggested.

SmartWoW tool was supposed to have six dimensions: physical environment, virtual environment, social environment, individual work practices, well-being at work and productivity. All these were found in confirmatory factor analysis. The results were mainly as expected, but one adjustment is needed. The part of well-being at work variables loaded more on social environment factor. This is also theoretically logical so it is possible to accept that WB5, WB7 and WB8 are part of the social environment factor. This leaves three variables for well-being at work factor which illustrate the personal work satisfaction and engagement. The amount of variables in this factor is low compared to the others, but loadings and consistency are on good level, so no changes required. Three factors, virtual environment, social environment and individual work practice are all divided into two first level factors. This makes sense as all those dimensions are very diverse and include many variables.

Some variables are not in the final CFA model because they did not load into any factor. Those are listed in Table 3, with the discussion about their future in part of the SmartWoW tool.

Table 3. Items that did not load into any factor and decisions should those still be a part of SmartWoW tool.

Variable	Decision	Justification
3PE: The facilities at my workplace enable spontaneous interaction between workers	Keep	It was the last variable that was dropped from the model and it is important theoretically, so it would have been nice to have it in final CFA.
4PE: The ergonomic arrangements of the work stations at my workplace are in order	Keep	Theoretically different than other variables in physical environment. Might still be an important driver for well-being at work and productivity.
10VE: Workers can see other workers' electronic calendar	More data needed	This was dropped from the final model, probably due to low variance in responses.

16SE: Telework is a generally accepted practice at my workplace	More data needed	Loading was just below the threshold of 0.5, probably due to that, it was not allowed in many of the organizations.
1IWP: I use technology (e.g. videoconferencing or instant messaging) to reduce the need to for unnecessary travelling	Keep	Does not belong to theoretical model, but it is interesting for managers to know if employees are utilizing possibilities or not.
2IWP: I utilize mobile technology in work situations where I have to wait about (e.g. working on the laptop or phone in the train)	Keep	Does not belong to theoretical model, but it is interesting for managers to know if employees are utilizing possibilities or not.
4IWP: I do things that demand concentration in a quiet place (e.g. in the quiet room or at home)	Keep	Does not belong to theoretical model, but it is interesting for managers to know if employees are utilizing possibilities or not.
8IWP: If necessary I close down disruptive software in order to concentrate on important work task	More data needed	The nature of the work might not allow this. It is an interesting variable for future research.
4WB: My work does not cause continuous stress	Drop	This variable is difficult to evaluate as it is unclear how much stress is good or bad.
6WB: My work and leisure time are in balance	Keep	This might be an explanation if well-being or productivity is low, but it is not theoretically close to anything to load into current factors.
4P: I have sufficient skills to accomplish my tasks efficiently	Keep	Theoretically important part of productivity, but it does not fit into any factors.
7P: The group(s) of which I am a member work efficiently as an entity	Keep	This was not supposed to load anywhere, but it offers an interesting angle to productivity as the results are significantly lower than in the other productivity variables.

In conclusion this research suggests keeping the structure of SmartWoW as it is. There is a statement that a couple variables from well-being at work dimension could be integrated into the social environment, but on the other hand those are also very typical variables in well-being at work surveys. Factor structure allows an opportunity to rearrange the order of variables, but this study cannot confirm how it would affect the results, so it is not changed. Usefulness of a couple (10VE, 16SE, 8IWP) of variables stays open and more data is needed to evaluate their place in the tool. It is suggested that 4WB be dropped as it didn’t load into any factor, and it is difficult to evaluate a good result.

5.2 Practical value, limitations and future

The practical value of the SmartWoW is demonstrated in Palvalin et al. (2015), and current interest also indicates a practical value. This research affirms its practical value by confirming the structure of SmartWoW and enabling dimension based analysis using the discovered dimensions. Organization results could be compared to the other organization results in dimension level, which makes information easier to handle.

