How Much Home Office is Ideal? A Multi-Perspective Algorithm

MARK COLLEY*, Institute of Media Informatics, Ulm University, Germany and Cornell Tech, USA
PASCAL JANSEN*, Institute of Media Informatics, Ulm University, Germany
JENNIFER JORINA MATTHIESEN*, Leuphana University of Lüneburg, Germany
HANNE HOBERG, Leuphana University of Lüneburg, Germany
CARMEN REGER, Leuphana University of Lüneburg, Germany
ISABEL THIERMANN, Leuphana University of Lüneburg, Germany

The COVID pandemic made home office organization a necessity. Even beyond COVID-19, many employees will want to continue working, at least part-time, from home. The home office trend has various advantages and drawbacks from both the employer's and the employee's perspectives. Therefore, determining the ideal proportion of home office work for each employee to balance this potential is important. However, what is the ideal proportion? While research on the organization of home office focused on identifying the jobs, tasks, or activities feasible at home, there is a research gap on how companies can use these categorizations to determine the proportion of home office, which leads to the most efficient work, saves resources and coincide with the preference of each employee. Therefore, this work presents an algorithm that considers multiple perspectives for determining the ideal proportion of home office on individual and company proportions. Three perspectives are taken into account: (i) the employer's point of view, (ii) the demographic and social factors of the employee, and (iii) the preferred proportion of home office from the employee. We combined the findings of several prior studies on the organization of home office and developed an algorithm that serves as a practical approach for determining the proportion of home office and can be used to identify potential discrepancies between the three perspectives.

CCS Concepts: • **Human-centered computing → Collaborative and social computing theory, concepts and paradigms**.

Additional Key Words and Phrases: Home office, Working from home, Ideal proportion, Teleworkability, Algorithm

ACM Reference Format:
Mark Colley, Pascal Jansen, Jennifer Jorina Matthiesen, Hanne Hoberg, Carmen Reger, and Isabel Thiermann. 2023. How Much Home Office is Ideal? A Multi-Perspective Algorithm. In *Annual Symposium on Human-Computer Interaction for Work 2023 (CHIWORK 2023), June 13–16, 2023, Oldenburg, Germany*. ACM, New York, NY, USA, 17 pages. https://doi.org/10.1145/3596671.3596672

1 INTRODUCTION

To contain the spread of the COVID-19 virus, governments decided to lock down their populations with far-reaching restrictions on public and private life. To reduce contacts, a large proportion of employees, therefore, had to start working from home. According to a survey by the Hans Böckler Foundation, the proportion of employees in home office was around 4% before the outbreak of the Corona pandemic [16]. During the first lockdown in April 2020, this proportion rose to 27%, an increase of 675%. While there are currently discussions about the return to working at the office both in academia [1, 38] and in broader industry[1], there will likely be no return to pre-pandemic office routines.

*Authors contributed equally to this research.
[1] https://tech.co/news/amazon-demands-staff-return-office; Accessed: 22.02.2023

Manuscript submitted to ACM

Over half of the employees would like to continue working from home at least part-time [23]. The trend toward home office has various advantages and drawbacks from both the employer's and the employee's perspectives. On the positive side, employers become more attractive to a wide workforce, can hire from a broader range of applicants, and can reduce office space. For the employee, the reduced commute time, flexibility, and reduced distraction are major perceived benefits. Regarding drawbacks, potentially less constructive meetings and "slacking off" are named by employers, while loneliness or reduced visibility to management could occur for employees [38].

To date, there is a noticeable gap in the literature regarding investigating how companies can leverage research findings to determine the ideal proportion of home office. The lack of research in this area prevents organizations from identifying the most efficient work arrangements, conserving valuable resources, and aligning with the preferences of their employees. Therefore, determining a home office proportion is a significant challenge for companies. Which duration can be defined as *ideal* for the employer or the employee, respectively?

Research on home office organization has primarily focused on how many tasks could be performed from home [2]. Others focused on determining single activities that would generally not permit a home office [12]. Much of this research focuses on analytical and survey-based domains. For instance, Cetrulo et al. [7] considered the occupational structure of Italy for quantifying the jobs that can be done at home. Lund et al. [25] and Microsoft [29] address the post-pandemic organization of remote work (including working from home) and discuss the potentials and trends. A discourse about the extent of telework in the EU before and during the COVID-19 outbreak was provided by Sostero et al. [36].

Our approach takes a comprehensive view by considering multiple perspectives, including the employer's and employee's, and compounding various methods for quantifying and categorizing work identified in related literature into a single framework that we call *HOMPA*[2]. In doing so, we identify potential discrepancies between employee wishes and employer expectations and discuss limitations in applicability. In the context of work, we distinguish between home office and remote work. Home office is working in a designated workspace in an individual's residence, while remote work allows work from *anywhere*. In this work, we will focus on the topic of home office. The terms "home office" and "working from home" are used interchangeably in this text for better readability.

Our work enables employers to incorporate multiple perspectives into their home office policy decisions while providing a basis for employees to communicate their home office preferences to their employers quantitatively. Thus, this work may serve as a foundation to align employers' and employees' home office perspectives and preferences.

Contribution Statement: This work contributes: (1) A framework for determining the ideal proportion of home office considering (i) the employer's perspective, (ii) social factors, and (iii) employee preferences. (2) An implementation of our framework as an interactive Google Colab notebook[3] that generates the ideal proportions of home office for custom inputs and provides data from two fictional and illustrative companies.

2 ON THE ADVANTAGES AND DRAWBACKS OF HOME OFFICE

Finding the ideal balance between working on-site at the company and in home office is a struggle. Both sides - the requirements of employers on the one hand and employees on the other - must be reconciled. As was the case many decades ago, work-life balance is still a central issue for home office today [3, 19]. Families must respond flexibly to situations such as a sick child or a family member needing care [18]. Additionally, long commutes to the office or workplace can trigger stress, harm the quality of life, and increases absenteeism [15]. According to Hamberger [15], the number of days absent from work is 11% higher among commuters, which negatively affects their productivity.

[2] https://github.com/jjmatthiesen/HOMPA
[3] see GitHub for link

The exemplary points are not only incentives or motivation for working in home office from the employee's point of view but are also essential aspects for employers. If employees can reconcile their private commitments with their job, this has a positive effect on, for example, employee satisfaction. In addition, home office can positively affect collaboration [21]. Accommodating employees' wishes is still an obstacle for employers due to a lack of trust and control over productivity [20]. Two factors play a significant role here: (a) using existing communication media and (b) cooperation with others. e.g., negotiations with customers or supervision of employees.

