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The gender gap in academic productivity during the pandemic: Is childcare responsible?*

Abstract

I investigate the impact of the COVID-19 pandemic and the subsequent surge in childcare demand on the research productivity of female economics. Using data from SSRN and a Difference-in-Differences approach, I show that around the timing of confinements, the gender production gap widens by around 20 percentage points, an adverse effect persisting up to 4 months later the beginning of social restriction measures. Declines in production, however, vanish during the school re-opening period suggesting a prominent role in childcare demand.

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1 Introduction

During the last two decades, working from home has become increasingly popular among firms and workers (Bloom et al. (2009)). The limited (experimental) evidence shows that working from home benefits productivity (Angelici and Profeta (2020); Bloom et al. (2015)), employee turnover (Bloom et al. (2015)), absenteeism, and improves well-being and gender balance within families (Angelici and Profeta (2020)).

The COVID-19 pandemic has renewed the interest in teleworking and its economic implications. Indeed, the virus has forced governments to encourage businesses to hold activities remotely. However, the homeworking experienced during the first wave of the pandemic is strikingly different from the usual remote flexibility firms offer. First, confinements obliged many people to stay at home while working remotely. Second, school closures forced many parents to look after their children while expected to continue to work, resulting in a dramatic increase in childcare demand and household chores, disproportionately borne by women.

In this paper, I leverage the COVID-19 pandemic to study how it has affected women's productivity while homeworking, considering the sudden increase of children and household chores.

Given the unavailability of appropriate and detailed data from the private sector, I focus on the academic sector. Indeed, Universities have immediately shifted their activities virtually without interrupting education, students' training and, in some cases, research activities. Nonetheless, ignoring the uneven effects of the COVID-19 pandemic on women's productivity risks backsliding on substantial progress for academic diversity (Woolston (2020)) and further escalating gender inequalities in the academic sector (Minello (2020)). Furthermore, I restrict my study to economic research since it typically begins to circulate as working papers well before peer reviews, allowing me to track economists' production almost in real-time, especially during the lockdown period.

Indeed, there is a scarcity of systematic evidence on whether and to what extent the pandemic has affected gender inequality in academia. Anecdotal evidence provides mixed support (Beck (2020); Dolan and Lawless (2020); Kitchener (2020)). Diversely from this evidence, I adopt a robust empirical approach to investigate the evolution of scientific production across genders during the pandemic. Furthermore, I also analyze whether childcare demand contributes to widening the gender production gap.

Exploiting a Difference-in-Differences approach, I explore whether the timing of the COVID-19 curfews impacts (female) academic production. I draw daily data on economics working papers through web-scraping techniques from the SSRN web archive. My sample comprises 4,778 pre-prints involving 8,651 authors (34.6% women) from January to November 2020.

My evidence shows that the lockdowns reduce the number of working papers written by female economists. My results suggest a widening of the gender production gap of about 20 percentage points, and this effect persists up to 4 months later the beginning of confinements. These estimates yield consistent results with the idea that lockdown policies have negatively affected the labour market performance of female economists. However, school re-openings counteract gender declines in production, suggesting that childcare demand has been an important channel in determining women's production drop. At the individual level, I show

that the dynamics of the daily number of female authors mirrors that of the gender production gap during confinements and school re-openings periods, highlighting that tenured economists working for Universities are those who most suffered (gained) during mobility restrictions (school re-openings) period. I also perform a series of robustness checks that rule out inaccuracy and seasonality concerns driving my results. Finally, I explore the hypothesis that a substitution effect can explain the widening of the gender production gap toward quality at the expense of quantity. A tentative analysis, based on two different proxies, rules out this hypothetical channel suggesting no changes in quality after lockdown policies.

This research is related to three main strands of the literature. First, it relates to the (scant) literature about the gender gap in academia during COVID-19. Several authors report negative evidence of the health shock crisis on female economists' productivity (Deryugina et al. (2021); Fuchs-Schundeln (2020); Rasul (2020); Shurkov (2020); Squazzoni et al. (2021)). On the contrary, Amano-Patiño et al. (2020) find that the share of women contributors to CEPR and NBER in 2020 remained comparable to previous years. As a result, this paper aims to be the first comprehensive analysis of the gender production gap arising from confinements and home production inequalities that COVID-19 has caused.

Second, it refers to studies investigating the labour market outcomes of female economists in academia. Despite substantial progress in women's educational attainment over the past 30 years, the fraction of women in economics at all stages of the educational and professional ladder has remained stubbornly low (Lundberg and Stearns (2019); Lundberg (2018); Bayer and Rouse (2016)). Recent research has highlighted the unequal treatment of women in academic economics, along several dimensions. Women in economics are less likely to be promoted, even conditional on productivity (Ginther and Kahn (2014); Ginther and Kahn (2004)), and to be preferred in a hypothetical hiring scenario (Williams and Ceci (2015)). Women receive less credit for co-authorship (Sarsons (2017)), are held to higher standards, and go through a longer process of peer review in top economics journals (Card et al. (2019); Hengel (2017)). They tend to produce fewer papers than men (Lundberg (2020)), write fewer single-author papers and prefer to maintain productive solid ties with a small circle of coauthors (Ductor et al. (2018)). Female instructors in economics receive lower teacher evaluations (Mengel et al. (2019); Boring (2017)), are underrepresented in principles of economics textbooks (Stevenson and Zlotnik (2018)), and face explicit hostility in an anonymous online forum with academic and professional purposes (Wu (2018)).

On a more general level, it also contributes to studies investigating the likely negative and unequal consequences of the COVID-19 crisis on labour market outcomes and productivity of men and women. Indeed, confinement adoptions have hardly impacted labour market functioning and dynamism. While past recessions were labelled as "he-cession" (Rubery and Rafferty (2013); Hoynes et al. (2012)), the COVID-19 pandemic has been relabeled as "she-cession". The pandemic shock has severely hit economic sectors not complying with social distancing, where the female employment share is usually higher (Alon et al. (2020)). Along with physical distancing and responsible commingling, school closures have further differentially affected men and women on home production, childcare responsibilities, and household chores (Adams-Prassl et al. (2020); Del Boca et al. (2020); Hupkau and Petrongolo (2020)).

The rest of the paper is organized as follows. Section 2 introduces a brief description of the data and presents the regression specification. Section 3 reports the results of the empirical

analysis. Section 4 tests the role of childcare demand and discusses other likely mechanisms underlying my results. Section 5 explores the individual dimension of the authors' data. Section 6 and 7 present some robustness checks and additional results. Section 8 investigates a trade-off in quantity for quality during the lockdown. Finally, Section 9 concludes.

