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Is Remote Working Effective
in the Public Utility Sector?
The Perspective of Resource
Allocation in Administrative
and Civil Services



ABSTRACT

Objectives: (1) assessing the effectiveness of resource allocation in the public utility sector groups during remote work, (2) examining the efficiency of remote work compared to stationary work from the entire public utility organization point of view.

Methodology: To operationalize the research aim, ten research questions (RQ1-RQ9) and a research hypothesis (H1) were prepared for the identification of the effectiveness of resource allocation (Table 1).

H1. If remote work improves time management effectiveness for daily tasks, employees are willing to invest their resources to work remotely.

Research question RQ10 was prepared to achieve this goal, and the second hypothesis (H2) was formulated.

H2. Remote working reduces public utility sector institutions' resource consumption (utility expenses).

Findings: (1) remote work requirements do not occupy a significant portion of annual budgets for public utility services, (2) remote work allows reducing the fixed costs of maintaining stationary working in the short term, (3) even if remote work is a cost-effective method for public utility services and decreases indirect employee costs, it has yet to be incorporated successfully.

Value added: Consequently, remote work saves resources and is cost-effective for employers. It lowers indirect employee costs (real tax deductible costs) in terms of utility expenses because employees work out of their institutions' premises in civil and administrative services. In addition, the employer does not finance the psychological and physiological needs of employees adapting to remote work in both services.

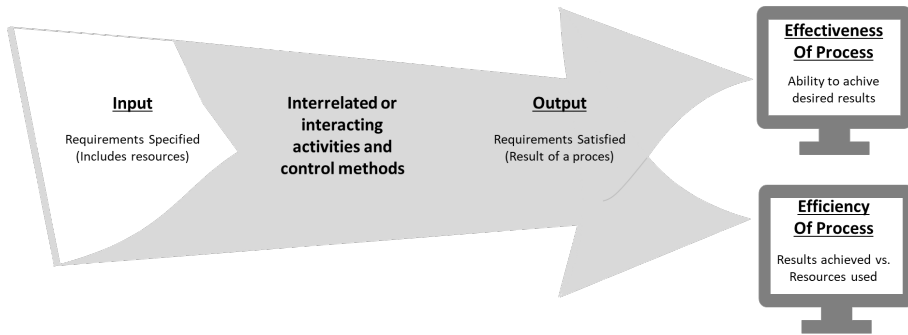
Recommendations: Future research will be essential to assess whether remote work applications have improved in the public utility sector in this regard. Additionally, it would be best practice to conduct a study with a similar research concept in the private sector to compare findings and implementation strategies and offer solutions to the challenges caused by remote work.

Key words: remote working, effectiveness of public utility service, efficiency of public utility service, civil service, administrative service, Belbin's Team roles, Jung's personality types concept

Introduction

Remote work is a response to the needs of modern economies, where private and public institutions operate and create networks of connections. Amongst them is the public utility sector, which refers to an activity, good, or service that brings benefits or collective interests to the residents of a country (Bruijn & Dicke, 2006). In this study, remote work is considered part of the work process in the public utility sector. According to ISO 9000, a "process" can be defined as a "set of interrelated or interacting activities, which transforms inputs into outputs". These activities require allocating resources such as people and materials (Corrie, 2004). Both inputs and desired outputs can be physical (such as equipment, materials, or components) or intangible (such as energy or knowledge) (Corrie, 2004). According to ISO 9000, effectiveness is the ability to achieve desired results (Tsim et al., 2002; Corrie, 2004). From this point of view, remote working is such an input employed to achieve desired output of the work process in the public utility sector (Figure 1). This study defines the effectiveness of remote working as the ability to achieve desired results from an economic perspective based on technological effectiveness, effectiveness of resource allocation, and management effectiveness perspectives.

Figure 1. Effectiveness of public utility sector – the key subject of research



Source: own compilation based on Corrie (2004).

Efficiency is the ratio of the results achieved to the resources used. *Efficiency* in the holistic meaning of remote working is difficult to estimate due to too complex cost categories, which are often immeasurable or difficult to value in money directly. We could only capture and measure the efficiency of remote working versus stationary work in the resource allocation context. When assessing the efficiency of remote working in the public utility sector, it can be assumed that the results are achieved at 100%, i.e., services are provided in full scope every year. In other words, the results are constant. In this case, the amount of resources used is assessed depending on how work is performed (stationary versus remote work) (Orzeł & Wolniak, 2022).

The public sector's ability to adapt to remote workability depends mainly on complying with institutional arrangements, quality and control management, and human resource management (Mousa & Abdelgaffar, 2021). Public sector entities apply the required organizational arrangements to implement remote working effectively. It can be achieved when: a) employees are equipped with critical information and communications technology (ICT) devices and solutions, applications, software, and online connectivity to internal and external networks; b) work guidelines are established and adopted, and remote communication and collaboration tools are used; c) the execution of management functions (planning, organizing, and leading, i.e., motivating and controlling) are adapted to remote work (Milasi et al., 2021).

Remote work can be used in both the private and public sectors. In the private sector, numerous studies indicate its advantages in achieving desired results (effectiveness) and results achieved vs. resources used (efficiency). In the literature, we can most often find research results on such areas of remote work effectiveness measurement as reduction of commuting costs (Marasigan, 2020), reduction of job maintenance costs (Gajendran, 2017), improvement of the efficiency of working time management (Beckmann, 2016), reduction of office service costs (Rayome, 2018), increase in work efficiency, increase in autonomy and self-reliance of employees (Bloom et al., 2015; Kam, 2023). Nevertheless, challenges remain in such areas as the ineffectiveness of motivation and communication (Madlock, 2013), personalization of working conditions (Perry et al., 2018), spatial differentiation of propensity to work remotely (Gallacher & Hossain, 2020), work-life balance, maintaining interest and productivity (Raj et al., 2023). Comprehensive measures for assessing the effectiveness of remote work are a challenge (EY, 2021; Deloitte Insight, 2021). Insufficient performance monitoring systems translate into the lack of sufficiently effective tools in remote work organizations.

