

# How did COVID-19 Affect Female Researchers' Output? Results from the Field of Social Science

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**Abstract**—Several studies indicate that the situation of female researchers decreased disproportionately in comparison to their non-female colleagues. This paper examines which obstacles female researchers faced in their working life and how the working situation of researchers has changed during the COVID-19 pandemic.

Germany and the UK were used to generate a sample of the two important European research intensive countries with different academic cultures. The ten highest ranked universities in both countries form the sample for an online survey of researchers in the field of social sciences.

The paper provides results regarding the variance of productivity of female and non-female researchers during the pandemic and the relevant influencing factors on researchers scientific output in general. The analysis show that the pandemic has decreased the working conditions, as well as the scientific output, in the field of social sciences. Female researchers are affected by this trend slightly more than their non-female colleagues are. The pandemic also led to a shift in tasks performed, corresponding to increasing teaching and service-related tasks and decreased research related tasks. Furthermore, the results prove that individual characteristics, especially the fact of having children living in the household had a significant impact on the scientific output.

**Index Terms**—Female researcher, academic output, research productivity, COVID-19, working conditions in academia.

## I. INTRODUCTION

More than a year into the global COVID-19 pandemic, it is apparent that social inequalities due to gender as well as other aspects persist and may have exacerbated [1]. During the COVID-pandemic, the submission and publication of research papers peaked in comparison to previous years [2]. However, research contributions submitted by women decreased in total numbers [3]. To examine the extent to which the pandemic affects female academics in comparison to their non-female colleagues, we conducted a survey with a set of questions related to their experiences during the pandemic as well as their general working conditions. This paper aims to identify gender inequalities in order to make them visible to research and to open up possibilities for action. Therefore, this study addresses the central research questions: Which influencing factors determine the academic output of female and non-female researchers during the COVID-19 pandemic? To what extent do societal and cultural gender stereotypes, organizational structures of universities, and private circumstances influence researchers' output?

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To gain insights regarding the working conditions of researchers, the aspects influencing their scientific productivity and the obstacles which especially female researcher might be facing need to be discussed from a broader perspective. This perspective goes beyond gender identity for female researchers. To get a fundamental understanding of the impact of the COVID-pandemic on researchers' situation, we outline reference not only to gender theory but also to institutional theory. The aim is to contribute towards the discussion on gender specific negative effects of the COVID-pandemic, but also to provide results regarding the general situation of researchers due to changed working conditions.

The first section of this paper describes the general situation of female researchers. We address the problem of gender gap in academia and the focus of women's performance in the research field during the COVID-pandemic. The second section discusses theoretical approaches to explain scientific productivity and the relevant influencing factors as well as their potential for the analysis. The third section describes the methods, the data set and the respective operationalisations such as the calculated regression models and the group comparisons using the survey data. This paper constructs an index containing various indicators to investigate scientific output from a broader perspective. The fourth section presents the overall results, comparing female and non-female researchers. The calculated regression models demonstrate the effects of various factors on scientific output. In section five, we will present conclusions regarding the working situation of female and non-female researchers and the impact the COVID-pandemic has had on this working situation as well as scientific output. Within the conclusion, we provide recommendations of potential measures to compensate or at least attenuate the negative impact of the pandemic on the situation of researchers in general and especially female researchers.

## II. THEORETICAL REFLECTIONS — SCIENTIFIC PRODUCTIVITY AND RELEVANT INFLUENCING FACTORS

In the following section, we present and discuss the theoretical background of our analytical models. The analysis aims to include a variety of potential influencing factors in scientific productivity, especially during the COVID-pandemic. Hence, we include different theoretical approaches and published research findings in our theoretical reflections. Organizational structures of universities (e.g. working hours, hierarchies) must be considered [4–7] as well as societal and cultural gender stereotypes (e.g. gender gap) [8–11]. Finally, individual characteristics (e.g. age, position,

[12]) and private circumstances (family matters as in [9]) must be taken into account.

#### A. General Complementary Explanations for Varying Scientific Productivity

Kwiek [13] states that in Europe the group of highly productive researchers is highly homogeneous. The similarities occur concerning structural factors, mostly individual rather than institutional. Furthermore, highly productive academics are similar from a cross-national perspective, while they differ substantially intra-nationally from their lower-performing colleagues.