2 Data and empirical strategy

I collected data from the Social Science Research Network (SSRN), a repository of pre-prints (working papers) aiming at rapidly disseminating academic research outputs in social science. In particular, through web-scraping techniques, I extracted all the working papers uploaded from January to November 17, 2020, on the repository's website regarding the *Economics Departments Research Papers* and *Economics Research Centers Papers*, that is the two most popular pre-prints series in the economic field available on SSRN. I gather information at the daily and working paper level on paper titles, authors' names, authors' affiliations, and their addresses.

From the records extracted, I kept only working papers submitted for online dissemination for the first time during the (almost) 11 months of 2020. The final number of papers amounts to 4,778 distinct pre-prints involving 8,651 authors from over 90 countries. In addition, by matching authors' names and their affiliations, I hand-collected their gender (2,217 female economists and 6,405 male economists) and their current job positions, obtaining detailed descriptions of their employment status for a total of 93.5% of the authors' sample.

Taking advantage of each author's country (of affiliation), I collect each country's lockdown start date from news sources and the United Nations' report. Based on this information, I assign to each author the respective lockdown date enacted in her country. Since many of the papers included in my sample are co-authored (84.5% of working papers), I compute the earliest lockdown date among those of each author for each working paper. However, suppose one paper has a female economist (or more) among its authors. In that case, I always consider as the earliest date that of the female economist whose country first introduced lockdown policies.

Then, I define a normalized daily time variable, simply the difference between the WP date publication on SSRN and the minimum lockdown (defined at the WP level). Thus, I leverage the timing of curfews instead of its variability across countries, and I determine whether a paper was uploaded on the platform before or after the confinements accordingly. This strategy allows (indirectly) also to control for any anticipation of the shock for authors in countries where curfew would not have started yet.

I adopt a Difference-in-Differences approach using the aggregated number of papers at the (normalized) daily level as an outcome variable. This methodology allows me to compare the productivity gap between female and male researchers before and after the confinements. The empirical model reads as follows:

$$no.\ papers_{i,t} = \alpha + \beta F_i + \theta F_i \times L_t + \lambda_t + \eta_{i,t} \tag{1}$$

where $no.\ papers_{i,t}$ represents the number of papers observed for gender i on day t, F_i is dummy variable that takes value of 1 if gender i is female, and 0 otherwise. The dummy variable L_t

equals 1 if day t occurs the day or after the lockdown measure was adopted, and λ_t includes a set of daily time dummies that control for time trends. The parameter of interest, measuring the effect of COVID-19 shock on the production level (that I expect to be negative), is given by θ that estimates the impact of the lockdown on female academics' research productivity relative to that of their male colleagues.

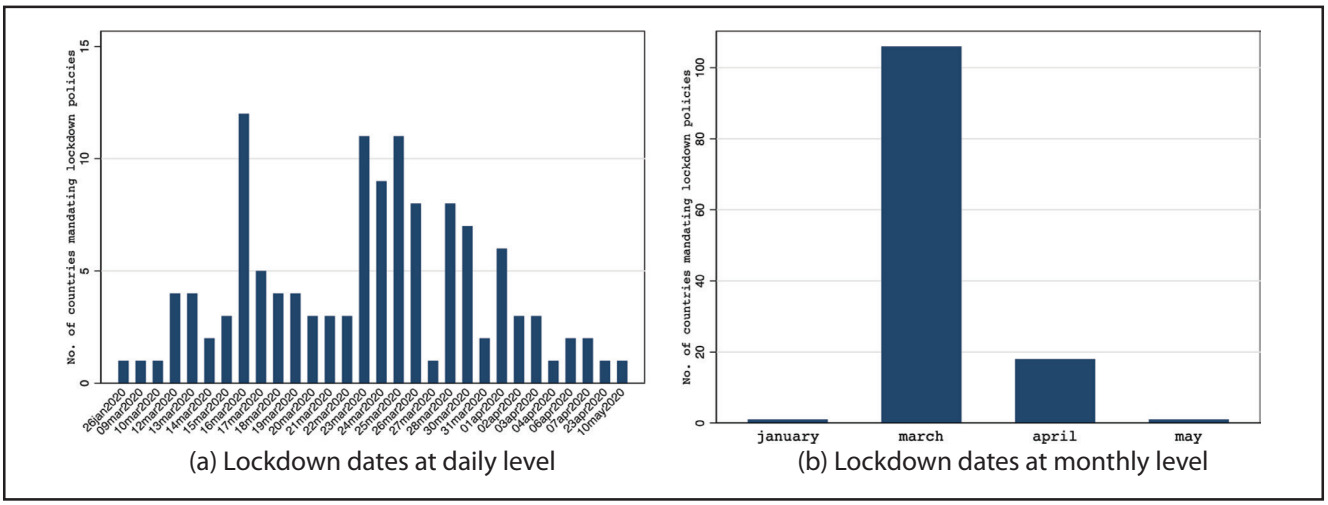
Moreover, I estimate Equation (1) using different bandwidths, measured in days, around the lockdown event, given that I can follow daily working paper production from 90 days before and up to 240 days after curfews. I estimate the model with three different symmetric bandwidths of ±30, ±60 and ±90 days around day 0. Then, I extend the post-treatment period to +120, +150, +180, +210 and +240 days after the lockdown to check whether and how long the effect is persistent.

The Difference-in-Differences estimate could have a causal interpretation provided that lockdown policies enacted in response to the COVID-19 pandemic represent a truly exogenous shock. As the recent literature highlights, this is not the case (Goodman-Bacon and Marcus (2020)). Government-packaged policies, reserve causality, voluntary precautions and anticipation cast severe concerns about causality.

Regarding the anticipation concern, the identification strategy requires that none of the two academic gender groups strategically anticipated the COVID-19 outbreak by quickly completing their current research works. However, the COVID-19 outbreak was assessed as a low-risk concern in many countries until the end of February 2020, with no meaningful actions aside from travel warnings for specific areas. Indeed, only after the declaration of a global pandemic by the World Health Organization on March 11, 2020, the number of countries enacting confinements increased (see Figures 1a and 1b).

However, packaged policies (e.g., social distancing encouragement), reserve causality (e.g., confinements length is a function of past infection rates), and voluntary precautions, despite affecting both gender groups, cannot be controlled in total for and may positively inflate the magnitude Difference-in-Differences estimates. Therefore, in the following, I will never claim causality, although there is convincing evidence about the robustness of my estimates.

Figure 1 Lockdown dates.