The unexpected outbreak of the COVID-19 pandemic affected the way public sector organizations operate (Schuster et al., 2020), with remote working rapidly increasing in popularity. Many organizations had to quickly transition to the remote work system (Bick et al., 2020) to ensure the continuity of public service delivery (Belzunegui-Eraso & Erro-Garces, 2020). Public institutions (e.g., universities and municipalities) also transitioned to remote working. In the public sector, research on the effectiveness and efficiency of remote work is much less advanced. Researchers focus primarily on the challenges and barriers limiting the use of remote work (Schuster et al., 2020).

The first group of challenges includes technical and technological aspects. Barriers noted include access to technology (OECD, 2020), operability of ICT solutions, or insufficient support infrastructure (Schuster et al., 2020). Another aspect concerns the costs, which are significant, especially for organizations that have limited adoption of digitization. Entities also lacked funding for this purpose (Choi, 2018). There are also threats related to the lack of experience, organization and work approaches, management resistance, and insufficient competencies

(especially technological ones). Although legislative policies regulate and enable total or partial implementation of remote work in public entities, concerns regarding cybersecurity, privacy, and information confidentiality were significant barriers (Berg et al., 2021).

In the traditional way of working, employees are motivated and monitored while at the workplace, interacting with supervisors and colleagues and coordinating activities together (Felstead & Henseke, 2017). Remote work reduces the possibility of supervising employees, triggering the search for new practices to enable effective staff management (Taskin & Edwards, 2007). Therefore, the adequate level of essential managerial competencies, especially in the public sector, for individuals operating in a virtual environment and leading remote teams presents a significant challenge (Maher & Bedawy, 2015; Trippner-Hrabi et al., 2023). Managers should follow the principles of dividing team roles according to Belbin or Jung's personality types concept. This is helpful when taking actions related to, for example, the division of duties, responsibilities or the selection of motivational tools (Diab-Bahman, 2021).

A particular area of challenges for improving remote work in the public sector is the feeling of lower job stability, weaker identification with the organization, more intense work, and blurring of the boundaries between work and private life. Employees who work remotely suffer from increasing work-life clashes (Filardi et al., 2020; Palumbo, 2020; Ferreira et al., 2021; Ipsen et al., 2021; Bloom et al., 2022). The more teleworkers feel that their e-work contributes to their task performance, the better their self-reported mental health and vitality are, and vice versa (Grant et al., 2019). However, de Vries et al. (2019) show that remote work did not negatively affect employee engagement. Remote work in public institutions is becoming an option since entities must be effective and efficient by adapting the work system to market requirements and customer needs. In addition, they operate based on networking, where they are members of many networks in which cooperation and communication are based to a significant extent on remote work. However, it should be remembered that in the public sector, particularly in the public utility sector, no market determinants are mobilizing for high work efficiency and effectiveness. The profit category is secondary. Priorities regarding the continuity of provision and access to public services are

not directly related to minimizing costs and maximizing income. Therefore, these institutions require systemic support at the level of diagnosing areas of ineffectiveness and disseminating tools to increase effectiveness.

Methodology for researching the effectiveness of resource allocation in terms of remote work

The evaluation of remote work is a multi-dimensional category. Identifying whether and under what conditions remote work is economically effective in the public utility sector requires a holistic approach. According to the definition adopted in the conducted research, the holistic effectiveness of remote work was defined in the area of three perspectives: effectiveness of resource allocation, technological effectiveness (topic analyzed in another paper), and management effectiveness (topic analyzed in another paper). Our research subject is evaluating the use of remote work from the allocation perspective. In this context, the first paper aims to assess the effectiveness of resource allocation in the public utility sector groups during remote work. That is why the paper focused only on the effectiveness of resource allocation. In order to operationalize the research aim, ten research questions (RQ1-RQ10) and a research hypothesis (H1) were prepared for the identification of the effectiveness of resource allocation (Table 1).

H1. *If remote work improves time management effectiveness for daily tasks, employees are willing to invest their resources to work remotely.*

The second aim is to examine the efficiency of remote work compared to stationary work from the point of view of the entire public utility organization. Research question RQ10 was prepared to achieve this goal, and the second hypothesis (H2) was formulated.

H2. *Remote working reduces public utility sector institutions’ resource consumption (utility expenses).*

Table 1. Research questions to identify the effectiveness of remote work from the perspective of resource allocation

Research question:	Code:
To what extent does remote work affect indirect employee costs (actual tax deductible costs)?	RQ1.
Do employees’ household expenses in utility spending get higher during remote working?	RQ2.
Does remote work improve time management for daily tasks?	RQ3.
What properties of human capital determine the effectiveness of remote work?	RQ4.
What part of annual budget is allocated to financing remote work requirements in the institution?	RQ5.
Does the employer finance employees’ psychological and physiological needs to adapting remote work?	RQ6.
To what extent can remote work replace work at the institution’s headquarters?	RQ7.
Does implementing the Plan-do-check-act Deming cycle during remote work improve time management efficiency for daily tasks?	RQ8.
Do R&D activities impact the level of achieving the goals of the public institution during remote work?	RQ9.
Does remote work save public institutions’ resources (water, electricity, consumption)?	RQ10.

Source: own elaboration.

According to the classic definition of the public utility sector, three types of public services can be distinguished:

- Administrative services (e.g., decision, strategic planning, registrations, local taxes),
- Civil services (e.g., education, culture, sports, social care),
- Technical/infrastructural services (e.g., water supply, public transport, maintenance of roads, public spaces).

Based on this typology, the study included administrative and civil services. We excluded infrastructure services because they are closely related to the use of technical infrastructure in the physical space. Hence, the virtual dimension is limited. In addition, these services are most often outsourced to the private sector. Units were selected for the survey if they provided civil and administrative services and met the following conditions:

- potentially highly advanced level of remote working,
- team working,
- innovation potential in services,
- highly able to use remote work,
- a complex range of tasks.

The criteria allow us to identify those areas of public sector activity that are most demanding in terms of work organization and management system. Administrative service providers include various types of departments, where residents and business entities are clients. The basic types of administrative services that meet the criteria defined above include those related to decision issuance, strategic planning, spatial planning, and marketing management. In this regard, city hall units with the greatest scope of autonomy were selected for the study to eliminate potential regional differences in the organization and provision of services. The survey was conducted in all 16 regional capitals in Poland. In each city, the survey was conducted in two selected departments. The total general population was 32 units. Ultimately, 26 units (81%) participated in the survey. Due to the substantive scope of the survey, the direct respondent was the unit head.