To identify the traits of highly productive researcher, this paper refers to literature on research productivity [14]–[17]. In this context, we have identified several individual and institutional factors that influence research productivity. *Institutional aspects* include the size of the department, disciplinary norms, and reward / prestige systems. *Individual aspects* include personal characteristics, motivation, and desire [18]–[22]. Certain aspects are perceived as predicting academic productivity, including the faculty's orientation toward research, time spent on research, gender, faculty collaboration, faculty academic training, years passed since PhD, as well as a cooperative climate and support at the institutional level [23]–[26].

*Individual Aspects on Researcher Productivity:* We are using different theories to explain the significant differences in individual research productivity, which we briefly describe here: the *Sacred Spark Theory*, the *Accumulative Advantage Theory* and the *Utility Maximizing Theory*. The *Sacred Spark Theory* [14] assumes substantial, predetermined differences between researchers regarding their ability and motivation to do creative scientific research [14], [27], [28]. Whilst faculty members with traits associated with the sacred spark theory tend to publish more in comparison to their peers, there seems to be more than just motivation and joy for having a higher quantity of published articles. Some of these traits seem to be based on the gender of researchers (men tend to have a higher affinity towards research), the career aim (if they want to stay within research) and the impact they generated so far with already published and cited articles [29]. The latter can be linked to the *Accumulative Advantage Theory* [16], which is supported by several studies [27], [30]. This theory claims that productive scientists, who already published a significant amount of research papers, are likely to be even more productive in the future. Vice versa, researchers with a low performance will stay less productive in the future. This theory is closely linked to the idea that being rewarded makes researchers more productive in the future [14], as they aim for higher career goals. Inconsistently, the *Utility Maximizing Theory* claims that researchers choose to reduce their research efforts over time. The reason being an underlying assumption that other tasks may be more advantageous to their career given their already established high professional reputation [31] and the rewards for research decline with age [32].

These three major theories of research productivity offer a brief understanding of influential factors, as they are equally applicable to the academic profession. Furthermore, they explain different aspects regarding research productivity over time. To approach general individual variables besides the

above research productivity theories this paper also refers to institutional theory and critical gender theory.

Institutional theory contends that the professionalization and structure of an academic career supports “normative isomorphism” as one approaches the highest rank of professor [33]. The academic profession contains codes of conduct and common socialization patterns, from the entry level to full professor, which operate as a filter for career progression. Throughout their career, professors observe a typical norm of time allocated to work by other faculty, which is mimicked and reinforced by the academic socialization and reward systems [34]. Furthermore, researchers with a PhD or higher rank are willing to spend more time doing research than researchers without a PhD [35]. As such, it can be assumed that the higher one's position, the higher one's professional success, in this case the production of scientific work [36], which leads to the following hypothesis 1.

*H1: A person's qualification level is positively related to scientific output.*

*Institutional Aspects on Researchers Productivity:* Bentley, Kyvik [37] referring to Meyer, Ramirez, Frank, Schofer [38] used Sociological Institutional Theory to analyse higher education as an institution and to interpret change in educational systems, structures and contents. They define typical tasks of a research university as producing knowledge (research), transmission of knowledge to students (teaching) and to societal stakeholders (service) [40]. Enders and Musselin [39] stated that the implementation of performance management of faculty and institutions have reduced self-determination how academics divide their time between teaching and research. Researchers are increasingly facing pressure to do more with fewer resources [40]. Although they still consider themselves as independent professionals, management discretion has grown relative to academic autonomy [41], [42].

Altbach [43] proved large differences exist between individual faculty members in research universities in how they spend their working time. Differences in working time patterns between universities within countries also occur [34, 44]. Abramo, D'Angelo, Di Costa [45] argue that to obtain a high level of scientific productivity, “the time and energy required for research activities are notably superior to the average, and imply an overwhelming dedication to work”, which leads to hypothesis 2.

*H2: A higher share of working hours dedicated to research is positively related to scientific output.*

Besides the above general factors influencing researchers' output we discuss specific factors related to the COVID pandemic in the following section.