The limitations of this study arise from data collection. The main part of the data is collected from public or third sector organizations, which means that there is a possibility that the work environment is biased. These organizations are typically a bit more conservative when it comes to work practices and hierarchy. It can be seen, for example, in the physical environment where more employees have their own room or in the virtual environment, which might not be as exploited as somewhere else. This might cause some low factor loadings. Response rates were very good in every organization, but there is always a possibility that a non-response bias exists.

For future research, this study offers two clear paths. The first is to continue validating this tool by countering the possible biases and testing it with the new data from different types of organizations. The second path is to use it to gather research data and analyze the results from the knowledge workers' points of view. This could contain, for example, analysis of what makes some knowledge workers more productive than others. The third option is to combine these two paths and find out if the framework based on literature works in practice, i.e. whether the work environment, individual work practices and well-being at work impact on productivity.

6 Conclusions

SmartWoW tool is an interesting approach for measuring impacts of work environment changes on knowledge work productivity. It gives information for managers on what the current state of the work environment is, individual work practices, well-being at work and productivity. Previously, there has not been a tool that combines all these dimensions, which is important with major work environment changes. The contribution of this study to this field of inquiry is that it improves the SmartWoW tool by confirming the structure, adding four variables to increase the reliability of the dimensions and dropping one variable as too difficult to understand. The results allow six dimensions to be used as sum variables, which could then be used for comparing the results of two organizations. Hopefully, this tool finds its way into many organizations and work environment change projects because it provides valuable information for managers. Even better, if the data were also available for researchers since there are many interesting methods of analysis from different angles.

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Appendix

Appendix 1. Variables, means, standard deviations, skewness and kurtosis.

Code	Key variable	Mean	Std.dev	Skewness	Kurtosis
1PE	There is a space available for tasks that require concentration and peace at our workplace when needed	3,82	1,44	-0,89	-0,70
2PE	There are enough rooms at my workplace for formal and informal meetings	3,32	1,44	-0,29	-1,35
3PE	The facilities at my workplace enable spontaneous interaction between workers	3,79	1,20	-0,78	-0,43
4PE	The ergonomic arrangements of the work stations at my workplace are in order	3,74	1,20	-0,78	-0,43
5PE	There are generally no disruptive factors in my work environment (like sounds or movements)	2,99	1,40	0,02	-1,37
6PE	There is a place in which I can discuss or talk on the phone about matters which I do not want others to hear	3,73	1,43	-0,77	-0,87
7PE	The facilities at my workplace are conducive to efficient working	3,72	1,25	-0,74	-0,53
8VE	The usability of the main software for doing my work tasks is good	3,78	1,07	-0,83	-0,06
9VE	I can access the information I need wherever I am	3,62	1,18	-0,68	-0,52
10VE	Workers can see other workers' electronic calendar	4,23	0,98	-1,39	1,56
11VE	Workers can communicate with instant messaging tools (e.g. Lync, Skype)	4,31	1,04	-1,65	2,10
12VE	My workplace has sufficient equipment for virtual negotiations	3,63	1,21	-0,54	-0,74
13VE	My workplace has electronic teamwork tools (e.g. Google docs, Trello, Yammer)	3,47	1,22	-0,41	-0,73
14VE	There are appropriate mobile devices available at my workplace (e.g. laptop, iPhone, tablet)	4,02	1,13	-1,20	0,68
15SE	I am able to work in the ways and at the times which suit me best	3,65	1,18	-0,70	-0,47
16SE	Telework is a generally accepted practice at my workplace	3,72	1,26	-0,70	-0,66
17SE	Operations at my workplace are open (e.g. decision-making and information flow)	3,23	1,16	-0,32	-0,85
18SE	Information flows well among the people important for my work	3,39	1,12	-0,46	-0,71
19SE	The meeting practices at my workplace are efficient	2,88	1,11	0,05	-0,87
20SE	Our workplace has clear guidelines regarding the use of IT and communication tools	3,25	1,08	-0,26	-0,64
21SE	I have clear goals set for my work	3,75	1,11	-0,82	-0,01
22SE	My work is assessed in terms of results achieved, not only hours worked	3,72	1,12	-0,77	-0,10
23SE	My work tasks constitute a reasonable whole	3,82	1,09	-0,87	0,09
24SE	New ways of working are actively explored and experimented at my workplace	3,08	1,15	-0,14	-0,76
1IWP	I use technology (e.g. videoconferencing or instant messaging) to reduce the need to for unnecessary travelling	3,83	1,15	-0,95	0,15
2IWP	I utilize mobile technology in work situations where I have to wait about (e.g. working on the laptop or phone in the train)	3,56	1,42	-0,64	-0,93
3IWP	I try to manage my workload by prioritizing important tasks	4,32	0,73	-1,15	1,99
4IWP	I do things that demand concentration in a quiet place (e.g. in the quiet room or at home)	3,50	1,36	-0,51	-1,01
5IWP	I prepare in advance for meetings and negotiations	4,06	0,84	-0,98	1,16
6IWP	I take care of my well-being during the working day (e.g. by changing my work position or the place I work in)	3,67	1,10	-0,59	-0,44
7IWP	I follow the communication channels at my workplace	4,08	0,85	-0,93	0,93
8IWP	If necessary I close down disruptive software in order to concentrate on important work task	3,42	1,20	-0,34	-0,91
9IWP	I regularly plan my working day in advance	3,32	1,11	-0,40	-0,67
10IWP	I actively seek out and test better tools and ways of working	3,50	1,01	-0,38	-0,37
1WB	I enjoy my work	3,98	0,99	-1,14	1,15
2WB	I am enthusiastic about my job	4,05	0,96	-1,04	0,78
3WB	I find my work meaningful and it has a clear purpose	4,19	0,92	-1,33	1,78
4WB	My work does not cause continuous stress	3,14	1,21	-0,12	-1,06
5WB	My work performance is appreciated at my workplace	3,57	1,07	-0,62	-0,18
6WB	My work and leisure time are in balance	3,69	1,09	-0,58	-0,53
7WB	The atmosphere at my workplace is pleasant	3,80	1,02	-0,85	0,38
8WB	Conflict situations at my workplace can be resolved quickly	3,24	1,11	-0,30	-0,56
1P	I achieve satisfactory results in relation to my goals	4,09	0,81	-0,90	0,95
2P	I can take care of my work tasks fluently	4,04	0,83	-0,91	1,00