The scope of civil service providers is much broader, as educational, cultural, recreational, social, and other services can be included. Similar selection criteria were applied to the selection of entities for administrative services. The criteria adopted allowed the selection of civil services in the higher education sector for the study. It was also assumed that regional differences in their organization and provision might exist. To this end, the best university in each region was selected (using the Perspectives 2021 comparative ranking of higher education institutions). A survey was conducted in the 16 best universities in each region.

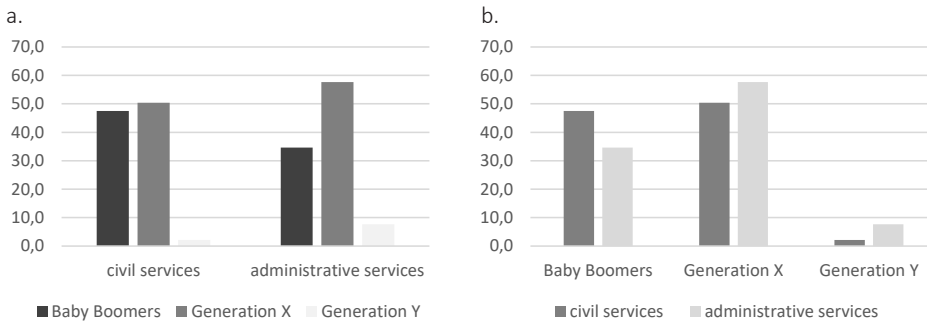
Unlike clerical and administrative work, academics work primarily with independent research teams. Each university has a specific organizational structure and varied self-governance. Hence, it was decided to survey the level of each independent organizational unit, that is, at the level of each faculty (a total of 185 faculties were identified). Faculties have their managers – deans – responsible for shaping how work is organized within the unit, including its structure and tools. Faculties are often divided into smaller organizational units, including departments, institutes, laboratories, and research teams.

Nevertheless, the environment for creating working conditions in these units is similar at the level of the entire department. Hence, using simple random sampling in each department, one unit (e.g., department, research team) was selected for the survey. The direct respondent was the head of this unit due to the substantive scope of the survey. Ultimately, the survey was implemented in 139 units, representing 75% of the general population.

The data were collected through an online survey that comprised 61 questions assigned to the research questions. When constructing the survey, in addition to the author's methodologies, the following concepts were used: Personality types (according to Jung, 1971), Team roles (according to Belbin, 2012), the PDCA (plan-do-check-act) cycle (according to Deming), the process approach (according to ISO 9000), Decision level concept: Empowerment and delegation stage (according to Conger et al., 1998), Work-Life Spill-Over (according to Felstead & Henseke, 2017). A 0 to 5 scale was used for the survey questions, with the percentage calculated as follows: 0 = 0%, 1 = 20%, 2 = 40%, 3 = 60%, 4 = 80%, and 5 = 100%.

Finally, research was conducted among 165 heads of departments in Poland's civil and administrative services departments. One hundred thirty-nine department leaders work in civil services and twenty-six in administrative services. Among the 139 civil services leaders that constitute the first sample group of the study, 66 are in the 58–76 age range (Baby Boomers), 70 are in the 42–57 age range (Generation X), and three are in the 27–41 age range (Generation Y). Among the 26 administrative services leaders that constitute the second sample group, nine are in the 58–76 age range (Baby Boomers), fifteen leaders are in the 42–57 age range (Generation X), and two are in the 27–41 age range (Generation Y), (Figure 2 (a, b)).

Figure 2 (a, b). The number of leaders (respondents) in administrative and civil services by age group



Source: own elaboration.

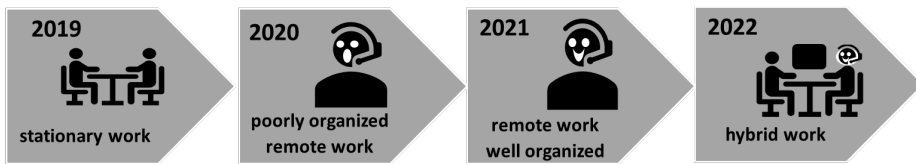
The average time worked by the civil services leaders in their department is ten years, and six years for administrative services department leaders. The marital status of the leaders is married 124 (89.2%) and single 15 (10.8%) for heads of departments in civil services, married 22 (84.6%) and single 4 (15.4%) for administrative services.

When department member profiles are examined (i.e., leaders and workers), civil services (139) on average comprised 18.86% of Baby Boomers, 47.62% of Generation X, 31.58% of Generation Y, and 1.94% of Generation Z. On the other hand, administrative services (26) on average comprised 14.56% Baby Boomers, 44.25% Generation X, 38.66% Generation Y, and 2.53% Generation Z. The national characteristics were 95.51% Polish and 4.49% foreigners for civil services, and 97.69% Polish and 2.31% foreigners for administrative services. Gender characteristics were 48.62% women and 51.38% men for civil services, 72.18% women, and 27.82% men for administrative services.

To sum up, when examining the effectiveness of remote work, we conducted research using surveys: (1) in all city halls that are the capitals of the Polish region (16 cases) and (2) at the best universities in each Polish region (16 cases). In order to achieve the second aim of the research and obtain results regarding allocation efficiency, we also collected data for the diagnosis of costs in financial terms in these units. These data allowed us to carry out simplified analyses in terms of efficiency. Using a separate questionnaire, we collected data on the costs or the amount of consumption of raw materials: water, electricity, gas, cleaning

agents, waste production, and the costs of monitoring and protecting buildings. We collected these data for 2019–2022, assuming that individual years, due to the COVID-19 Pandemic, have different characteristics in terms of the use of remote work in public sector organizations. These characteristics are presented in Figure 3.

Figure 3. The dominant form of work in the public utility sector in the period 2019–2022 in Poland



Source: own elaboration.

Results

The study uses independent expressions to evaluate related research questions and hypotheses. On the other hand, the Plan-Do-Check-Act (PDCA) Deming cycle, R&D activities and Remote Work Participation and Time Allocation evaluations were made with multiple dependent expressions; therefore, exploratory factor analysis was performed to evaluate construction reliability. The suitability of the data for factor analysis was examined using the Kaiser-Meyer-Olkin (KMO) coefficient and the Bartlett Sphericity test.