There is a trend toward an increase in the number of companies willing to offer home office to their employees. In 2014, this was still the case for 22% of companies, while it increased to 39% in 2018 [37]. However, according to the study of Arntz et al. [2], only 31% of jobs in Germany can be performed entirely in home office currently. Additionally, other potential drawbacks of home office include additional workload, professional expenses, blurring of work and leisure time, as well as distractions by other members of the household [38]. This work presents an algorithm that considers these aspects when deciding on home office and calculating the ideal proportions. The resulting algorithm provides a decision-making basis for companies to design the ideal working algorithm for the future - tailored to the individual employee and the job's financial requirements.

3 FRAMEWORK FOR DETERMINING THE PROPORTION OF HOME OFFICE

Many researchers have investigated important factors in the home office organization [2, 5, 7, 12, 21, 23]. While taking these factors into account, we take three different perspectives to determine the ideal proportion of home office: (i) the employer's point of view P_{ER}, (ii) social factors P_{social}, and (iii) the preferred proportion of home office P_{prefer}. For the employer, we determine the maximum proportion of home office H_{max} based on the executed tasks and the ideal proportion of home office H_{opt}, which also respects the proportion of interaction required for the particular tasks. The factors of P_{social} and P_{prefer} are aggregated into H_{social} and H_{prefer} respectively. We distinguish an individual's and the company's total result for each perspective. Based on this, discrepancies between employers and employees and any need for discussion are identified. The methodological derivation is explained for each step before we deduce the calculation and its implementation in the algorithm.

3.1 Data

To show the applicability of the presented algorithm for a variety of companies that share similar characteristics, we modeled a retail store for sportswear (Table 1: Sport GmbH) and a bank (Table 2: Bank ZWEI AG).

Table 1. Company profile of Sport GmbH.

Company 1: Sport GmbH	
This is a small company with 17 employees, which operates in the field of retail (stationary and online). For example, this could be the headquarter and the branches of a company in Germany that sells sportswear and has a few independent stores. At the head office, all activities such as the online store, purchasing, marketing, and sales are executed.	
Business category	Small company with <50 employees (there are 2.6 million small and medium-sized enterprises in Germany)
Sector	Trade / Service
Sales revenue in millions	=<10

To test *HOMPA*, we generated representative sets of employees of the two companies (see an example in Appendix B). The employee lists include (a) the employee with demographic information (usually filed with the employer), (b) an activity description that could be extracted from the job description, and (c) individual information about the employees, which would have to be collected by a short employee survey. *HOMPA* can be applied to companies in different industries

Table 2. Company profile of Bank ZWEI AG.

Company 2: Bank ZWEI AG	
This is a direct bank with ≈5,000 employees that operates nationally. The Bank ZWEI AG does not maintain branches; customer service is handled by telephone or digitally. The activities range from customer service, incl. lending to controlling, risk management, and treasury to purchasing, human resources management, and marketing.	
Business category	Financial institution with ≈5,000 employees
Sector	Finance
Balance sheet total	approx. 180 billion euros
Inlays	approx. 140 billion euros

and sizes. This is illustrated by using two companies as a data basis and explaining differences in the assessment of home office proportions.

3.2 The Employer's Perspective

Recent studies investigated the executability of jobs from home [2, 12], addressing the employer's perspective. Cetrulo et al. [7] noted that working from home requires material and immaterial infrastructure. In addition, increased proportions of home office can lead to increased isolation and decreased collaboration [29].

Therefore, we include in this relatively economical perspective whether (i) the activity can be executed to the same extent at home, (ii) the infrastructure is sufficient, and (iii) the company's *Sense of Belonging* is given. Based on the determination that the field of activity can be executed from home, we include an additional proportion to take the field of activity and the specific task within the field into account. Using the Group Task Circumplex Model of McGrath [26], a fourth factor regarding if the tasks are suitable for home office is included in the presented algorithm.

3.2.1 The Teleworkability-Index. Several researchers addressed whether an activity can generally be performed in home office. Bonin et al. [5], Cetrulo et al. [7], Kamouri and Lister [21], Kunze et al. [23] have categorized various fields of activity with regard to their suitability for home office.

Dingel and Neiman [12] used O*NET (Occupational Information Network Surveys) surveys to determine the theoretical maximum number of activities that could be performed entirely in home office in the USA. They found that 37% of all jobs in the USA can be performed in home office. Besides only using data on the USA, Dingel and Neiman [12] did not consider whether fields of activity are actually performed in the home office and only excluded activities that would generally not permit home office (e.g., construction, cleaning). It can be assumed that the actual proportion of activities performed in the home office is lower. Boeri et al. [4] used a similar methodology to determine the proportion of activity fields suitable for home office in various European countries (from Italy with 23.9% to the UK with 31.4%). However, their study is based on pre-pandemic data from 2012.

These drawbacks do not apply to the teleworkability index, which is developed for Germany by Arntz et al. [2]. This index makes a more granular distinction between activities that can be performed entirely or partially by teleworking and, thus, in home office. In addition to general tasks, self-assessments of the home office possibility of 20,000 employees performing this activity in Germany were also considered. Therefore, the teleworkability-index is applied as the basis for the first evaluation step of the activity.

According to this index, an activity is considered *teleworkable* if more than two-thirds of the tasks can be performed at home and less than 20% of the people surveyed in this field of activity state that the activity cannot be performed from home. In contrast, an activity is considered *non-teleworkable* if more than one-third of the respondents in this field of activity indicate that the activity cannot be performed from home or more than half of the tasks cannot be performed

in the home office. An overview of the fields of activity and their classification can be found in Table 3. Based on this, we extracted several variables for the created algorithm (see Appendix A).

Table 3. Teleworkability Index after Arntz et al. [2].

Non-teleworkable tasks	**Other, potentially teleworkable, tasks**
- Manufacturing, producing goods and commodities	- Providing advice and information
- Measuring, testing, quality control	- Advertising, Marketing, Public Relations, PR
Monitoring, control of machines, plants, technical processes	- Organizing, planning and preparing work processes
- Repairing, renovating	- Developing, researching, constructing
- Transporting, storing, shipping	- Gathering information, researching, documenting
- Entertaining, accommodating, preparing food	- Working with computers
- Nursing, caring, healing	- Use of the Internet or e-mail processing
- Protecting, guarding, monitoring, regulating traffic	- Purchasing, procuring, selling
- Cleaning, waste disposal, recycling	

Based on the teleworkability index of Arntz et al. [2], we group the fields of activity into 16 subcategories: $T_1 - T_{16}$. The variables T_9 to T_{16} refer to the fields of activity that can generally be performed in home office (see the overview of variables in Appendix A). As part of the data collection, the percentage of time an employee spends on tasks in the fields of activity is recorded for each job and assigned to the variable T_i. On this basis, the maximum proportion of home office H_{max} for each employee e_j is calculated, where $0 < j \leq$ number of employees:

$$H_{\max}(e_j) = \sum_{i=9}^{16} T_i \tag{1}$$

3.2.2 Infrastructure. Following Cetrulo et al. [7], material and immaterial infrastructure must be accessible to ensure productive remote work. Considering infrastructure increases *HOMPA*'s applicability as the same activities with similar tasks can lead to different home office proportions in companies that provide less support and infrastructure [7]. For our algorithm, we decoded the information about the sufficient infrastructure I as a Boolean variable. The activities for which the infrastructure is insufficient are excluded. The maximum proportion of home office is then adjusted with respect to the infrastructure:

$$H_{\max_{\text{infra}}}(e) = \begin{cases} \text{false}, & \text{if } I < \rho \\ H_{\max}(e_j), & \text{otherwise} \end{cases} \tag{2}$$

where ρ is the minimum requirement of the infrastructure.