#### B. COVID-specific Factors and their Expected Influence on Scientific Productivity

The COVID pandemic affected researchers' working and private life regarding the extent of *working from home* as well as possibly *intensified parenthood and caring duties*.

*Working from home:* In academia, before the pandemic started, most university workers did not work from home full time, but many worked at home one or two days a week, at nights and on the weekends. Academics worked on trains, in hotels, in parks e.g. [48]. Modern work technologies enabled organizations to extend their control into the home [49] and

working from home increases the pressure on employees to work more [50].

The COVID-pandemic caused an indefinite period of working from home, which led many university employees and faculty to a significant change in their work methods, schedules, and responsibilities. AbuJarour, Ajjan, Fedorowicz, Owens [46] discovered that both personal and technology-related factors affect the individuals' attitude towards working from home and their productivity depending on their situation at home. If there are children below the age of 18 at home, individuals tend to be more distracted. Furthermore, the technical equipment in terms of usability and susceptibility to errors is a critical point to support productivity. In general, job satisfaction and a positive attitude towards work increases the likelihood of employees to achieve higher productivity levels [47]. Before the pandemic, employers promoted virtual offices and working from home as a way to improve organizational performance by providing flexibility to employees [48, 49]. However, many employees have difficulties in balancing work and family responsibilities as well as dealing with increased stress [50]. The ambiguity of working from home has increased the flexibility in performing work-related tasks and positively relates to overall job satisfaction, but at the same time it potentially leads to more job-induced stress and negative personal wellbeing due to work overload and work-life conflicts [51, 52]. The pandemic disrupted employees' work and personal lives [53], with a large impact related to the unexpected shift towards working from home. AbuJarour, Ajjan, Fedorowicz, and Owens [46] examined the impact of the new COVID-induced circumstances on the effectiveness of academic work, stressing the potential negative effect of converging roles and new working conditions on productivity.

*H3: The share of working from home is related negatively to the scientific output.*

The reduction in working hours is often attributed to the intensified care requirements, especially for children under 18, which is why this aspects needs to be considered [46].

*Parenthood and the intensifying effect due to the COVID-pandemic:* Edwards, Wajcman [54] state that academics are most likely to benefit from the blurring of work and home, with especially mothers benefitting from an ability to combine employment with childcare. Probert [55] investigating work and family demands of academics in Australia, concluded that the largest obstacle to women's careers is their family responsibilities. Therefore, working from home seems to be an efficient approach to combine both work and family, especially for young mothers.

However, academics perceived the flexibility of time and space negatively, because the opportunity to work from home often forced women to perform household tasks, childcare, and their paid work parallel. Pronouncing the gendered distribution of responsibilities within the household [56], [57], the lockdown caused by the COVID-19 pandemic and the related closures of schools and day-care facilities have significantly increased childcare responsibilities and impacted parents' division of labor at home [58]. The boundaries between work and family became blurred. As household work still usually falls on women [59, 60] and female full-time faculty members tending to have partners

who also work full time [68], working from home intensifies working conditions and increases home/life conflict [61, 62].

O'Laughlin, Bischoff [63] found that a flexible work schedule leads to more work at home, especially outside of the regular working hours. Juggling several different tasks is also associated with higher work/family distress. Women report a higher level of academic stress than men, which may be related to a greater amount of time dedicated to childcare and family obligations [63]. This inequity, combined with a "winner takes all approach" in academia, which encourages faculty to work longer hours and publish more, makes it especially difficult for women [64, 65], because researchers who are parents already work less than researchers without children do [66].

According to Minello [67], gender inequalities worsened during the lockdown as the double burden for women regarding both family and work increased [59, 68]. The results from Yildirim and Eslen-Ziya [58] indicate that the presence of children are the most important predictor of perceived changes related to work and housework, especially affecting women and their work life balance, resuming in less academic research. This evidence leads to our final hypothesis 4.