Plan-Do-Check-Act (PDCA) Deming cycle

The KMO value is 0.867. The results of the Bartlett Sphericity test are also significant ($\chi^2 = 516.169$, $p < 0.001$). Upon reviewing the outcomes of both tests, it was deemed appropriate to conduct factor analysis on the data related to Plan-Do-Check-Act (PDCA) Deming cycle. In this regard, Principal Component

Analysis (Pearson, 1901) was applied as an estimation method, and the Varimax Rotation Method (Kaiser, 1958) was adopted.

Table 2. Results of the Exploratory Factor Analysis Related to Plan-Do-Check-Act (PDCA) Deming cycle

Corresponding Items	Plan-Do-Check-Act (PDCA) Deming cycle
Decision-Making in Team	0.862
Team Activity Proportion	0.846
Execution of Strategic and Ongoing Activities	0.845
Team Communication	0.794
Task and Project Control	0.766
Goal Achievement	0.648
Total Variance Explained	63.51%

Source: own elaboration.

A total of six expressions related to the one-dimensional construction in the study were subjected to factor analysis. The analysis revealed the existence of one dimension with an eigenvalue exceeding 1. These one-dimension constructions account for a total variance of 63.51%.

Research and Developments (R&D) Activities

The KMO value is 0.617. The results of the Bartlett Sphericity test are also significant ($\chi^2 = 64.793$, $p < 0.001$). Upon reviewing the outcomes of both tests, it was deemed appropriate to conduct factor analysis on the data related to Research and Developments (R&D) Activities. In this regard, Principal Component Analysis (Pearson, 1901) was applied as an estimation method, and the Varimax Rotation Method (Kaiser, 1958) was adopted.

Table 3. Results of the Exploratory Factor Analysis Related to Research and R&D Activities

Corresponding Items	R&D Activities
Employer Facilitation of Knowledge-Sharing Meetings for Remote Employees	0.808
Employer Documentation of Informal Knowledge Exchange in Remote Work	0.803
Remote Work Equipment Needs: Employer Survey	0.660
Total Variance Explained	57.75%

Source: own elaboration.

A total of three expressions related to the one-dimensional construction in the study were subjected to factor analysis. The analysis revealed the existence of one dimension with an eigenvalue exceeding 1. These one-dimension constructions account for a total variance of 57.75%.

Remote Work Participation and Time Allocation

The KMO value is 0.500. The results of the Bartlett Sphericity test are also significant ($\chi^2 = 119.800, p < 0.001$). Upon reviewing the outcomes of both tests, it was deemed appropriate to conduct factor analysis on the data related to *Remote Work Participation and Time Allocation*. In this regard, Principal Component Analysis (Pearson, 1901) was applied as an estimation method, and the Varimax Rotation Method (Kaiser, 1958) was adopted.

Table 4. Results of the Exploratory Factor Analysis Related to Remote Work Participation and Time Allocation

Corresponding Items	Remote Work Participation and Time Allocation
Proportion of Team Employees Engaging in Remote Work	0.928
Extent of Monthly Time Devoted to Remote Work by Team Employees	0.928
Total Variance Explained	86.11%

Source: own elaboration.

A total of two expressions related to the one-dimensional construction in the study were subjected to factor analysis. The analysis revealed the existence of one dimension with an eigenvalue exceeding 1. These one-dimension constructions account for a total variance of 86.11%.

Moreover, Cronbach's alpha values were evaluated to exhibit reliability regarding internal consistency for research constructions. According to Rószkiewicz (2020) and Yıldız and Uzunsakal (2018), an instrument is deemed reliable when its Cronbach's alpha value exceeds 0.60. Plan-Do-Check-Act (PDCA) Deming cycle value evaluated as 0.876, R&D Activities value as 0.620 and Remote Work Participation and Time Allocation value as 0.818. The values indicate reliability in terms of internal consistency for research constructions.

Effectiveness of resource allocation in the public utility sector

In the following parts, the main research questions and hypotheses will be evaluated in the order in which they are presented in Table 1 according to the average mean value of correspondent survey questions and required statistical analyses.

In Table 5, the extent to which remote work affects indirect employee costs (RQ1) is evaluated separately with *Internet Cost Coverage by Employers* and *Support for Home Office Maintenance Costs* items for both utility services. As a result, it was revealed that they lower indirect employee costs (real tax deductible costs) in terms of utility expenses (electricity, water, CO, garbage, internet) because they do not bear any related costs. On the other hand, these scores lead us to evaluate research question RQ2 positively. Because employees need to finance their household expenses on their own during remote work. In other words, this confirms that employees' household expenses in terms of utility spending get higher for both services.

Table 5. Evaluation of to what extent remote work affects indirect employee costs (real tax deductible costs) and employees’ household expenses

Corresponding Items		Mean	Median	Skewness	Kurtosis	Std Dev.	U	P
Internet Cost Coverage by Employers	CS	0.37	0.00	3.14	8.97	1.14	1599.000	0.070
	AS	0.00	0.00	0.00	0.00	0.00		
Support for Home Office Maintenance Costs	CS	0.09	0.00	7.55	57.52	0.62	1837.000	0.615
	AS	0.12	0.00	5.09	26.00	0.58		

Description: Mann-Whitney’s test statistic; p – significance level- CS: Civil Services, AS: Administrative Services

Source: own elaboration.

In addition, Mann-Whitney’s test indicates no significant difference regarding *Internet Cost Coverage by Employers* and *Support for Home Office Maintenance Costs* for civil and administrative services.

In the following part, whether remote work improves time management efficiency for daily tasks will be evaluated for both utility services separately. The related scores are represented in Table 6.

Table 6. Evaluation of whether remote work improves time management efficiency for daily tasks

Corresponding Items		Mean	Median	Skewness	Kurtosis	Std Dev.	U	P
Remote Work Impact on Time Management Efficiency	CS	1.90	2.00	0.47	-0.92	1.67	1935.000	0.559
	AS	2.08	2.00	0.23	-1.04	1.62		

Description: Mann-Whitney’s test statistic; p – significance level – CS: Civil Services, AS: Administrative Services

Source: own elaboration.

According to the result, there is no significant difference regarding *Remote Work Impact on Time Management Efficiency* for civil and administrative services. Finally, the scores confirm that remote work does not improve time management efficiency for daily tasks in both services (RQ3).