3.2.3 Sense of Belonging to Company. COVID-19 showed that home office can lead to an increased risk of team isolation [24] and silo formation in networks. This is particularly problematic for new hires as interaction with colleagues beyond the boundaries of one's team is an essential part of the onboarding process [6]. In addition, loyalty to the company could be lower when employees work solely from the home office from the outset. For this reason, Microsoft states that employers should exclude home office during the probationary period or the first six months [29]. We take this criterion into account as follows. First, the company's Sense of Belonging is calculated as the difference between today's date and the entry date in days. If this difference is less than 180 days (6 months), the maximum home office proportion is zero.

$$H_{\max_{\text{aff}}}(e_j) = \begin{cases} \text{false}, & \text{if } D_{\text{now}} - D_{\text{start}} \leq 180 \\ H_{\max}(e_j), & \text{otherwise} \end{cases} \tag{3}$$

where D_{now} and D_{start} are the current and the entry date, respectively. Subsequently, the maximum proportion of home office for the entire company $H_{max_{total}}$ is defined as the mean of H_{max} of all employees:

$$H_{\max_{\text{total}}} = \frac{1}{n} \sum_{j=1}^{n} H_{\max}(e_j) \tag{4}$$

3.2.4 Task-Media-Fit Model. Directly taking the maximum proportion of home office is insufficient because the quality of collaboration with others significantly impacts employee productivity. This is reinforced by related literature, which shows that managers and employees spend 85% of their time communicating [28]. Therefore, selecting the right form of collaboration is a key factor in the decision for or against home office from the employer's perspective and is reviewed in the next evaluation step. The basis of the decision model is the highly cited Task-Media-Fit model of McGrath [26] as an extension of the media richness theory of Daft and Lengel [10]. Media richness theory states that the selection of the appropriate communication medium depends on the conveyed information type. The medium types are (from low to high richness): unaddressed documents; written, addressed documents; 2-way radio; telephone; video conferencing; and face-to-face. A richer medium should be used if the information is of great depth. However, if a situation requires little information exchange, a rich medium can lead to distraction and be ineffective [28].

McGrath [27] demonstrated that not only the situation or task and its information is needed, but that the collaboration process impacts the suitability of a medium, therefore, extending the media richness theory to the Task-Media-Fit model. Tasks requiring collaboration are first categorized based on the process and the information content to identify the ideal communication medium. The Group Task Circumplex model of McGrath [26] provides a suitable basis for this (see Appendix 2).

The information content for the tasks in the quadrants increases from Quadrant I to IV. Therefore, the need for rich communication also increases. Using the Task-Media-Fit model, the ideal communication media can be assigned to each quadrant [28]. While groups can collaborate in Generate (I), Choose (II), and Execute (IV type 8) tasks remotely, for example, via video conferencing, resolving conflicts in negotiations (III) or contests (IV type 7) benefits from face-to-face contact that also conveys conversation tone and body language. Therefore, in the presented algorithm, we exclude the home office option for group tasks suited for face-to-face contact. Accordingly, tasks in quadrants I and II and quadrant IV type 8 are suitable for home office, while tasks in quadrants III and IV type 7 should be done in person. Data is collected for each category represented by Q, where Q_1 corresponds to Quadrant I, Q_2 to Quadrant II, etc. Quadrant IV is divided into $Q_4.1$ (tasks of type 7) and $Q_4.2$ (tasks of type 8) (see Appendix 2). For each worker, the ideal proportion of home office can now be determined as the difference between the previous maximum proportion of home office and the sum of the group tasks that do not allow home office:

$$H_{\text{opt}}(e_j) = H_{\max}(e_j) - \sum_{x=3}^{41} Q_x \tag{5}$$

The ideal proportion of home office for the company is calculated as the arithmetic mean of the employee values.

$$H_{\text{opt}_{\text{total}}} = \frac{1}{n} \sum_{i=j}^{n} H_{\text{opt}}(e_j) \tag{6}$$

3.3 Social Factors

The proportion of home office depends on various factors, including socio-demographic factors. For instance, a survey on the work-from-home experience by Kamouri and Lister [21] revealed that specific generations prefer a certain proportion of home office. Bonin et al. [5] discuss education and its influence on the proportion of home office. They state that higher education leads to significantly higher proportions of home office. This can be explained by the activity type of educated workers being more cognitively demanding and less related to specific materials. Besides (i) differences between generations and (ii) education levels, we include (iii) the commute time as it influences the quality of life and work [34]. As discussed by Arntz et al. [2], women with children are more likely to be out of paid employment than men. Therefore, we also include (iv) caring responsibilities in our algorithm. In addition, (v) the employee personality may affect the ideal proportion of home office. The socio-demographic perspective to determine the proportion of home office incorporates the different points addressed in related research on home office experience to provide a basis for systematic discussions on the allowed proportion for each employee, given that the job permits this.

3.3.1 Different Generations. According to Kamouri and Lister [21], employees belonging to the baby boomer generation (1946-1965) would prefer to work ≈2.4 days/week (48%) in home office and employees of Generation X (1965-1980) with ≈2.5 days/week (50%), only slightly more. The preferred number for Generation Y (1980-1994) is ≈2.3 days/week (44%) and for Generation Z (1995-2010) ≈1.4 days/week (28%). The proportion of home office with respect to the generation of the employee e can be formally described as:

$$H_{\text{gen}}(e_j) = \begin{cases} 48, & \text{if } Y_{\text{birth}} \in \{1946, 1964\} \\ 50, & \text{if } Y_{\text{birth}} \in \{1965, 1980\} \\ 44, & \text{if } Y_{\text{birth}} \in \{1981, 1994\} \\ 28, & \text{otherwise, see Gen Z [21]} \end{cases} \tag{7}$$

where Y_{birth} is the year of birth of the employee.