*H4: The presence of children in the household is negatively related to the scientific output.*

### III. METHODOLOGY AND SAMPLE

The results presented in this paper derive from an analysis of the research conditions during the first year of the COVID pandemic in Germany and England with a focus on gender. The data was collected via a standardised online questionnaire sent to researchers listed on the respective homepages of the social and economic studies departments of the ten highest-ranked universities [69] in both Germany and England. We chose the area of social and economic sciences as gender differences are relatively well balanced within this discipline. Previous research confirmed that social science is dominated by women, while economics is dominated by men [66]. Other subject areas such as engineering were not selected, as these tend to be dominated by men due to the strong technical and mathematical orientation [66]. Furthermore, humanities and cultural sciences also differ greatly in subject matter from country to country, which leads to excluding them within this research. Individual researchers were identified as being part of the social sciences and economics departments based solely on university homepages. We provided each respondent an individual link via e-mail to prevent multiple participations. We offered the questionnaires with equivalent content in German and English based on university location. We contacted the researchers between December 2020 and January 2021, with the questionnaire staying accessible for two weeks following the invitation.

Variables regarding change in scientific output (scientific results, conference participation), social demographics (gender, formal degree), working environment (working country, working hours, share of research, share of work from home), as well as the presence of children were used for the descriptive analysis and as input for the regression models. Out of this set of variables the scientific results and the

participation at conferences were selected for the scientific output index ( $n = 314$ ,  $M = 2.34$ ,  $SD = 0.91$ , Cronbach's  $\alpha = 0.51$ ). Both variables have a scale from 1 (decreased substantially) to 5 (increased substantially), which was adapted accordingly for the index.

Working time (absolute number of weekly working hours) and time for research (percentage) were combined to build the construct time for own research via simple multiplication.

We dichotomized the formal degree, creating the opponents Master and Non-Master - the latter including Bachelor (only 6 participants in the sample), PhD and postdoctoral qualifications as highest titles.

Equally, we dichotomized the variable gender into female and non-female, which includes male and diverse. Working country, percentage of working from home and presence of children in the household (dummy variable) were used without any explicit recoding.

We used ordinal logit models for testing the below given hypotheses:

*H1: A person's qualification level is positively related to scientific output.*

*H2: A higher share of working hours dedicated to research is positively related to scientific output.*

*H3: The share of working from home is related negatively to the scientific output.*

*H4: Presence of children in the household is negatively related to the scientific output.*

Within the data collection and recoding, nine areas of scientific output were differentiated, where a value of 1 refers to high penalties due to the COVID pandemic to research, whilst 5 refers to a relatively constant scientific performance in comparison to prior to the pandemic.

#### IV. RESULTS

The results show the effects of personal characteristics as well as working circumstances on scientific performance, focusing on the impact of the pandemic. The dataset of respondents included 182 female (55.83 % of the sample) and 144 non-female (44.17 %) respondents. The descriptive results show some preliminary differences between genders. Female and non-female researchers are compared regarding different measures concerning their scientific output focussing on the impact of the COVID-pandemic. The results reported always show the change of the respective task during the pandemic in comparison to the status before (see Table I).

TABLE I. IMPACT OF THE COVID-19 PANDEMIC ON FEMALE AND NON-FEMALE RESEARCHERS IN COMPARISON

Variable	Female (n= 182)		Non-Female (n = 144)	
	Mean	SD	Mean	SD
Part 1: During the COVID-19 pandemic, I was able to... (Min = 1 "strongly disagree"; Max = 5 "strongly agree")				
Define research strategies	3.12	1.26	3.25	1.28
Establish cooperation	2.46	1.32	2.58	1.27
Acquire cooperation or third-party funding	2.22	1.41	2.49	1.36
Develop or set up a research project	2.89	1.45	3.09	1.37
Supervise or complete long-term projects	2.50	1.45	2.67	1.44
<b>Publish in peer-reviewed journals</b>	<b>2.61</b>	<b>1.46</b>	<b>3.11</b>	<b>1.53</b>