Table 7. Evaluation of whether R&D activities have any impact on the level of achieving public institution goals during remote work

Corresponding Items		Mean	Median	Skewness	Kurtosis	Std Dev.	U	P
R&D activities	CS	1.34	1.00	0.68	-0.27	1.14	1907.000	0.653
	AS	1.70	1.33	1.04	-0.07	1.69		

Description: Mann-Whitney's test statistic; p – significance level – CS: Civil Services, AS: Administrative Services

Source: own elaboration.

Table 7 evaluates whether R&D activities impact achieving public institution goals during remote work for both utility services separately. The scores reveal that the employer does not effectively conduct R&D activities to improve the effectiveness of remote work in both services. In addition, there is no significant difference regarding *R&D activities* for civil and administrative services.

In the following part, what properties of human capital determine the effectiveness of remote work (RQ4) will be evaluated according to Jung's Personality types concept and Belbin's Team roles concept.

Table 8. Evaluation of Jung's personality types concept (one employee may be fit for several personalities)

Personality Types	The average percentage of employees in civil services (n = 139)	The average percentage of employees in administration services (n = 26)
A. people who like to have everything in order in their lives, plan everything, like a stable environment and procedures	55%	41%
B. essential people, quick in making decisions, practical, responsible, courageous, task-oriented at work	46%	34%
C. calm people who value harmony, do not like changes, with a high level of empathy and at the same time not very assertive	32%	25%
D. people who are spontaneous, communicative, joyful, self-confident, deriving satisfaction from civil contacts	40%	34%

Source: own research.

In this study, Jung’s personality types concept is one of the concepts that has been used to assess the properties of human capital in civil services and administrative services. The concept has four different types of personality that are type A (people who like to have everything in order in their lives, plan everything, like a stable environment and procedures), type B (essential people, quick in making decisions, practical, responsible, courageous, task-oriented at work), type C (calm people who value harmony, do not like changes, with a high level of empathy and at the same time not very assertive), and type D (people who are spontaneous, communicative, joyful, self-confident, deriving satisfaction from civil contacts) (Cooper et al., 2023). According to Table 8, the average percentage of employee profiles varies for both services. Both services have four different types of people in their institutions; however, the dominant personality types percentage shows differences concerning service types.

Table 9. Evaluation of Belbin’s Team roles concept (one employee can perform several roles)

Type of Team roles	Type of Service			
	Civil Services		Administrative Services	
Practical organizer	Yes (n = 139)	No (n = 0)	Yes (n = 24)	No (n = 2)
Coordinator – the natural leader	Yes (n = 135)	No (n = 4)	Yes (n = 23)	No (n = 3)
Innovator – Creator	Yes (n = 136)	No (n = 3)	Yes (n = 23)	No (n = 3)
Analyst – Judge	Yes (n = 130)	No (n = 9)	Yes (n = 21)	No (n = 5)
Source-seeker – a man of contacts	Yes (n = 135)	No (n = 4)	Yes (n = 21)	No (n = 5)
Perfectionist – meticulous performer	Yes (n = 137)	No (n = 2)	Yes (n = 24)	No (n = 2)
Group man – team soul – group player	Yes (n = 134)	No (n = 5)	Yes (n = 21)	No (n = 5)
Executor – implementer	Yes (n = 136)	No (n = 3)	Yes (n = 23)	No (n = 3)
Expert	Yes (n = 137)	No (n = 2)	Yes (n = 25)	No (n = 1)

Source: own research.

In this study, Belbin’s Team roles concept is another concept that has been used to assess the properties of human capital in civil services and administrative services. The concept has nine different types of team roles that are Practical

organizer, Coordinator – the natural leader, Innovator – Creator, Analyst – Judge, Source-seeker – a man of contacts, Perfectionist – meticulous performer, Group man – team soul – group player, Executor – implementer, and Expert. Table 9 shows that the dominant quantity of institutions has nine different types of team roles in both services.

Table 10. Evaluation of what part of the annual budget is allocated to financing remote work requirements in the institution

Corresponding Items		Mean	Median	Skewness	Kurtosis	Std Dev.	U	P
Allocation of Annual Team Budget for ICT Infrastructure and Software Access	CS	0.83	1.00	1.68	3.70	0.96	1134.500	0.001
	AS	0.27	0.00	1.92	3.20	0.53		
Allocation of Annual Team Budget for Skill Training	CS	0.27	0.00	3.16	11.93	0.64	2069.000	0.103
	AS	0.42	0.00	2.16	6.09	0.70		

Description: Mann-Whitney’s test statistic; p – significance level – CS: Civil Services, AS: Administrative Services

Source: own elaboration.

In Table 10, what part of the annual budget is allocated to financing remote work requirements in the institution (RQ5) is evaluated separately within *Allocation of Annual Team Budget for ICT Infrastructure and Software Access* and *Allocation of Annual Team Budget for Skill Training* for both utility services. As a result, there is a significant difference in favour of civil services in *Allocation of Annual Team Budget for ICT Infrastructure and Software Access*. There is no significant difference regarding *Allocation of Annual Team Budget for Skill Training*. However, it was revealed that the institution has a small annual budget assigned to pay for its remote work requirements. Requirements for remote work do not occupy a significant portion of annual budgets for both services. In other words, remote work is a cost-effective working method for employers.

Table 11. Evaluation of whether the employer finances the psychological and physiological needs of employees adapting to remote work

Corresponding Items		Mean	Median	Skewness	Kurtosis	Std Dev.	U	P
Employer-Funding for Remote Work Adaptation	CS	0.33	0.00	3.77	15.38	0.91	1545.000	0.068
	AS	0.08	0.00	5.09	26.00	0.39		

Description: Mann-Whitney’s test statistic; p – significance level – CS: Civil Services, AS: Administrative Services

Source: own elaboration.

There is no significant difference regarding *Employer-Funding for Remote Work Adaptation*. However, these scores confirm that the employer does not finance employees’ psychological and physiological needs adapting to remote work in both services (RQ6).