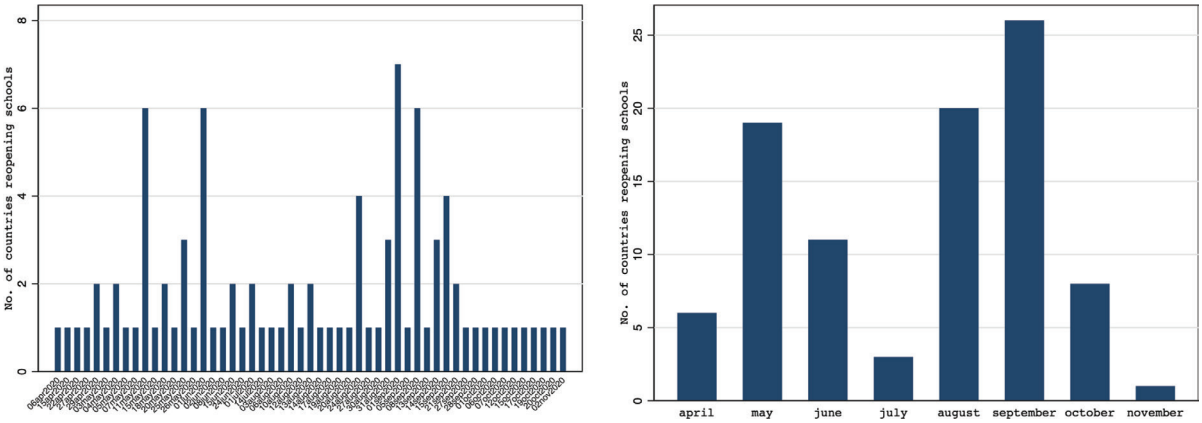
(a) Lockdown dates at daily level (b) Lockdown dates at monthly level

Source: My own calculation based on newspapers and official statements.

2.1 **Descriptive statistics**

According to Table 1, at least a female economist has written 44.2 percent of the working paper. Each paper has, on average, approximately three authors, is 47 pages long, and has had its abstract viewed online 111 times and downloaded over 20 times over the sample period. Out of the 4,778 pre-prints, about 26 percent of them were published during May and June 2020 (see Figure 3). The gender comparison reveals no differences except for the number of authors, abstract views, and downloads.

Figure 2 School re-openings dates.



(a) School re-openings dates at daily level **(b)** School re-openings dates at monthly level

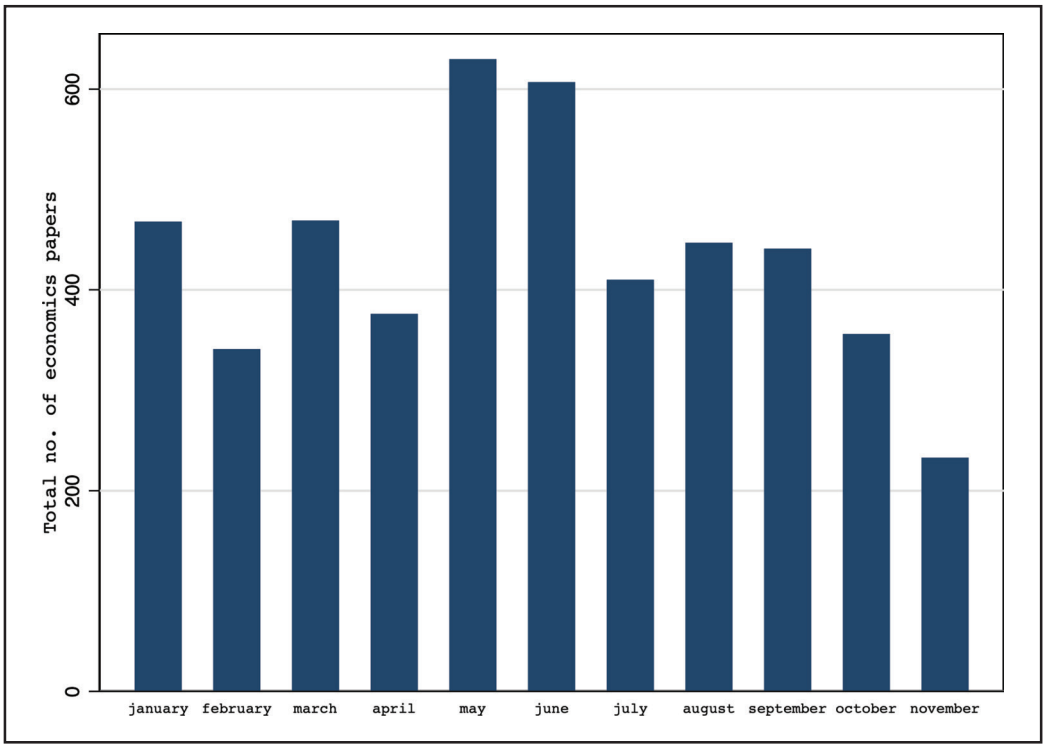
Source: My own calculation based on COVID-19 Impact on Education and Education Week.

Table 1 Economics working papers summary statistics

	Mean	SD	min.	Max.	Obs.
All observations:					
Tot. authors	2.738	1.366	1	18	4,778
No. of downloads	19.502	78.726	0	3,615	4,778
No. of views	111.341	458.425	1	28,396	4,752
No. of pages	47.186	23.789	2	564	4,745
Female author	0.442	0.497	0	1	4,778
Total no. of female	0.625	0.852	0	7	4,778
Intensity female	0.22	0.297	0	1	4,778
At least one female author:					
Tot. authors	3.199	1.549	1	18	2,112
No. of downloads	16.143	56.201	0	1,545	2,112
No. of views	103.014	228.24	1	8,121	2,098
No. of pages	48.073	21.5	4	250	2,098
Total no. of female	1.415	0.725	1	7	2112
Intensity female	0.498	0.247	0.071	1	2112
Only male authors:					
Tot. authors	2.374	1.07	1	9	2,666
No. of downloads	22.163	92.691	0	3,615	2,666
No. of views	117.923	578.851	1	28,396	2,654
No. of pages	46.483	25.438	2	564	2,647

Notes: Sample period goes from January to November (17^{th}) 2020.

Figure 3 Number of working papers by month.