Write qualification theses	2.32	1.34	2.54	1.47
Achieve scientific recognition	2.72	1.36	2.66	1.25
Present research at conferences	2.71	1.52	2.51	1.42
Part 2: Since last year regarding the share of work of the following part... (Min = 1 "decreased substantially"; Max = 5 "increased substantially")				
Hours worked per week	3.54	0.98	3.36	1.04
<b>Teaching tasks</b>	<b>4.02</b>	<b>0.94</b>	<b>3.69</b>	<b>1.07</b>
<b>Student counselling</b>	<b>3.69</b>	<b>0.81</b>	<b>3.45</b>	<b>0.99</b>
Scientific work	2.88	1.14	2.87	1.19
Scientific results	2.62	0.95	2.66	1.04
Participation to conferences	2.06	1.13	1.93	1.11
<b>Academic self-administration</b>	<b>3.40</b>	<b>0.93</b>	<b>3.17</b>	<b>0.93</b>
Promotion of young scientists	2.85	0.92	2.63	0.83
Unique Variables				
Variable 1: Due to COVID-19 my working conditions... (Min = 1 "worsened"; Max = 3 "improved")	1.62	0.72	1.54	0.69
Variable 2: My household situation due to COVID-19 has...	1.86	0.70	1.79	0.66

Both female and non-female respondents report that they have near equal opportunities to define research strategies as pre-pandemic. Furthermore, female as well as non-male respondents disagreed that they were able to establish cooperation within their research area as before the pandemic. This disadvantage was slightly higher for female than for non-female researchers. During the pandemic, all genders were unable to acquire cooperation or third party funding as they used to pre-pandemic. Again, women were slightly less able to do so than non-women were. Regarding the ability to develop or set up a research project, females predominantly disagreed that they were able to do so as easily during the pandemic, whereas non-females report comparable abilities as pre-pandemic. Respondents disagreed that they were able to supervise or complete long-term projects, with women being slightly less able to do so. The aspect of publishing their results in peer-reviewed journals shows a gender difference in terms of female disagreeing to have the same ability to do so as much as pre-pandemic, while non-female stated that there was no change in this regard due to the pandemic. The Welch Two Sample t-test suggests that the effect of identifying as female is negative, significant and small (difference = -0.50, 95% CI [0.16, 0.83],  $t(295.88) = 2.94$ ,  $p < 0.01$ ; Cohen's  $d = 0.34$ , 95% CI [0.11, 0.57]). Women's ability to write qualification theses decreased, which was also the case for the group of non-female (to a smaller extent). Respondents report more difficulty in achieving scientific recognition during the pandemic than prior. Furthermore, respondents disagreed that they were able to present their research at conferences to the same extent as pre-pandemic (with females less impacted than non-females). Overall, the differences among the researchers within both groups (female as well as non-female) is high, for females especially for presenting at conferences and publishing in peer-reviewed journals; for non-female regarding the sub items of writing qualification theses and publishing in peer-reviewed journals as well.

Respondents stated that since the COVID pandemic their working hours per week increased, with females slightly more impacted than non-females. Regarding the shift of tasks where those hours were spent, the share of working hours spent for teaching increased for both female and non-female researchers – with female workers more impacted. The

Welch Two Sample t-test testing the difference of teaching tasks by gender suggests that the effect is positive, significant and small (difference = 0.33, 95% CI [-0.57, -0.09],  $t(253.20) = -2.67$ ,  $p < 0.01$ ; Cohen's  $d = -0.34$ , 95% CI [-0.58, -0.09]). The share of student counselling also increased for both groups, though again female were more affected. Differentiating the task of student counselling by gender suggests that the effect is positive. The finding is significant, although small (difference = 0.24, 95% CI [-0.46, -0.02],  $t(234.17) = -2.10$ ,  $p < 0.05$ ; Cohen's  $d = -0.28$ , 95% CI [-0.53, -0.02]). The share of work used for scientific work as well as scientific results on average slightly decreased from pre-pandemic levels among all respondents. Out of the set of tasks within the survey, the working hours spent to participate in conferences decreased the most, slightly more for non-female respondents than for females. We observed the opposite regarding the amount of academic self-administration, which increased for all respondents, with a stronger increase for female researchers. This result is positive, significant and small (difference = 0.23, 95% CI [-0.46, -8.67e-03],  $t(264.61) = -2.05$ ,  $p < 0.05$ ; Cohen's  $d = -0.25$ , 95% CI [-0.49, -9.31e-03]). The promotion of young scientists decreased among all respondents, but for non-women slightly more than for women. As this task does not apply to all researchers, only 59% of females responded and 69% of non-females to this question.