Table 12. Evaluation of to what extent remote work can replace work at the institution’s headquarters

Corresponding Items		Mean	Median	Skewness	Kurtosis	Std Dev.	U	P
Remote Work Participation and Time Allocation	CS	2.29	2.00	-1.34	-1.34	1.56	1784.500	0.919
	AS	2.27	2.50	-0.22	-1.05	0.96		

Description: Mann-Whitney’s test statistic; p – significance level – CS: Civil Services, AS: Administrative Services

Source: own elaboration.

Table 12 shows to what extent remote work can replace work at the institution’s headquarters (RQ7) and is evaluated for both utility services separately. There is no significant difference regarding *Remote Work Participation and Time Allocation* for utility services. However, it was revealed that remote work replaces almost 50% of work at the institution’s headquarters. In the following part, Spearman’s correlation for civil services evaluates the relationship between the research variables.

Table 13. Correlation analysis results regarding research variables for civil services

Variables	Mean	Median	SD	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1. PDCA Deming cycle	1.94	1.89	1.15										
2. Remote Work Participation and Time Allocation	2.29	2.00	1.56	0.45**									
3. R&D Activities	1.34	1.00	1.14	0.15	0.01								
4. Internet Cost Coverage by Employers	0.37	0.00	1.14	0.01	-0.03	0.15							
5. Support for Home Office Maintenance Costs	0.09	0.00	0.62	0.09	0.06	0.01	0.28**						
6. Remote Work Impact on Time Management Efficiency	1.90	2.00	1.67	0.44**	0.22**	0.23**	-0.04	-0.03					
7. Goal Achievement	2.40	2.00	1.61	0.72**	0.27**	0.22**	0.03	0.06	0.58**				
8. Allocation of Annual Team Budget for ICT Infrastructure and Software Access	0.83	1.00	0.96	0.06	0.04	0.31**	0.19*	-0.01	0.10	0.09			
9. Allocation of Annual Team Budget for Skill Training	0.27	0.00	0.64	0.10	0.07	0.21*	0.22**	0.17*	0.01	0.12	0.28**		
10. Employer-Funding for Remote Work Adaptation	0.33	0.00	0.91	-0.04	0.08	0.17*	0.14	0.05	-0.08	-0.01	0.14	0.09	
11. Employer Ownership of Office Equipment	2.35	2.00	1.65	-0.01	0.14	0.26**	0.17*	0.12	0.05	0.11	0.15	0.33**	0.03

Note: Spearman's correlation has adopted **p < .01, *p < .05, n = 139

Source: own elaboration.

According to the results, there is a significant and positive relationship between *the PDCA Deming cycle* and *Remote Work Participation and Time* ($r = 0.45$, $p < 0.01$), and *Goal Achievement* ($r = 0.72$, $p < 0.01$). In addition, there is a significant and positive relationship between *the PDCA Deming cycle* and *Remote Work Impact on Time Management Efficiency* ($r = 0.44$, $p < 0.01$). This finding lets us positively evaluate that implementing the Plan-do-check-act Deming cycle during remote work improves time management efficiency for daily tasks (RQ8) in civil services.

There is a significant and positive relationship between *R&D Activities*, *Remote Work Impact on Time Management Efficiency* ($r = 0.23$, $p < 0.01$), *Goal Achievement* ($r = 0.22$, $p < 0.01$), *Allocation of Annual Team Budget for ICT Infrastructure and Software Access* ($r = 0.31$, $p < 0.01$), *Allocation of Annual Team Budget for Skill Training* ($r = 0.21$, $p < 0.05$), and *Employer-Funding for Remote Work Adaptation* ($r = 0.17$, $p < 0.05$). In other words, R&D Activities are critical to being proactive regarding goal achievement and funding employee needs for civil services. These scores lead us to verify that if the employer conducts R&D activities to improve the effectiveness of remote work, achieving the public institution goals is higher in civil services (RQ9).

H1 suggested that: *If remote work improves time management efficiency for daily tasks, employees are willing to invest their resources to work remotely.* According to the correlation analysis result, no significant relationship exists between *Remote Work Impact on Time Management Efficiency* and *Employer Ownership of Office Equipment*. These scores lead us to reject H1 for civil services. In the following part, Spearman's correlation for administrative services evaluates the relationship between the research variables.

Table 14. Correlation analysis results regarding research variables for administrative services

Variables	Mean	Median	SD	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1. PDCA Deming cycle	1.71	1.66	0.94										
2. Remote Work Participation and Time Allocation	2.26	2.50	0.96	0.49*									
3. R&D Activities	1.70	1.33	1.69	0.52**	0.19								
4. Internet Cost Coverage by Employers	0	0	0	0	0	0							
5. Support for Home Office Maintenance Costs	0.12	0	0.58	-0.09	-0.08	-0.05	0						
6. Remote Work Impact on Time Management Efficiency	2.08	2.00	1.62	0.61**	0.15	0.09	0	0					
7. Goal Achievement	3.12	4.00	1.77	0.82**	0.24	**0.64	0	0	-0.21		0.41*		
8. Allocation of Annual Team Budget for ICT Infrastructure and Software Access	0.27	0	0.53	-0.13	0.12	0.02	0	0	-0.11	0.01	-0.06		
9. Allocation of Annual Team Budget for Skill Training	0.42	0	0.70	0.01	0.20	-0.01	0	0	0.26	0.07	-0.03	0.60**	
10. Employer-Funding for Remote Work Adaptation	0.08	0	0.39	-0.13	-0.08	0.16	0	0	-0.04	0.24	-0.08	0.45*	0.40*
11. Employer Ownership of Office Equipment	1.54	1.00	1.65	0.24	-0.03	0.32	0	0	0.18	0.20	0.19	0.13	0.19
													0.34

Note: Spearman’s correlation has adopted **p < .01, *p < .05, n = 26

Source: own elaboration.

According to the results, there is a significant and positive relationship between *the PDCA Deming cycle* and *Remote Work Participation and Time* ($r = 0.49$, $p < 0.05$), and *Goal Achievement* ($r = 0.82$, $p < 0.01$). In addition, there is a significant and positive relationship between *the PDCA Deming cycle* and *Remote Work Impact on Time Management Efficiency* ($r = 0.61$, $p < 0.01$). This finding lets us positively evaluate that implementing the Plan-do-check-act Deming cycle during remote work improves time management efficiency for daily tasks (RQ8) in administrative services. Overall, RQ8 has been evaluated positively for both services.