With regards to authors, 34.6% are women. Figure 4a shows that most female authors are affiliated with institutions based in the US, followed by Germany, the UK, Italy, Russia, and France. A similar pattern is also observed for the sample of male researchers (see Figure 4b). Figures 5a and 5b show the percentage distributions of the 8,651 authors by gender and job position. Male authors are more likely than women to hold full-professor positions (35.6% vs 20% of women). On the contrary, the percentage compositions of the remaining positions do not differ between the two groups. However, given the considerable heterogeneity in employment positions, I grouped them on whether they can be considered tenured staff. I defined tenured as those holding the following positions: senior assistant- associate or full professors, economists or senior economists, researcher or senior researchers, and senior research fellows; otherwise, as not tenured. According to Figure 6, 58.6% of women hold a tenured position (69 percent men), whereas 41.4% are not (31% men).

Figure 7a plots the evolution over time of the gender production gap. Before the imposition of confinements, it alternates positively and negatively and worsens only with lockdowns (up to 100-120 days later). With the lift of social restrictions (after 100-120 days), it started to behave as during the pre-lockdown period. Figure 7b shows the average daily production by gender before, during the lockdown and in the aftermath of school re-openings. During the pre-lockdown period, no remarkable difference in production emerges (average daily production is about 6 working papers per gender). During confinements, although daily production for men somewhat increased, that of women declined. However, with schools opening, the gap closes (although lower production is observed for both male and female authors). A similar pattern is also followed by the daily average number of authors across periods, tenure and gender, as shown in Figure 8.

Figure 4 Distribution of authors by gender and country of affiliation.

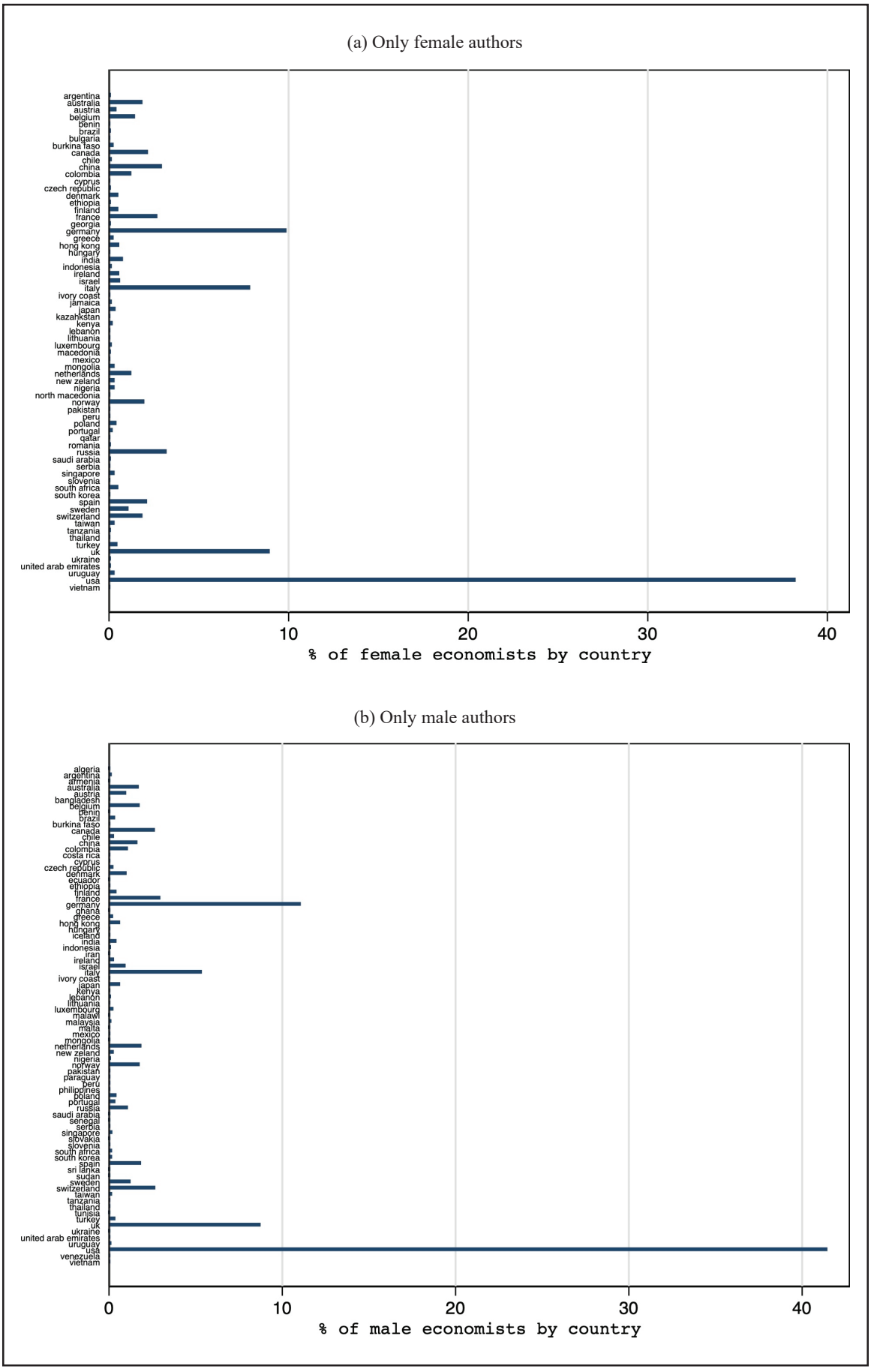
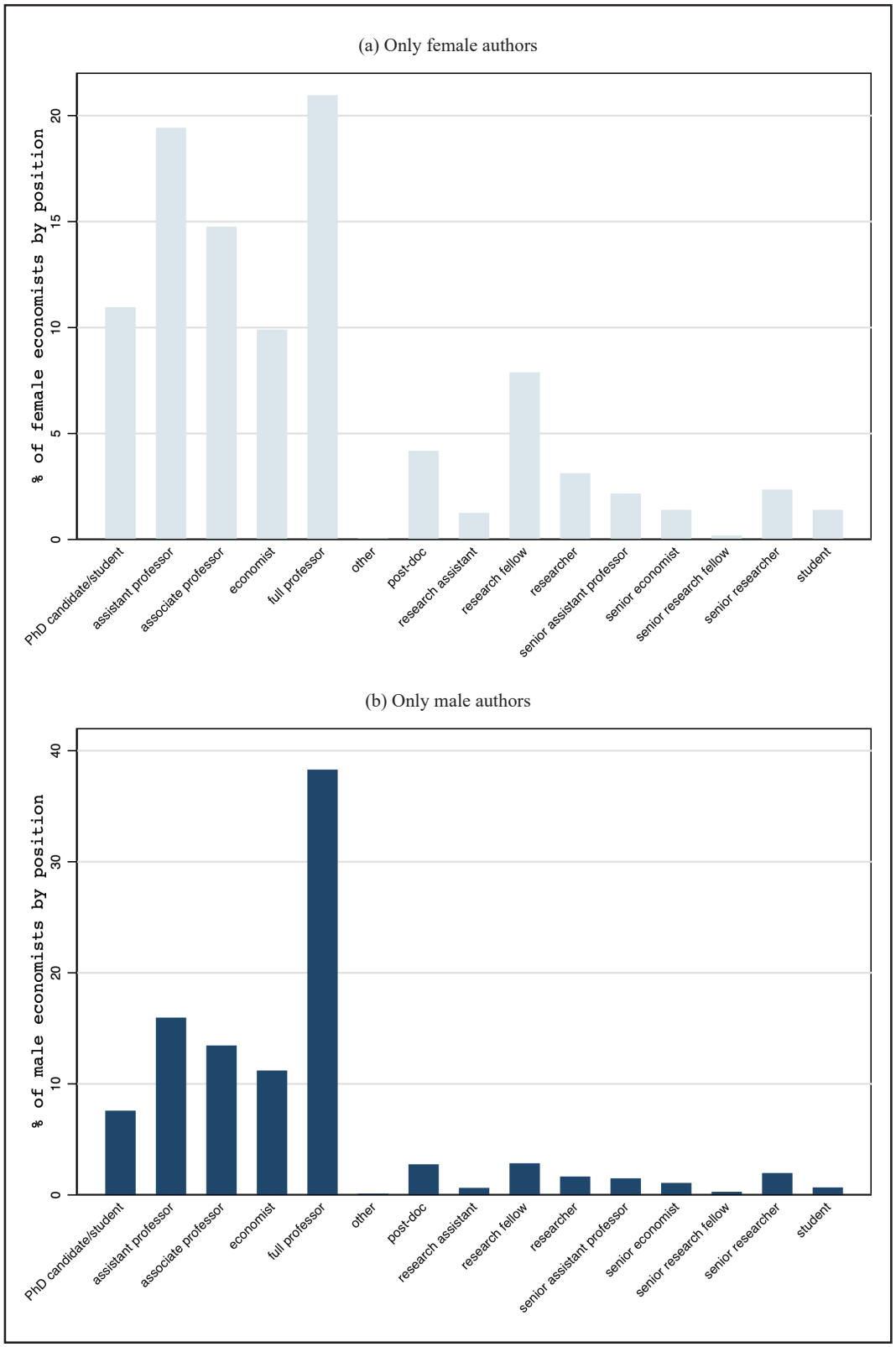