The pandemic situation created worse working conditions at respondents' universities, with non-female respondents reporting a slightly larger decline. The same trend was seen when asked how the pandemic changed respondents' household situation - with an overall decline by both groups with non-female reporting a slightly larger decline.

In the following, we first describe the most important variables used in our multivariate analysis. Then in a second step, we combine them in a conjoint regression model. Table 2 gives an overview of all variables included in the regression models and their characteristics.

TABLE II. DESCRIPTION OF THE VARIABLES USED IN THE REGRESSION MODELS

Variable	Obs.	Mean	Std. Dev.	Min	Max
Scientific output (DV)	314	2.34	0.91	1	5
Working country (1=England)	335	1.72	0.45	1	2
Gender (1=male)	326	1.56	0.50	1	2
Presence of children in household (1=yes)	335	0.27	0.45	0	1
Degree (1=Master)	335	0.49	0.50	0	1
Hours dedicated to research (value in hours)	318	13.05	9.58	0	48
Share working from home (value in percent)	326	77.69	27.12	0	100

The dependent variable (scientific output), ranges from 1 (decreased substantially) to 5 (increased substantially), and has a mean of 2.34 with a standard deviation of 0.91, which can be interpreted as the pandemic slightly discouraging researchers from fulfilling their tasks.

71.94% of respondents work in Germany, 28.06% in England. 55.82% of them identified themselves as female, whereas the rest of the participants were categorised as non-female. 27.16% of respondents have children living in their household.

Regarding the highest degree, 48.96% state that in their case this is a Master degree. Accordingly, 51.05% of the respondents are holding another degree, mainly a PhD or higher (e.g. professor position respectively habilitation).

The number of hours per week a researcher is dedicating to research ranges from 0 to 48, while the average is 13.05 hours and the standard deviation is 9.58.

The share of working from home during the pandemic ranges from 0% to 100%. In the sample, the average share is about 77.69% with a standard deviation of 27.12.

To enhance interpretability, the results are given in odds ratio (OR). Furthermore, the observations were kept stable throughout the models, which reduced the sample to 286 cases. In the following, the full model (Model 4) is step wisely built by inclusion of constructs.

TABLE III. REGRESSION ANALYSIS

	Model 1	Model 2	Model 3	Model 4
Scientific Output (DV)				
Working country: Germany (Ref: England)	0.90	0.92	0.80	0.99
	(0.26)	(0.29)	(0.26)	(0.32)
Gender: female (Ref: non-female)	1.04	0.85	1.00	1.04
	(0.24)	(0.20)	(0.26)	(0.27)
Age	0.79*	0.86	0.87	1.03
	(0.08)	(0.08)	(0.08)	(0.11)
Age <sup>2</sup>	1.00*	1.00*	1.00*	1.00
	(0.00)	(0.00)	(0.00)	(0.00)
Degree: Non-Master (Ref: Master)		0.48*	0.45*	0.52*
		(0.15)	(0.14)	(0.17)
Time since hiring		0.89***	0.89***	0.89***
		(0.02)	(0.02)	(0.02)
Hours dedicated to research		0.97*	0.97*	0.97*
		(0.01)	(0.01)	(0.01)
Share working from home			1.00	0.99
			(0.00)	(0.00)
Housework during pandemic: No (Ref.: Yes)			1.26	1.28
			(0.17)	(0.17)
Presence of children in household: Yes (Ref: No)				0.32***
				(0.10)
Observations	228	228	228	228
Pseudo R <sup>2</sup>	0.008	0.042	0.047	0.062

Exponentiated coefficients; Standard errors in parentheses, Reference categories in parenthesis for dichotomous variables

\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

The first model tests, whether the working country, gender and age of the researchers influenced their scientific output

during the pandemic. This shows that only age has a small effect. Even though the effect size for women ( $OR = 1.04, p = 0.88$ ) and for the country ( $OR = 0.90, p = 0.71$ ), in this case Germany, show a correlation with the dependent variable, the effects are non significant.