3.3.2 Education. In July/August 2020, higher-skilled workers were likelier to work from home than lower-skilled workers. For example, 48% of employees with a high school diploma worked from home during this period. Of the employees with a middle school diploma, only 17% worked from home, while the proportion was around 8% among the workers with a lower secondary school [5]. This can be explained by the fact that less-educated workers are more likely to perform activities that cannot be done in home office [5]. We assume that this causality will continue to exist in the future and derive the proportion of home office as a function of education proportion L_{edu} as follows:

$$H_{\text{degree}}(e_j) = \begin{cases} 48, & \text{if } L_{edu} = \text{"high school"} \\ 17, & \text{if } L_{edu} = \text{"middle school"} \\ 8, & \text{otherwise} \end{cases} \tag{8}$$

3.3.3 Commute Time. A survey for the Happiness Atlas [34] concluded that a commute time of less than 20 minutes daily has only a minor impact on the quality of life of the respondents. A commute time of more than 40 minutes

already significantly worsened the quality of life [34]. It can be assumed that employees with more than 40 minutes commute to work two to three days (46%) in home office, while a commute time below 20 minutes has no impact. We represent the impact between 20 and 40 minutes of commute time as a linear increase with a slope of 2.3 to make the function linear from 46 to 0 in the time range from 20 min to 40 min. The proportion of home office regarding the commute time t_{commute} is thus calculated as follows:

$$H_{commute}(e_j) = \begin{cases} 46, & \text{if } t_{\text{commute}} > 40 \\ 2.3 * t_{\text{commute}} - 46, & \text{if } t_{\text{commute}} \in [20, 40] \\ 0, & \text{otherwise} \end{cases} \tag{9}$$

3.3.4 Caring Responsibility. Even during the pandemic, employees with children work from home more often than their childless colleagues, making it easier to combine family and career. Compared to men, women spend more time on childcare [2]. Following Arntz et al. [2], the proportion of home office is determined as a function of gender $G \in \{f, m, other\}$ and whether an employee has caring responsibilities C as below. The chosen numbers represent the percentage of those already working from home and wishing to do so (if the job allows them to do so). 50% represents the ambiguity of not knowing people's preferences if no caring responsibility is given.

$$H_{caring}(e_j) = \begin{cases} 56.1, & \text{if } C \text{ and } G = \text{f} \\ 52, & \text{if } C \text{ and } G = \text{m} \\ 50, & \text{otherwise} \end{cases} \tag{10}$$

3.3.5 Personality Factors. Based on the personality measurement based on the TIPI [31] and the Grit-S [13], Kawakubo and Arata [22] evaluated the productivity of different personality traits in home office. They found that openness (OPN), neuroticism (NCM), as well as perseverance and passion (PP) significantly affect productivity. Openness and neuroticism were measured on a scale from 2-14, while perseverance and passion had a range from 1-5. For example, workers whose openness score was over eight have 6.1% increased comprehensive productivity on average. Workers who scored less than eight points increased their comprehensive productivity by just 1.2% on average. Based on their results, we defined the following equations.

$$H_{\text{OPN}}(e_j) = \begin{cases} 1.2, & \text{if Openness} \in [2, 8] \\ 6.1, & \text{otherwise} \end{cases} \tag{11}$$

$$H_{\text{NCM}}(e_j) = \begin{cases} 6.3, & \text{if Neuroticism} \in [2, 7] \\ 2.2, & \text{otherwise} \end{cases} \tag{12}$$

$$H_{\text{PP}}(e_j) = \begin{cases} 1.7, & \text{if Perseverance and passion} \in [1, 3] \\ 6.5, & \text{otherwise} \end{cases} \tag{13}$$

$$H_{\text{personality}}(e_j) = \frac{H_{\text{OPN}}(e_j) + H_{\text{NCM}}(e_j) + H_{\text{PP}}(e_j)}{6.1 + 6.3 + 6.5} * 100 \tag{14}$$

In the last step, the social factor for determining the proportion of home office (H_{social}) is calculated for each employee from the mean of the five previously identified proportions of home office ($H_{\text{generation}}$, H_{degree}, H_{commute},

H_{caring} and $H_{\text{personality}}$). The social factor of home office from the company's perspective ($H_{\text{social}_{\text{total}}}$) is then calculated from the average of the social factors for all employees:

$$H_{\text{social}_{\text{total}}} = \frac{1}{n}\sum_{j=1}^{n} H_{social}(e_j) \tag{15a}$$

where:

$$H_{\text{social}}(e_j) = \frac{H_{\text{generation}}(e_j) + H_{\text{degree}}(e_j) + H_{\text{commute}}(e_j) + H_{\text{caring}}(e_j) + H_{\text{personality}}(e_j)}{5} \tag{15b}$$

3.4 Employee Requests

Following Kamouri and Lister [21], the preferred proportion of home office, even post-COVID-19, will increase significantly. An analysis from Lund et al. [25] across over 2,000 tasks used in some 800 occupations confirmed that remote work as well as working from home might persist after the pandemic. The last element of our algorithm includes, therefore, the request of the employees of how many days per week they intend to work in home office in the future. This can range from 0% (wish to work at the office all the time) to 100%. We transform the given days per week into percentages, assuming a five days workweek, as follows:

$$H_{prefer}(e_j) = \left(\frac{H_{wish}(e_j)}{5}\right) * 100 \tag{16}$$

For each employee, the actual desire to work from home is then compared with the maximum and ideal proportion calculated and the social factors determined in the sections above.

3.5 Difference Between the Calculated Proportion of Home Office and Preference

The resulting deviations, in particular the difference between the ideal proportion and the preferred proportion of home office, show if there is a need for discussion between employer and employee. The individual solution can then be defined for both sides. Figure 1 depicts the entire process and shows the different perspectives we considered. Table 4 contains an overview of the results for all home office proportions for Sport GmbH and Bank ZWEI AG. A complete table for the individual proportion for each employee can be found in Appendix B.

Table 4. Comparison of the proportion of home office for all employees of the exemplary data.

proportion of home office	Equation	**Sport GmbH**	**Bank ZWEI AG**
maximum proportion	see Equation 4	56%	81%
ideal proportion	see Equation 6	40%	65%
Social factors	see Equation 15a	35,88%	36,09%
preferred proportion	see Equation 16	24,71%	36,36%

The maximum proportion of home office for Sport GmbH is lower than the proportion for Bank ZWEI AG. The differences in the maximum proportion of home office for the two companies lie in the infrastructure. Sport GmbH can offer home office to 56%, at the bank 81% can work in home office. The proportion of employees in the probationary period at Sport GmbH is 18% and at the bank 9%. Based on the Task-Media-Fit model, the ideal proportion of home office at Sports GmbH is 40%, which is dominated by the stationary trade of Sport GmbH; salespersons and branch managers perform 50% of their activities, which lie in quadrant 3. For Bank ZWEI AG, the ideal proportion of home office according to the Task-Media-Fit model is 65%. The values for the social factor of home office are very balanced,