3P	I can use my working time for matters which are right for the goals	3,62	0,99	-0,61	-0,07
4P	I have sufficient skills to accomplish my tasks efficiently	4,26	0,77	-1,19	2,06
5P	I can fulfill clients' expectations	4,01	0,79	-0,78	1,00
6P	The results of my work are of high quality	4,11	0,72	-0,52	0,20
7P	The group(s) of which I am a member work efficiently as an entity	3,53	1,00	-0,56	-0,15

Appendix 2. EFA pattern matrix.

	Factor									
	1	2	3	4	5	6	7	8	9	10
8WB	,888									
7WB	,851									
17SE	,769									
18SE	,677									
19SE	,612									
24SE	,409									
5WB	,404									
7P	,365									
20SE	,355									
6P		,852								
1P		,796								
5P		,779								
2P		,743								
4P		,630								
3P		,502								
1PE			,901							
7PE			,827							
6PE			,746							
5PE			,716							
2PE			,456		,340					
4PE			,383					,321		
3PE										
10IWP				,599						
9IWP				,555						
8IWP				,484						
5IWP				,464						
6IWP				,437						
3IWP				,377						
7IWP				,352						
12VE					,753					
13VE					,557					
11VE					,495					
10VE										
2WB						,944				
3WB						,701				
1WB						,627				
4WB							,779			
6WB							,736			
8VE								,528		
9VE								,476		
14VE					,370			,439		
15SE								,376		
21SE									,683	
22SE	,315								,596	
23SE									,575	
2IWP										,516
4IWP										,408
1IWP										,395
16SE										

Appendix 3. CFA model.