The second model includes the degree (reference category: Master). The results show that researchers with a degree higher than a Master had a significantly smaller scientific output ( $OR = 0.48, p = 0.02$ ). Hence, the higher the level of education, the less output was generated during the pandemic. Furthermore, the time since the surveyed researchers' hiring at their current organisation has a negative effect on their output. The proportion of time used for the own research is also significant, although the effect size is negligible ( $OR = 0.97, p = 0.04$ ). Overall, the variables measuring seniority have a negative impact on the individual research performance by trend.

Subsequently, in the third model the share of work that has been done from home and the obligation to do housework have been included. The results show that neither of these variables had a significant effect on the scientific output of the surveyed researchers during the pandemic.

Finally, the presence of children in the household (reference category: no children) was included in the full model. The respective results suggest that this variable seems to be strongly influencing the scientific output ( $OR = 0.32, p = 0.00$ ). In the full model, except for the time since hiring at the current institution, all other tested variables either do not have a strong effect or are no longer significant. The final model accounts for roughly 7% of the variation in the scientific output for the analysed sample.

## V. DISCUSSION

The purpose of the analyses was to examine the impact of the COVID pandemic on scientific output of researchers and the factors that influenced this change with a focus on gender inequalities.

Regarding the general change of scientific output due to the pandemic, the results show a rather homogenous directional impact when comparing female and non-female researchers. However, they also present a differentiated picture of different tasks of researchers and to what extent they were influenced. The results show that besides the opportunities of defining research strategies, for female researchers all other tasks typically performed were affected from the pandemic in the regard that they had less opportunities to perform them than pre-pandemic. The results confirm previous findings showing that peer-reviewed publications on average increased for non-female researchers, while female researchers reported a decrease in peer-reviewed publications [5].

For their non-female colleagues, the situation is slightly better as their opportunities setting up projects and publishing in peer-reviewed journals increased marginally during the pandemic. Furthermore, the descriptive data indicate that females perceive a higher decrease in their own opportunities to establish cooperation and to acquire third party funding than their non-female colleagues do. This decrease is alarming, because it may result in long-term negative effects

on researchers' networks, and future research projects due to the inability to set them up during the pandemic. This potential future effect exacerbates, because researchers also indicate a decreased ability to supervise or complete long-term projects as well as to work on qualification theses. In this regard, women appear to be subjectively more negatively affected than their non-female colleagues are.

The only aspect regarding which both groups perceive a comparable decrease of opportunities during the pandemic is the achievement of scientific recognition. Overall, the results show that researchers are working in poorer conditions due to the pandemic, while female researchers perceive their situation as slightly more affected than their non-female colleagues do. Consistent with prior research, female researchers are affected by the pandemic not only through decreased publication outputs, but also disproportionately on the academic tasks that they perform. However, the relatively high variance in the given answers among the researchers in both surveyed gender-groups must be mentioned. Hence, our sample does not allow a clear general annotation of gender specific characteristics.

The change of working time spent on different tasks due to the pandemic provides a partial explanation for the overall reported decrease of scientific output, excluding the publication output of non-female researchers. While the pandemic did increase the working hours of all respondents, the results show a shift or reallocation of tasks with some gender-specific differences.

The results clearly demonstrate diminished general working situations during the pandemic. Furthermore, they indicate a shift from research related tasks towards other administration and teaching tasks. Here, gender-specific tendencies can be identified. Female respondents reported that their teaching tasks, as well as their scientific self-administration tasks increased during the pandemic to a stronger extent than their non-female colleagues did. Furthermore, both groups of respondents reported that their scientific work, their scientific results and the participation in conferences decreased from pre-pandemic levels. These results suggest that tasks, which are often gender-attributed to women, such as teaching and counselling, seem to have increased due to the pandemic. Research and administration, as theoretically male-attributed tasks, have been reweighted during the pandemic for both gender groups in the surveyed sample.

There is no effect of the working country on the change of scientific output during the pandemic. This supports former research suggesting that the productivity of researchers is comparable from a cross-national perspective, while differences occur mainly within a country [13].