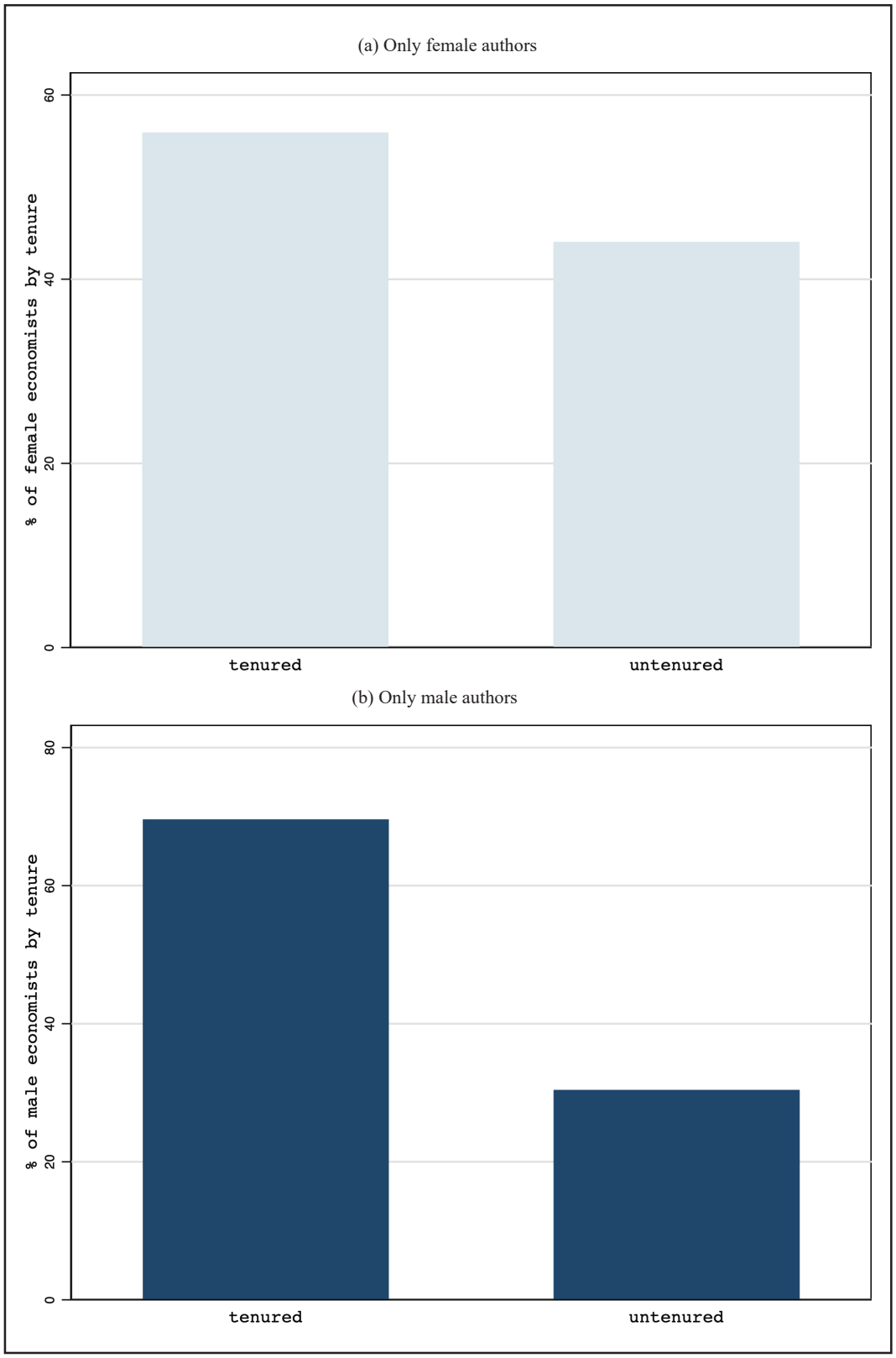
Figure 5 Distribution of authors by gender and position.