There is a significant and positive relationship between *R&D Activities* and *Goal Achievement* ($r = 0.64$, $p < 0.01$). In other words, R&D Activities are critical to being proactive regarding goal achievement and funding employee needs for administrative services. These scores lead us to verify that if the employer conducts R&D activities to improve the effectiveness of remote work, achieving the public institution goals is higher in administrative services (RQ9). Overall, RQ9 has been evaluated positively for both services.

H1 suggested that: *If remote work improves time management efficiency for daily tasks, employees are willing to invest their resources to work remotely.* According to the correlation analysis result, no significant relationship exists between *Remote Work Impact on Time Management Efficiency* and *Employer Ownership of Office Equipment*. These scores lead us to reject H1 for administrative services. Overall, H1 has been rejected for both services.

Efficiency of resource allocation in public utility sector – general insights

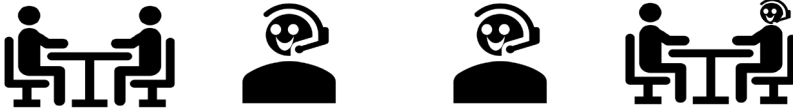
The analysis of the collected data allows answering research question RQ10: Does remote work save public institutions' resources (water, electricity, consumption)? All collected data have been converted into monetary values. When comparing data between years, the inflation rate was taken into account. During the energy crisis, this was a significant price differentiator. The data were converted into the number of employees employed in organizations (technical and office workers (scientists and officials)). However, the number of employees in individual organizations was not a category that affected the differentiation

of results between the years under study. Gross prices were included in the research. Only in the scope of raw materials for which the government introduced special privileges due to the energy crisis in 2022 (tax exemptions) were net prices taken into account so as not to falsify the results between the compared years.

Moving on to the analysis, the category that is the most important in the costs of operating the utility sector is electricity. Its value in 2022 is abnormal due to the global energy crisis, so it should be treated exceptionally. For most resources, the forced transition to remote work in 2020 generated savings (electricity, water, heating buildings). The only increased expenses were observed in the increased use of cleaning products, which is understandable in the face of the COVID19 Pandemic. The costs of building security and monitoring also slightly increased, which then in 2022 decreased almost to the value from the base year. In this case, the increase in 2020-21 can be explained by long-term contracts, usually related to public institutions. The decrease in costs due to switching to remote work is also noticeable in the Total annual resource consumption indicator.

Nevertheless, a more important year to observe the costs of organizing remote work was 2021. It was when public institutions prepared for remote work at the technical level and in implementing procedures. In 2021, the total annual resource consumption increased by 7 percentage points compared to the base year 2019. In 2021, we observed savings only in water management and waste collection. However, in 2022, hybrid remote work did not compensate for the costs. There was an increase in costs (Total annual resource consumption) by 5 percentage points, excluding electricity, which increased by 10 percentage points (Table 15).

Table 15. Annual resource consumption in the public utility sector in Poland (PLN/per capita; fixed prices)

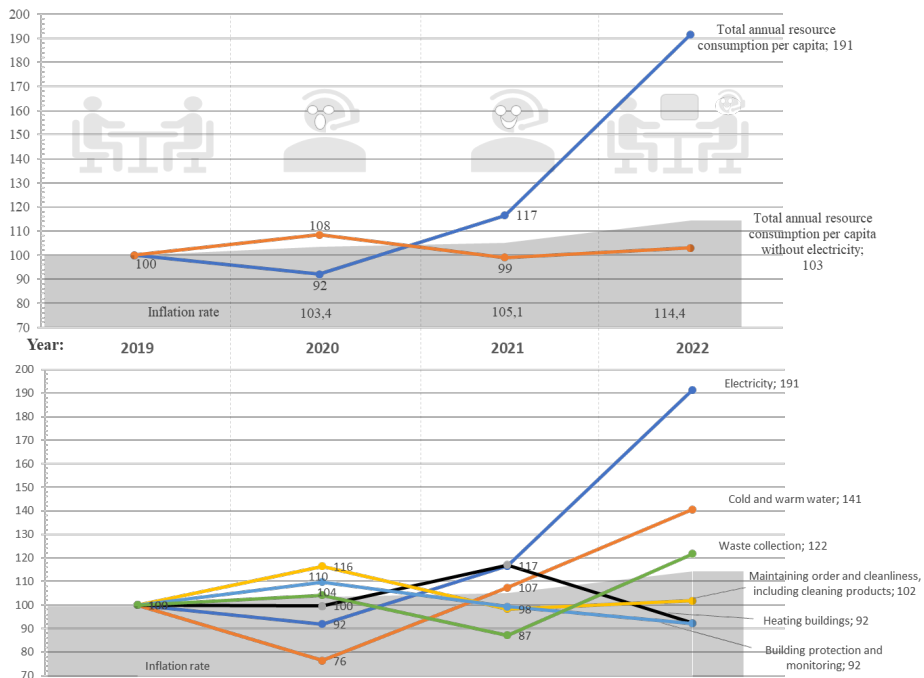


	2019	2020	2019 = 100	2021	2019 = 100	2022	2019 = 100
Electricity	13 547 998	12 457 054	92	14 525 918	107	27 809 334	205
Cold and warm water	6 172	4 713	76	5 062	82	7 117	115
Heating buildings	1 226	1 220	100	1 429	117	1 319	108
Maintaining order and cleanliness, including cleaning products	24 585	28 627	116	28 145	114	28 656	117
Building protection and monitoring	19 645	21 571	110	21 429	109	19 738	100
Waste collection	3 765	3 921	104	3 417	91	4 163	111
Total annual resource consumption	13 603 390	12 517 106	92	14 585 400	107	27 870 327	205
Total annual resource consumption without electricity	55393	60052	108	59482	107	60993	110

Source: own elaboration.

It is also interesting to know the dynamics of changes in the value of annual consumption of resources expressed in constant values concerning the dynamics of changes in the inflation rate (Figure 4). These indicators are not similar to each other. The costs of none of the resources correlated with the fluctuation of the inflation rate. In 2021 and 2022, the costs of all resources and related services grew slower than the inflation rate. It is worth noting that in 2021 (remote work well organized) compared to 2020 (poorly organized remote work), we observed a decrease in the cost of all resources except electricity. Among other things, this observation allows us to verify and confirm the second research hypothesis *H2. Remote working reduces public utility sector institutions' resource consumption (utility expenses)*.