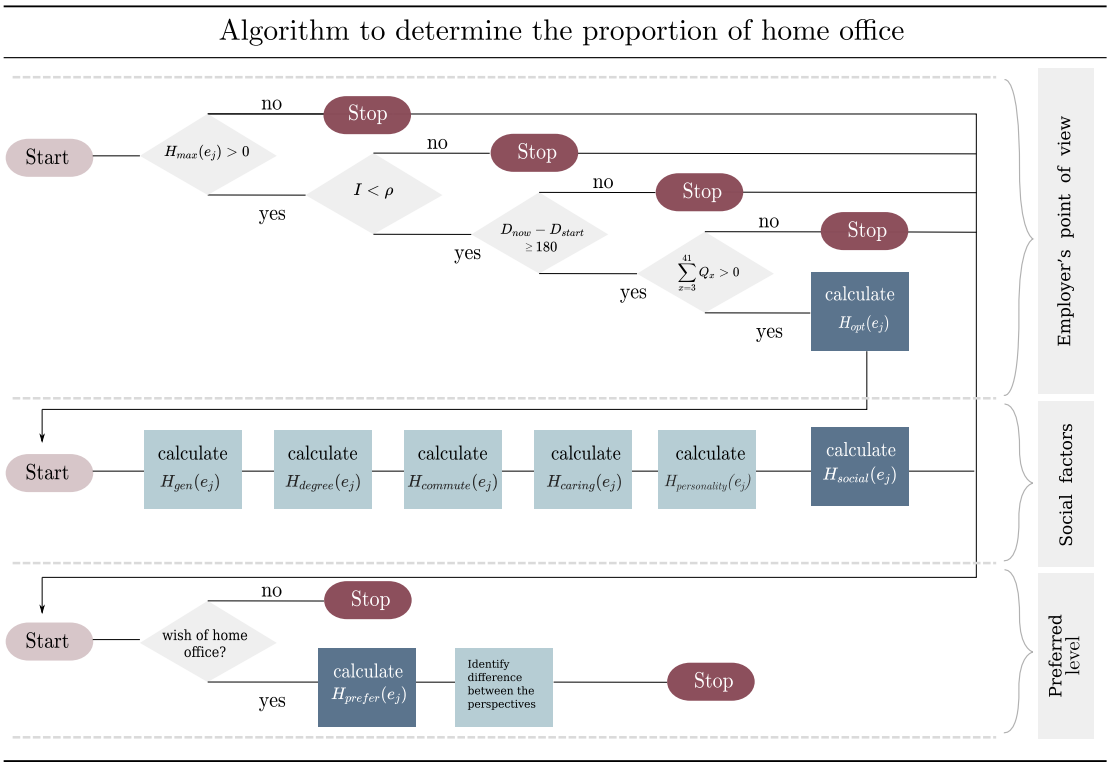

Fig. 1. Algorithm to determine the proportion of home office from the different perspectives.

indicating very similar distribution for both companies. However, the preferred proportion of home office differs. Only 25% of employees at Sport GmbH want to work in home office, whereas 36% at the bank want to work in home office.

4 DISCUSSION

The outbreak of the COVID-19 pandemic in the early 2020s propelled the concept of home office into the forefront of public and corporate discourse. In some instances, it became mandatory for individuals to work remotely from their homes or for companies to offer such arrangements. The pandemic presented a unique opportunity for employers and employees alike to gain a better understanding of the advantages and disadvantages of working from home. Indeed, prior to the pandemic, the subject of home office had already gained significant attention in many organizations. Nevertheless, it is expected that the experience gained during the pandemic will further increase interest in this work arrangement. Employees have grown accustomed to the benefits associated with home office and are likely to continue to demand such arrangements in the future. Moreover, recent trends indicate that employers are increasingly receptive to implementing work-from-home options and recognize the associated benefits for their businesses.

4.1 Negotiating the Algorithm with Personal Preferences

The teleworkability index [2] and the Task-Media-Fit model [27] are used to determine the ideal proportion of home office, while further demographic information is used to determine the social factor. The employer can effortlessly discover possible discrepancies by surveying the employees' preferences. For example, an employee would like to do significantly more home office than the job allows. This can be used as a basis for a discussion to find a suitable solution for both sides. Another aspect that became quite clear during the pandemic is the possibility of significantly reducing office costs. Once it is known how many employees will be on-site, the employer can start optimizing the space and save energy, for example, by reducing lighting and heating of unused offices [17].

4.2 Practical Implications

The listed criteria (social-demographic criteria) can be mainly gained through existing information from personnel systems. Only the Task-Media-Fit model requires that the different roles must be assigned beforehand. In addition, a survey of employees would have to be conducted to determine specific values of the home office proportion. Once the ideal home office proportion has been determined, employers have several options to take advantage of the result.

Some companies will use the extra budget gained to make existing offices more attractive or can save on rent for office space, especially in metropolitan areas. According to PricewaterhouseCoopers International (PwC), 60% of companies expect to save 20% on office space over the next three years [32]. As the possibility of home office is a decisive factor for many employees when looking for a job, it is important for employers to offer home offices in the future [35]. Home office is, therefore, an essential factor in the struggle for talent. Despite some limitations, our developed algorithm offers several opportunities and can be easily applied by employers to provide a systematic and quantitative discussion base.

The developed algorithm and its assigned proportion of home office could significantly impact employees' work-life balance, motivation, and overall well-being. Additionally, different home office proportions could impact team dynamics and productivity. This has to be studied in the future.

We mainly addressed the topic of home office in this work. The developed framework can also be applied to specific types of remote work if the conditions are satisfied (e.g., no to little commute time to a co-working space). Some other parts of the framework, like H_{caring}, need to be adapted when considering certain kinds of remote work (e.g., working from the train).

4.3 On Potential Mismatches of Home Office Preference and Calculated Ideal Proportion

HOMPA provides an easy and literature-based approach to determining the ideal proportion of home office. However, several factors are currently not included. Factors contributing to mismatches include individual work styles and discrepancies between company-assigned and custom home office setups (e.g., the number of displays or tables).

Additionally, *HOMPA* currently does not include the possibility of quickly changing preferences due to unforeseen circumstances (e.g., a sick child). It is also an open question whether some parts of the factors should be weighted more (e.g., personal preference).

Finally, *HOMPA*'s accuracy depends on the accuracy of the available data. It seems obvious that personality factors are inherently difficult to measure and that some will try to conceal parts of their identity to their benefit. Additionally, some subequations rely currently on empirical insights from singular studies, which makes the results not particularly robust.