3 COVID-19 and female academic productivity

Table 2 reports the estimated effects of the pandemic shock on research productivity at the aggregate daily level. As explained in Section 2, I estimate Equation (1) using different bandwidth sizes around the (normalized) timing of confinements. Specifically, I start using three

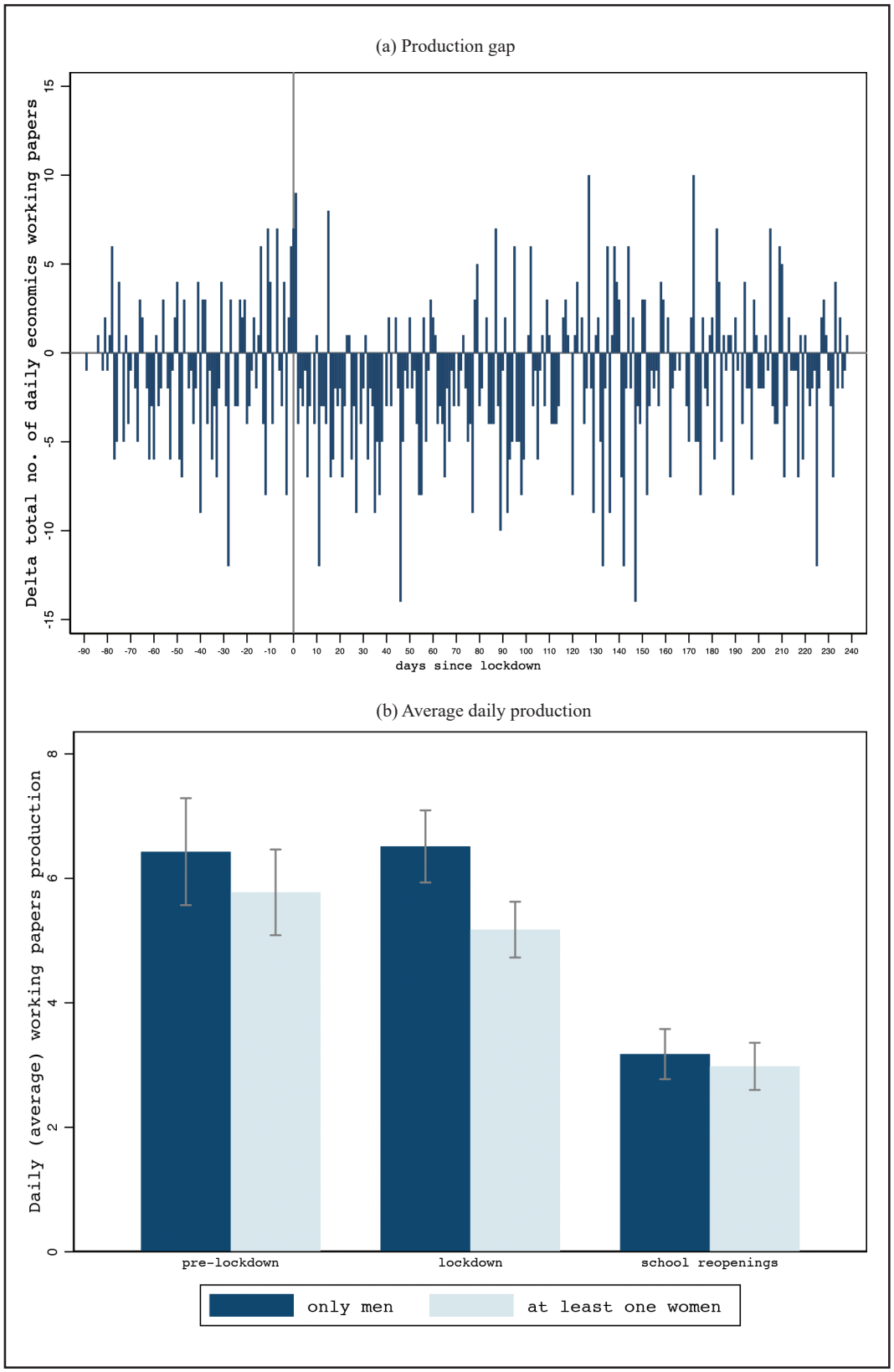
Figure 6 Distribution of authors by gender and tenure.



symmetric bandwidths of sizes ±30, ±60, ±90 (Columns (1)-(3)), and I extend the post-lockdown period from 120 to 240 days (Columns (5)-(8)).

The estimated coefficients suggest that adopting social distancing measures negatively affects female economists' labour market performance. First, in line with the descriptive evidence

Figure 7 Aggregate number of papers by gender.



Notes: Mean values (bars) and 95% confidence interval.

in Table 1, women in economics produce fewer papers than male colleagues. Furthermore, I find that the relevant coefficient of interest (F*L) is always negative but statistically significant when I consider bandwidths size of ±60, ±90 and −90, +120 days around the timing of

Figure 8 Average no. of authors by period, gender and tenure.