Figure 4. Dynamics of annual resource consumption in public utility sector



Source: own elaboration.

Conclusions and discussions

As a result, it was revealed that if public institutions work remotely, they lower indirect employee costs (real tax deductible costs) in terms of utility expenses (electricity, water, CO, garbage) because they do not bear any related costs (RQ1). In other words, employees need to finance their household expenses during remote work regardless of the type of utility services (Civil and Administrative Services). Hence, it can be concluded that employees' household expenses in utility spending get higher for both services (RQ2).

The research results allowed us to answer whether remote work improves time management for daily tasks (RQ3).-The results show that remote work does not improve time management efficiency for daily tasks in both services. In other words, employees must spend slightly more time covering their daily tasks during remote work than working from offices in both services.

Research question RQ4 has been evaluated to find what properties of human capital determine the effectiveness of remote work according to Jung's Personality types concept and Belbin's Team roles concept for civil and administrative services individually. It was revealed that the average percentage of employee profiles varies for both services. According to Jung's Personality types concept, both services have four different types of people that are type A (people who like to have everything in order in their lives and plan everything, like a stable environment and procedures), type B (essential people, quick in making decisions, practical, responsible, courageous, task-oriented at work), type C (calm people who value harmony, do not like changes, with a high level of empathy and at the same time not very assertive), and type D (people who are spontaneous, communicative, joyful, self-confident, deriving satisfaction from civil contacts) in their institutions; however, the dominant personality types percentage shows differences concerning service types.

Belbin's Team roles concept is another concept that has been used to assess the properties of human capital in civil services and administrative services. The concept has nine different types of team roles that are Practical organizer, Coordinator – the natural leader, Innovator – Creator, Analyst – Judge, Source-seeker – a man of contacts, Perfectionist – meticulous performer, Group man – team

soul – group player, Executor – implementer, and Expert. According to the findings, the dominant quantity of institutions has nine different team roles in both services

Research question RQ5 has been evaluated to find what part of the annual budget is allocated to financing remote work requirements in the institution. The results verify that the institutions have a small annual budget assigned to pay for their remote work requirements. Requirements for remote work do not occupy a significant portion of annual budgets for both services. In other words, remote work is a cost-effective method.

Next research question, RQ6, has been evaluated to find whether employers finance employees working remotely to help in adapting to remote work: for example, adapted workplace ergonomics and consultations with a physiologist or psychologist. The scores lead us to conclude that the employer does not finance the psychological and physiological needs of employees adapting to remote work in both services.

Another important topic was the answer to the question: To what extent can remote work replace work at the institution's headquarters? (RQ7). It was revealed that remote work almost replaces 50% of work at the institution's headquarters in both services.

There is a significant and positive relationship between the PDCA Deming cycle and Remote Work Impact on Time Management Efficiency for civil services ($r = 0.61$, $p < 0.01$) and administrative services ($r = 0.44$, $p < 0.01$). This finding lets us positively evaluate that implementing the Plan-do-check-act Deming cycle during remote work improves time management efficiency for daily tasks (RQ8) in civil and administrative services. Overall, RQ8 has been evaluated positively for both services.

According to the finding, the employer does not effectively conduct R&D activities to improve the effectiveness of remote work in both services. The study assessed whether conducting R&D activities impacts achieving the public institution's goals during remote work (RQ9). The outcome of the correlation analyses led to the conclusion that there is a significant and positive relationship between R&D Activities and Goal Achievement for civil services ($r = 0.22$, $p < 0.01$) and administrative services ($r = 0.64$, $p < 0.01$). In other words, R&D Activities are critical to being proactive regarding goal achievement. Conducting R&D activities to

improve remote work's effectiveness positively impacts accomplishing planned tasks while working remotely in both services. Overall, research question RQ9 has been positively evaluated for both services.

Studying the efficiency of remote work by identifying the consumption of raw materials and services directly related to them made it possible to achieve the second aim of the research. Consequently, a positive answer can be given to research question RQ10: Yes, the use of remote working in institutions of the public utility sector saves resources. In addition, hybrid work does not allow for achieving the same benefits; on the contrary, it increases costs, even concerning the alternative, traditional stationary work.

H1 suggested that: *If remote work improves time management efficiency for daily tasks, employees are willing to invest their resources to work remotely.* According to the correlation analysis result, no significant relationship exists between *Remote Work Impact on Time Management Efficiency* and *Employer Ownership of Office Equipment*. These scores lead us to reject H1 for civil and administrative services. Overall, H1 has been rejected for both services.

The use of remote work in institutions of the public utility sector allows the employer to decrease resource consumption (utility expenses). However, managing remote and stationary work (hybrid) does not reduce resource consumption and savings. The research results verified and confirmed the second hypothesis, H2, which suggested: *Remote working reduces public utility sector institutions' resource consumption (utility expenses).*

Consequently, it was concluded that remote work saves resources and is cost-effective for employers. It lowers indirect employee costs (real tax deductible costs) in terms of utility expenses (electricity, water, CO, garbage) because employees work out of their institutions' premises in civil and administrative services. In addition, the employer does not finance the psychological and physiological needs of employees adapting to remote work in both services. Moreover, institutions have a small annual budget assigned to pay for their remote work requirements. Requirements for remote work do not occupy a significant portion of annual budgets for both services.

These findings demonstrate that even if remote work is a cost-effective method for public utility services and decreases indirect employee costs, it has yet to be

incorporated successfully. In this regard, it is evident that the institutions need to enhance their processes and techniques to achieve better results when working remotely. It should be remembered that public utility services had to fast switch their working practices to remote working owing to COVID-19 restrictions while it is believed that remote work has yet to be implemented successfully into utility services. Due to the need for fast implementation, the most effective application of remote work is likely to be challenging. On the other hand, remote work regulations in labor laws may be updated already; therefore, circumstances are likely to differ.

Nevertheless, when it has been taken into account that the institutions have gained more and more implementation experience since Covid-19 in public utility services, it is more likely that remote work has been applied effectively nowadays. Future research will be essential to assess whether remote work applications have improved in the public utility sector in this regard. Additionally, it would be best practice to conduct a study with a similar research concept in the private sector to compare findings and implementation strategies and offer solutions to the challenges caused by remote work.

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