We stress that *HOMPA*'s outcome should only be used as a basis for discussion and recalculated if company infrastructure or employees' preferences change. We also refrain from, for example, linearly combining the subfactors into one single score as this score could easily misrepresent the actual situation (e.g., the employer does not want home office while the employee wants 100% home office would lead to a score of 50%). Besides altering the home office proportion, there are other possibilities to arrange for a fruitful collaboration, such as providing more flexible scheduling and work arrangements, implementing employee feedback mechanisms, and open communication between employer and employees.

4.4 Ethical Considerations

While the presented algorithm provides a practical solution for determining the ideal proportion of home office, it raises ethical concerns.

According to Orphanou et al. [30], a key concern is algorithmic fairness. Preventing potential biases related to gender, age, or race is crucial, as a biased algorithm could result in unfair treatment of employees, impacting their mental health and the company's working atmosphere. For example, employees might still want the right to home office regardless of actually using it to be treated equally.

Protecting against algorithm misuse, such as altering data, falsely assessing teleworkability, or invading employee privacy, is also important (see [8, 9, 11]). There is a risk that *HOMPA* could be extended in a way that solely benefits the employer (see [14]), creating an unjust system. Thus, it is necessary to ensure that any modifications or updates to *HOMPA* serve the interests of all stakeholders and do not undermine the fundamental rights of employees.

Another important ethical consideration is who should determine whether *HOMPA* should be applied. Should it be the employer, the employees, or employee representatives? In line with Das Swain et al. [11], it is essential to consider the interests of all stakeholders in the decision-making process, including the potential impact of *HOMPA* on employee satisfaction, morale, and mental health.

Moreover, the frequency of recalculating the proportions of home office is an ethical consideration. *HOMPA* must be updated frequently enough to ensure that it remains relevant and accurate while also considering that frequent recalculation may impose additional organizational and mental efforts on employees and the company if the ways of work often change.

4.5 Limitations

In this work, we presented an algorithm to determine the ideal proportion of home office from the employer's and employee's perspective, which has some limitations that we address in this chapter.

Local applicability: In Section 3.2.4, the Task-Media-Fit model and its application were discussed in detail. As *HOMPA* is based on a survey of employees in Germany, the algorithm could lead to a different or inaccurate result in other countries. The cultural aspect is therefore not taken into account. Furthermore, the Task-Media-Fit model does not consider the activities "training, instructing, teaching, education", as these were considered to be only partially but not completely *teleworkable*. The Corona crisis has shown that teaching and instructing also work digitally [33].

Company data: *HOMPA* was simulated in the context of this project work based on two different companies. These companies were modeled after real-world companies. In principle, *HOMPA* should, therefore, also work with real company data, whereby an internal company survey can validate the assumptions for the social factors for home offices and, if necessary, modified specifically for the company. Aspects of data protection must be taken into account.

Selection of social criteria: Various social criteria were selected for the formation of *HOMPA*. The criteria most frequently mentioned in previous studies were used [2, 5, 21, 34]. However, it can be assumed that other criteria can also shape the motivation for home office. Examples include membership of minorities or possible conflicts at the workplace. One criterion used in *HOMPA* is gender. Here, only male and female genders are considered, as no data has been found for gender diversity (presumably, none is available). One criterion that was not considered is trust between employee and employer. As trust exists for mostly personal reasons - or not, the objective approach for an algorithm was missing.

Legal considerations: An algorithm for home office implementation may also face limitations due to legal considerations and external factors that could override its results. For instance, during the COVID-19 pandemic, the urgent need for increased work from home may supersede *HOMPA*'s recommendations as health and safety concerns become the top priority.

5 CONCLUSION AND FUTURE WORK

Discussion about home office became even more relevant due to COVID-19. However, to date, there does not exist a mathematical formulation of a potentially ideal solution to the proportion of home office. Our developed algorithm is an approach to offer employers an objective assessment of the "home office" option based on related literature. As we took both the employer's and employee's point of view into account, there is a very good chance for high acceptance. We used our algorithm to evaluate two fictional companies. In the future, our algorithm can help employees and employers determine appropriate measures for home office for the best of both sides. Additionally, to evaluate *HOMPA*'s effectiveness, it is crucial to compare its results with actual home working experiences in practice, identifying areas of improvement or discrepancies. By analyzing these findings, refinements can be proposed to enhance *HOMPA*'s accuracy and adaptability to evolving work-from-home scenarios and requirements.

REFERENCES

[1] Rianne Appel-Meulenbroek, Astrid Kemperman, Amke van de Water, Minou Weijs-Perrée, and Jan Verhaegh. 2022. How to attract employees back to the office? A stated choice study on hybrid working preferences. *Journal of Environmental Psychology* 81 (2022), 101784. https://doi.org/10.1016/j.jenvp.2022.101784

[2] Melanie Arntz, Sarra Ben Yahmed, and Francesco Berlingieri. 2020. Working from home and Covid-19: The chances and risks for gender gaps. *Intereconomics* 55, 6 (2020), 381–386.

[3] Lutz Bellmann and Olaf Hübler. 2021. Working from home, job satisfaction and work–life balance–robust or heterogeneous links? *International Journal of Manpower* 42, 3 (2021), 424–441.

[4] T Boeri, A Caiumi, and M Paccagnella. 2020. Mitigating the work-Security trade-off while rebooting the economy. Covid Economics Vetted and Real-Time Papers No. 2. https://cepr.org/voxeu/columns/mitigating-work-security-trade-while-rebooting-economy.

[5] Holger Bonin, Werner Eichhorst, Jennifer Kaczynska, Angelika Kümmerling, Ulf Rinne, Annika Scholten, and Susanne Steffes. 2020. s. , 140 pages.

[6] Andrew R Carlos and Daisy C Muralles. 2022. Onboarding in the age of COVID-19. *IFLA journal* 48, 1 (2022), 33–40.

[7] Armanda Cetrulo, Dario Guarascio, and Maria Enrica Virgillito. 2020. The privilege of working from home at the time of social distancing. *Intereconomics* 55 (2020), 142–147.

[8] Shreya Chowdhary, Anna Kawakami, Jina Suh, Mary L Gray, Alexandra Olteanu, and Koustuv Saha. 2023. Can Workers Meaningfully Consent to Workplace Wellbeing Technologies? *arXiv preprint arXiv:2303.07242* (2023).

[9] Marios Constantinides and Daniele Quercia. 2022. Good Intentions, Bad Inventions: How Employees Judge Pervasive Technologies in the Workplace. *IEEE Pervasive Computing* 22, 1 (2022), 69–76. https://doi.org/10.1109/MPRV.2022.3217408

[10] Richard L Daft and Robert H Lengel. 1986. Organizational information requirements, media richness and structural design. *Management science* 32, 5 (1986), 554–571.

[11] Vedant Das Swain, Lan Gao, William A Wood, Srikruthi C Matli, Gregory D Abowd, and Munmun De Choudhury. 2023. Algorithmic Power or Punishment: Information Worker Perspectives on Passive Sensing Enabled AI Phenotyping of Performance and Wellbeing. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems*. ACM, New York, NY, USA, 1–17.