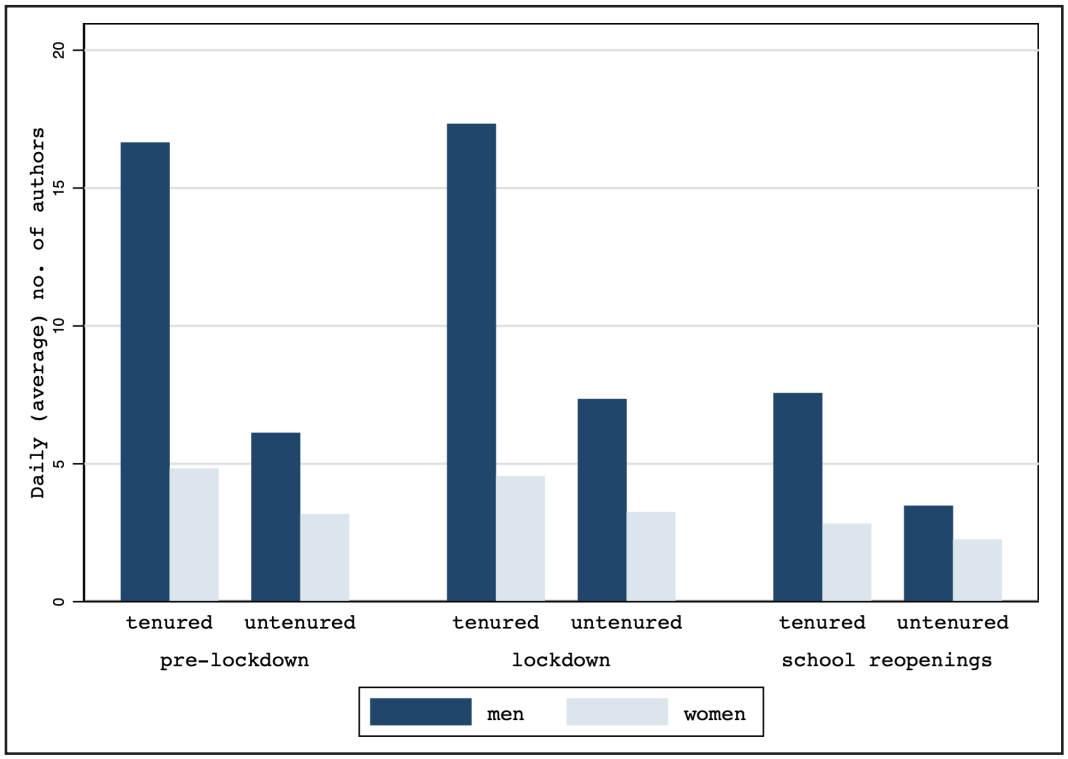


Table 2 Impact of lockdown on gender production

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
BW:	±30	±60	±90	−90,+120	−90,+150	−90,+180	−90,+210	−90,+240
F	−0.4643	−0.8929	−0.8974^{+}	−0.8974*	−0.8974^{+}	−0.8974^{+}	−0.8974^{+}	−0.8974*
	(0.8674)	(0.5711)	(0.4582)	(0.4501)	(0.4715)	(0.4596)	(0.4570)	(0.4466)
F*L	−1.8690	−1.5478^{+}	−1.3071*	−1.1291^{+}	−0.9476	−0.7634	−0.5282	−0.4971
	(1.2060)	(0.7973)	(0.6293)	(0.5851)	(0.5868)	(0.5546)	(0.5407)	(0.5204)
Days FE	yes	yes	yes	yes	yes	yes	yes	yes
Avg. Dep. Var. before	5.7931	6.1754	5.7750	5.7750	5.7750	5.7750	5.7750	5.7750
Obs.	116	230	332	382	440	498	546	592
R^2	0.2349	0.4719	0.4970	0.5082	0.4766	0.4862	0.4835	0.5034

Notes: Difference-in-Differences estimates on aggregate daily economics working papers based on different bandwidths, measured in days, around the timing of lockdowns (day 0). Robust standard errors in parentheses. Statistical significance denoted as follows: $^{+}p < 0.10$, $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

restrictions. In particular, the interaction term suggests a relative average reduction in women's production, compared to that of men, of 26% (±60 days), 22.6% (±90 days), and 19.6 percent (−90, +120 days).

Hence, the empirical evidence consistently supports the idea that the COVID-19 shock has amplified inequalities within the labour market. My results support the view that lockdown policies have somehow affected women more than men, documenting a widening of the gender production gap of about 20 percentage points. Furthermore, the negative effect persisted for up to four months (around +120 days) after the timing of social distancing measures, dissipating during/after their mild lift, which occurred in almost every country during the summer season.

4 Possible mechanism

So far, my estimates show that during the first acute phase of the pandemic, which obliged governments to put in place substantial mobility restrictions, female economists' productivity dropped considerably. This evidence also appears to be consistent with a large body of literature examining gender productivity gaps in academia and studies describing the detrimental side effects of lockdown measures. Unfortunately, I have limited information on researchers' data (such as parental status), which prevents me from directly testing the mechanism underlying the observed empirical patterns. However, I can use the gradual re-opening of schools to test the role of childcare demand. Also, previous and recent research may shed light on other possible mechanisms underlying gender productivity gaps exacerbated during the pandemic.

Finally, although my estimates are specific to one academic field, there is evidence that other disciplines also saw a widening of the gender production gap (Deryugina et al. (2021); Squazzoni et al. (2021)), particularly those where gender balance was the lowest of all academic fields (see, for example, King and Frederickson (2020) for STEM disciplines).

4.1 Childcare and household chores

With confinements and school closures, many parents have been responsible for caring for and homeschooling while homeworking. The economic literature has always documented a gender gap in household chores, primarily shouldered by women, likely to widen during the health crisis. Consequently, such an extraordinary burden increase can negatively affect labour productivity.

Previous evidence shows that women in academia are subject to a severe fertility gap (National Science Foundation (2019)). Nonetheless, they burden most of the childcare in their families (Schiebinger and Gilmartin (2010)). Furthermore, women in academia dedicate less time to research because of childcare and household chores (Misra et al. (2012)) and often report lower work-family balance (Fox et al. (2011)). During the first wave of COVID-19, academics with young dependents report a reduction in research time of 17%, with an additional 5% penalty for women (Carlson et al. (2020); Myers et al. (2020)).

To investigate the role of childcare demand on the gender production gap, I use data on worldwide school re-openings from COVID-19 Impact on Education (Unesco) and EducationWeek for the US[1]. In Figure 2, I report school re-opening dates based on the authors' country (of affiliation). Most re-openings occurred during the 2020/2021 school year, while few began at the end of the 2019/2020 school year. Only six countries have never mandated school closures[2].

Symmetrically to the computation of the lockdown date at the working paper level, I compute each author's latest school re-opening date for each working paper. However, if a paper has a female economist among its authors, I always consider the latest date of the female economist

1 In the US, despite many states mandated school closures in the aftermath of the COVID-19 outbreak, they left school re-openings decisions to local education districts and public health authorities. Each school district, hence, in accordance with the local health authority, decided whether to re-open schools with in-person lessons or to continue with distance-learning (or also to adopt a flexible and hybrid way of learning, that is a mix of in-person and distance learning). Given the high degree of fragmentation within each state, I adopted the following rule: if more than half of the state-specific school population was allowed to go back in class, I consider schools in that state as opened, otherwise not.