The analyses also provide results regarding the effect of additional individual characteristics. The results show a significant correlation between the individual qualification level and scientific output. Interestingly, a higher level of education leads to a more pronounced decrease of scientific output during the pandemic. Keeping in mind the limited sample and the focus on the research field, this finding is still to some extent contradictory to the general assumption that a higher academic position or degree relates to a higher scientific output [35, 36], which leads to a rejection of our hypothesis 1 (H1). The results of this survey mostly support

the utility maximizing theory. The rationale behind this theory that researchers reduce their research efforts over time due to the assumption that other tasks may be more advantageous once their professional reputation is established [31] and perceive decreasing rewards for research over time [32]. This is a sound explanation for the results of this survey focusing on the pandemic situation. However, these special circumstances may have led to the situation that more senior researchers taking responsibility for other tasks besides research to guarantee the continued provision of teaching and services for students.

The results show a significant but negligible relationship between time spent for research and academic output, which does not confirm our hypothesis 2 (H2). This result neither contradicts nor supports the findings of former studies. Abramo, D'Angelo and Di Costa [45] suggest that extreme differences in scientific productivity may only occur within a rather small group of top performing researchers who put significantly more time into their research than most researchers. This effect may be lost in the above analyses due to the lack of a specific top performing researcher group in the analyses.

Regarding individual working conditions, the share of work done from home does not have any relevant effect on the change of scientific output during the pandemic, which leads to a rejection of hypothesis 3 (H3). This result contributes to the general discussion about the effects of working from home triggered by the pandemic. The potential effects of working from home range from positive effects like increased flexibility to negative effects like increased job-induced stress, negative personal wellbeing and work-life conflicts [48, 49, 51, 52]. The results of this survey suggest that these positive and negative effects cancel each other to a certain extent for researchers within social science. This is contradictory to previous research showing a negative impact of working from home on scientific productivity on average in various disciplines [46, 53].

The presence of children at home strongly influences scientific output. The respective effect is comparatively strong and highly statistically significant, which confirms hypothesis 4 (H4). This result aligns with other studies that have shown that children strongly determine if researchers are affected by pandemic-related measures such as lockdowns [58]. An interaction effect between working from home and the presence of children in the household was not calculated due to the limited sample size, but might increase effects.

## VI. CONCLUSION

The results indicate a decreased scientific output of researchers in social science during the pandemic. To compensate further negative effects from this change, various measures could be implemented. In this regard, the pandemic context should be considered when evaluating young researchers for tenure positions and when determining if fixed-term employment contracts of researchers should be extended. Furthermore, the results indicate that there is a directionally increased negative impact of the pandemic on the working situation of female researchers than on their non-

female colleagues. In this context, we recommend a customized support of certain groups, including the consideration of gender-based criteria. Temporary support for disproportionately affected researcher groups seems to be an adequate solution to prevent an increase of inequalities to already disadvantaged groups. In general, it is important to stop discriminatory factors such as favouritism and to strengthen the support for all genders [70]. This is also supported by the result of this study regarding researchers with children. The results clearly revealed a strong negative effect on scientific output during the pandemic for parents with their children living in their household compared to the other researchers without children in their household. Due to this, universities as employers should provide appropriate solutions solving the care issue arising from the closures of day care and educational institutions. Here, reducing teaching obligations for parents may be a possible measure (see also [1]). However, it is problematic that such measures would likely disadvantage either colleagues without children who would be required to carry additional teaching burdens to compensate or students who would be offered a reduced course selection. This example shows the decisional trade-off between the interests of various stakeholder groups, which seems to be characteristic for the pandemic situation in general. Consequently, appropriate measures need to be sufficiently discussed and established, as well as evaluated in terms of their effectiveness, in order to support researchers regardless of their family situation.

## CONFLICT OF INTEREST

The authors declare no conflict of interest.

## AUTHOR CONTRIBUTIONS

Ms. Annen wrote the research paper. Mr. Thürer, Ms. Preböck and Ms. Annen analyzed the data, and Ms. Sailer conducted the collection of data. All authors have approved the final paper.

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