[12] Jonathan I Dingel and Brent Neiman. 2020. How many jobs can be done at home? *Journal of Public Economics* 189 (2020), 104235.

[13] Angela Lee Duckworth and Patrick D Quinn. 2009. Development and validation of the Short Grit Scale (GRIT–S). *Journal of personality assessment* 91, 2 (2009), 166–174.

[14] Sandy JJ Gould, Anna Rudnicka, Dave Cook, Marta E Cecchinato, Joseph W Newbold, and Anna L Cox. 2023. Remote work, work measurement, and the state of work research in human-centred computing. *Interacting with Computers* (2023).

[15] Beatrice Hamberger. 2020. Pendeln kostet Zeit und Nerven. https://www.tk.de/techniker/magazin/life-balance/balance-im-job/pendeln-kostet-zeit-und-nerven-2048874

[16] Hans-Böckler-Stiftung. 2021. Studien zum Homeoffice und mobiler Arbeit. https://www.boeckler.de/de/auf-einen-blick-17945-Auf-einen-Blick-Studien-zu-Homeoffice-und-mobiler-Arbeit-28040.htm

[17] David A Hensher, Edward Wei, and Matthew J Beck. 2023. The impact of COVID-19 and working from home on the workspace retained at the main location office space and the future use of satellite offices. *Transport Policy* 130 (2023), 184–195.

[18] Margo Hilbrecht, Susan M Shaw, Laura C Johnson, and Jean Andrey. 2008. 'I'm home for the kids': contradictory implications for work–life balance of teleworking mothers. *Gender, Work & Organization* 15, 5 (2008), 454–476.

[19] E Jeffrey Hill, Brent C Miller, Sara P Weiner, and Joe Colihan. 1998. Influences of the virtual office on aspects of work and work/life balance. *Personnel psychology* 51, 3 (1998), 667–683.

[20] Viviane Illegems and Alain Verbeke. 2004. Telework: what does it mean for management? *Long Range Planning* 37, 4 (2004), 319–334.

[21] Anita Kamouri and Kate Lister. 2020. Global Work-from-Home Experience Survey - Findings from a global research effort to understand the Work-from-Home experience, benefits, and barriers to success. USA.

[22] Shun Kawakubo and Shiro Arata. 2022. Study on residential environment and workers' personality traits on productivity while working from home. *Building and Environment* 212 (2022), 108787.

[23] Florian Kunze, Kilian Hampel, and Sophia Zimmermann. 2020. Homeoffice in der Corona-Krise: eine nachhaltige Transformation der Arbeitswelt? , 7 pages.

[24] Julia Christine Lengen, Ann-Christin Kordsmeyer, Elisabeth Rohwer, Volker Harth, and Stefanie Mache. 2021. Soziale Isolation im Homeoffice im Kontext der COVID-19-Pandemie: Hinweise für die Gestaltung von Homeoffice im Hinblick auf soziale Bedürfnisse. *Zentralblatt Fur Arbeitsmedizin, Arbeitsschutz Und Ergonomie* 71, 2 (2021), 63.

[25] Susan Lund, Anu Madgavkar, James Manyika, Sven Smit, Kweilin Ellingrud, and Olivia Robinson. 2021. The future of work after COVID-19. https://www.mckinsey.com/featured-insights/future-of-work/the-future-of-work-after-covid-19

[26] Joseph Edward McGrath. 1984. *Groups: Interaction and performance*. Vol. 14. Prentice-Hall, Englewood Cliffs, NJ, USA.

[27] Joseph E McGrath. 1993. Putting the" Group" Back in Group Support Systems: Some Theoretical Issues About Dynamic Processes in Groups with Technological Enhancements. *Group Support systems: New perpectives* (1993), 78–96.

[28] Brian E Mennecke, Joseph S Valacich, and Bradley C Wheeler. 2000. The effects of media and task on user performance: A test of the task-media fit hypothesis. *Group decision and negotiation* 9, 6 (2000), 507–529.

[29] Microsoft. 2021. The next great disruption is hybrid work-are we ready? https://www.microsoft.com/en-us/worklab/work-trend-index/hybrid-work

[30] Kalia Orphanou, Jahna Otterbacher, Styliani Kleanthous, Khuyagbaatar Batsuren, Fausto Giunchiglia, Veronika Bogina, Avital Shulner Tal, Alan Hartman, and Tsvi Kuflik. 2022. Mitigating Bias in Algorithmic Systems—A Fish-Eye View. *ACM Comput. Surv.* 55, 5, Article 87 (dec 2022), 37 pages. https://doi.org/10.1145/3527152

[31] Atsushi Oshio, ABE Shingo, and Pino Cutrone. 2012. Development, reliability, and validity of the Japanese version of Ten Item Personality Inventory (TIPI-J). *Japanese Journal of Personality* 21, 1 (2012), 13 pages.

[32] Dennis Pagel. 2020. Weniger Büroflächen: Homeoffice-Trend kann sich für viele Unternehmen langfristig lohnen. https://www.pwc.de/de/pressemitteilungen/2020/weniger-buroflachen-homeoffice-trend-kann-sich-fur-viele-unternehmen-langfristig-lohnen.html

[33] Juan-Ignacio Pozo, María-Puy Pérez Echeverría, Beatriz Cabellos, and Daniel L. Sánchez. 2021. Teaching and Learning in Times of COVID-19: Uses of Digital Technologies During School Lockdowns. *Frontiers in Psychology* 12 (2021), 11 pages. https://doi.org/10.3389/fpsyg.2021.656776

[34] B. Raffelhüschen and R. Schlinkert. 2018. *Deutsche Post Glücksatlas 2018*. Penguin Verlag, Munich, Germany. https://books.google.de/books?id=x3ByDwAAQBAJ

[35] Katie Reid and Greg Lewis. 2021. LinkedIn Data Shows Women and Gen Z Are More Likely to Apply to Remote Jobs. https://iscjobs.com/linkedin-data-women-gen-z-more-likely-to-apply-to-remote-jobs/

[36] Matteo Sostero, Santo Milasi, John Hurley, Enrique Fernandez-Macias, and Martina Bisello. 2020. *Teleworkability and the COVID-19 crisis: a new digital divide?* Technical Report. JRC working papers series on labour, education and technology.

[37] Frauke Suhr. 2019. Immer mehr Unternehmen erlauben Homeoffice. https://de.statista.com/infografik/16711/anteil-der-unternehmen-die-homeoffice-erlauben/

[38] Diane-Gabrielle Tremblay and Laurence Thomsin. 2012. Telework and mobile working: analysis of its benefits and drawbacks. *International Journal of Work Innovation* 1, 1 (2012), 100–113.

A EXTRACTED VARIABLES WITH SOURCE

Based on the selected literature, we defined variables for the different steps to determine the proportion of home office for employees and companies.

Table 5. Variables for the presented algorithm.

Evaluation Step	Variable	Type	Literature source
1a - Field of activity	T_1 (Manufacturing industry/ Production)	Float	[2]
	T_2 (Quality Control/ Repair/ Renovation)	Float	[2]
	T_3 (Transportation/ shipping/ logistics/ loading)	Float	[2]
	T_4 (Gastronomy or hotel trade)	Float	[2]
	T_5 (Entertainment Industry)	Float	[2]
	T_6 (Nursing professions)	Float	[2]
	T_7 (Traffic control/ traffic monitoring)	Float	[2]
	T_8 (Recycling/waste management/cleaning)	Float	[2]
	T_9 (Advice/ Consulting)	Float	[2]
	T_{10} (Marketing/ PR/ Advertising)	Float	[2]
	T_{11} (Planning/ organization/ preparation of processes)	Float	[2]
	T_{12} (Research and Development)	Float	[2]
	T_{13} (Information gathering and documentation)	Float	[2]
	T_{14} (Working with computers)	Float	[2]
	T_{15} (Internet use/ email processing)	Float	[2]
	T_{16} (Purchasing/ Sales)	Float	[2]
1b- Infrastructure	Infrastructure	Boolean	[7]
1c - Trial period	entree date	Date	[29]
1d - group work (based in the task Media Fit Hypothesis)	Q_1 Generate plans and tasks	Float	[26]
	Q_2 Solving Problems and Decision making	Float	[26]
	Q_3 Negotiate	Float	[26]
	$Q_{4.1}$ Resolving Conflicts of Power	Float	[26]
	$Q_{4.2}$ Executing Performance Task	Float	[26]
2a - Generation	Y_{birth}	Date	[21]
2b - Education	L_{edu}	String	[5]
2c- Commute time	t_{commute}	Integer	[34]
2d - Caring Responsibility	G	String	[2]
	C	String	
2e - Personality	OPN	Integer	[22]
	NCM	Integer	
	PP	Integer	
3 - Employees' requests	H_{wish}	Boolean	[21]
	$H_{\text{wish}_{\text{days}}}$	Integer	[21]

B INDIVIDUAL PROPORTION OF HOME OFFICE FOR EVERY EMPLOYEE

Table 6. Results for each employee of the Sport GmbH.

Job	H_{social}	H_{opt}	H_{max}	H_{prefer}	diff_to_max	diff_to_opt	diff_to_social
Cleaner	38.5	0	0	0.0	0	0	38
Controller	36.9	0	0	40.0	-40	-40	-3
HR Manager	43.4	60	100	40.0	60	20	3
IT specialist 1	43.5	100	100	80.0	20	20	-36
IT specialist 2	43.4	100	100	100.0	0	0	-56
Janitor	26.2	0	0	0.0	0	0	26
Marketing Manager	43.0	100	100	40.0	60	60	2
Purchasing Manager	35.6	70	100	0.0	100	70	33
Sales Representative	31.8	45	100	0.0	100	45	31
Secretary	38.98	100	100	60.0	40	40	-21
Salesman	43.5	0	0	0.0	0	0	43
Salesman	33.0	0	0	0.0	0	0	32
Salesman	43.0	0	0	0.0	0	0	42
Salesman	35.0	0	0	0.0	0	0	34
Store Manager	29.25	20	80	20.0	60	0	8
Store manager	24.5	20	80	40.0	40	-20	-5
Team Manager - Finances	47.0	70	100	0.0	100	70	42

Table 7. Results for each employee of the Bank Zwei AG.

Job	H_{social}	H_{opt}	H_{max}	H_{prefer}	diff_to_max	diff_to_opt	diff_to_social
Controller	42.59	100	100	80	20	20	-37
Purchasing manager	43.0	65	100	100	0	-35	-57
Janitor	35.4	0	0	0	0	0	35
IT specialist	47.6	100	100	20	80	80	27
Customer care	38.2	80	100	40	60	40	-1
Customer care	49.6	75	100	100	0	-25	-50
Marketing manager	42.7	75	100	40	60	35	2
HR Manager	50.6	50	100	20	80	30	30
Cleaner	34.6	0	0	0	0	0	34
Secretary	36.8	100	100	0	100	100	36
Team Manager - Finances	49.0	70	100	0	100	70	48

C GROUP TASK CIRCUMPLEX MODEL

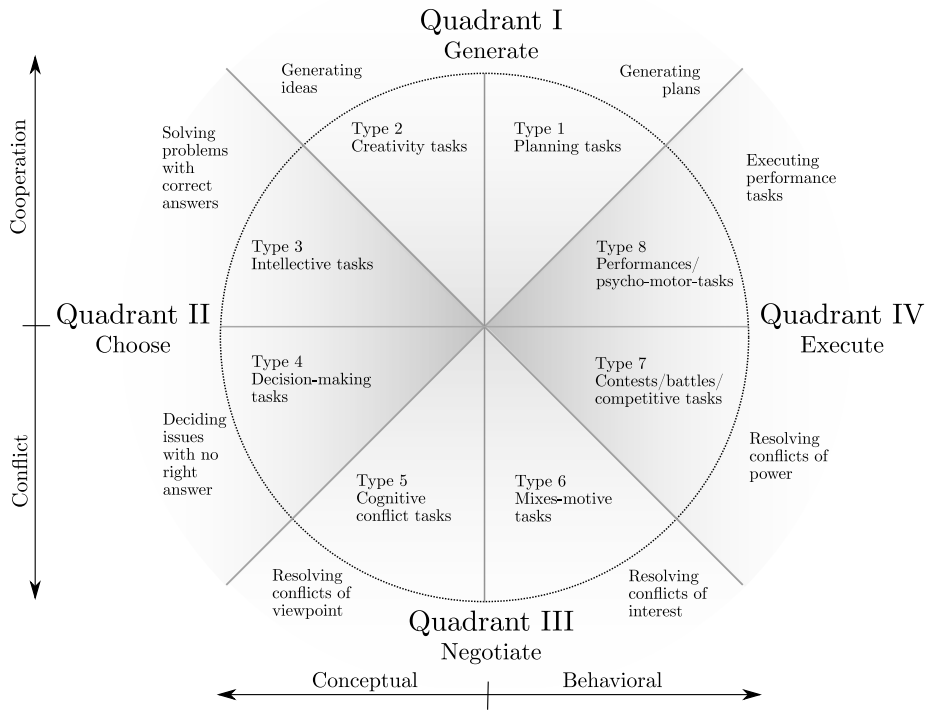

Fig. 2. Group Task Circumplex model according to McGrath [26].