2 These countries are: Australia, Iceland, New Caledonia, Russia, Sweden and Taiwan.

Table 3 Impact of lockdown and school re-openings on gender production

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
BW:	±60	±90	−90,+120	−90,+150	−90,+180	−90,+210	−90,+240
F	−0.8929	−0.8974^{+}	−0.8974^{+}	−0.8974^{+}	−0.8974^{+}	−0.8974^{+}	−0.8974^{+}
	(0.6017)	(0.4790)	(0.4712)	(0.4849)	(0.4785)	(0.4811)	(0.4812)
F*L	−1.5478^{+}	−1.2624^{+}	−1.1290^{+}	−0.9639	−0.7486	−0.4704	−0.4511
	(0.8400)	(0.6573)	(0.6119)	(0.6029)	(0.5767)	(0.5680)	(0.5591)
SO	−9.2372***	−6.4873***	−5.8632***	−5.4167***	−4.4943***	−3.7537***	−3.1366***
	(1.2475)	(0.6534)	(0.5297)	(0.4557)	(0.3956)	(0.3554)	(0.3266)
F*SO	−0.5888	0.0696	0.1271	0.3525	0.3820	0.5345	0.4894
	(1.5732)	(0.8914)	(0.7603)	(0.7026)	(0.6524)	(0.6218)	(0.5986)
Days FE	yes	yes	yes	yes	yes	yes	yes
Obs.	252	402	489	595	697	803	909
R^2	0.4432	0.4769	0.4790	0.4601	0.4367	0.3942	0.3669

Notes: Difference-in-Differences estimates on aggregate daily economics working papers based on different bandwidths, measured in days, around the timing of lockdowns (day 0). Robust standard errors in parentheses. Statistical significance denoted as follows: $^{+}p < 0.10$, $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

whose country last mandated in-person school. Then, I augment Equation (1) with a variable that captures the staggered school re-openings ($SO_{i,t}$) and its interaction with the gender dummy. The empirical model I estimate reads as follows:

$$no.papers_{i,t} = \alpha + \beta F_i + \theta F_i \times L_t + \varphi SO_{i,t} + \delta F_i \times SO_{i,t} + \lambda_t + \eta_{it} \quad (2)$$

and I expect, if childcare demand has played a role, that in the aftermath of school re-opening δ to be close to 0 or at least not statistically significant. To be consistent with the previous evidence, I estimate Equation (2) using the same bandwidths as before with Equation (1), but in this case, I am forced to drop the tightest bandwidth (that is ±30 days) given that during the first 30 days in the aftermath of the lockdown no school was opened yet.

The results of this further analysis are available in Table 3. In line with the previous evidence, discussed in Section 3, overall production is lower for females, and the persistence of the adverse effects implied by the lockdown lasts up to 120 days later. During the school re-opening, however, I observe a substantial and statistically significant decline in overall production in line also with the descriptive evidence of Figure 7b, whose magnitude declines as the bandwidth size increases. Interestingly, the coefficient associated with the interaction of the school re-opening period and the female dummy is never statistically significant, and its magnitude is very close to 0. Therefore, this seems to suggest that childcare demand has played a role in determining productivity deterioration for female economists during the lockdown period[3].

4.2 **Teaching duties**

A second possible explanation for the reported drop in female economist productivity is an increase in teaching responsibilities during the pandemic.

3 I obtain the same estimates even controlling for lockdown length in an attempt to address a possible attenuation bias (estimates not reported).

Past research, indeed, showed that women have academic positions that generally require higher teaching, mentoring, and service commitments (Guarino and Borden (2017); Misra et al. (2012); Misra et al. (2011); American Association of University Professors (2001)).

The COVID-19 crisis and the subsequent university closures urged rearranging academic plans. This huge administrative effort has been dealt with very often by creating working groups that included faculty members, most of whom were women.

Furthermore, lockdown measures imposed instructors a quick transition to online teaching. Recent evidence suggests that online teaching takes more time, especially when initially creating a class, than in-person teaching (Myers et al. (2020)), thus creating greater demands on the time of faculty members with larger teaching activities.

4.3 Psychological and mental well-being

Mental well-being deterioration constitutes a third potential mechanism for understanding the worsening of the gender production gap. Indeed, lockdowns and social-distancing measures have limited individuals' possibility to meet and socialize with others. This significant disruption in daily life and routine may have contributed to a deterioration of people's mental health, besides other negative consequences of the pandemic. Moreover, mental health and subjective well-being influence individual choices and behaviours that may influence economic outcomes, such as productivity.

Early indicators from COVID-19 specific surveys have already shown lower levels of subjective well-being and higher depression and anxiety levels than those observed in the last quarter of 2019. Several studies using these sources have revealed a significant decline in subjective well-being during the lockdown times. The evidence shows sizable effects of the pandemic on mental health, larger for women than for men (see for instance Armbruster and Klotzbücher (2020); Arpino et al. (2020); Banks and Xu (2020); Brülhart and R. (2020); Tubadji et al. (2020); Yamamura and Tsutsui (2020)).

5 The role of tenure

My results show a substantial deterioration of the gender production gap during confinements. However, my evidence about the author dimension of the data remains silent. Because of data limitations, the only way to proxy motherhood is to focus on the employment status of the researchers (tenured or not).

Tenured and untenured scholars may have different incentives in research production. Promotion requirements are usually measured through research output, and skipping even a single year of publication can significantly reduce the likelihood of career advancement (Ioannidis et al. (2014))[4]. Women in academia suffer from a fertility gap at the descriptive level, but being a mother correlates positively with tenure levels (along with biological age; National

4 Nonetheless, Universities recognized the strain that the COVID-19 pandemic had on non-tenured faculty. According to a researchers-made list, about 261 Universities reevaluated tenure and promotion processes to account for the disruption caused by COVID-19. While it might be true that tenure extension and promotion timelines may have a direct impact on the quality of a given working paper and subsequently on its publication journal, it is doubtful that it will influence the decision to start circulating it as a working paper, also in light of the time that elapses between the working paper circulation and its publication within the economics field.

Science Foundation (2019)). Consequently, the effect of the COVID-19 on gender production may depend not only on tenure levels but also on the probability of motherhood within tenure levels (as also a proxy for biological age).

To test this hypothesis, I estimate Equation (2) separately for tenured and not tenured scholars through a sample split Difference-in-Differences using the daily count of authors by gender and tenure as dependent variable. I expect that the production gap at the working paper level comes from a reduction of tenured and untenured female economists, although with a larger magnitude for tenured economists.

For this analysis, I report graphical evidence where the bars represent the associated re-scaled point estimates in terms of the sample average, different bandwidth sizes, from darker representing the confinement period to lighter the school re-opening phase. For clarity, if one of the estimated coefficients is not statistically significant, I report a null effect labelled with a zero[5].

According to Figure 9a, the daily number of female contributors reduces, almost to the same magnitude, for tenured and untenured economics around the timing of confinements. However, the recovery during the school re-opening period is markedly higher for those women with a tenured position. In Figure 9b, I replicate the previous findings, concentrating only on women working in academia. Indeed, academics enjoy higher flexibility compared to non-academic economists. Economists outside universities are naturally subject to more stringent working requirements, time schedules, and deadlines, and their inclusion may result in an attenuation bias. Figure 9b suggests that the number of tenured female economists declines considerably more than untenured economists in academia (but also relative to the evidence in Figure 9a). However, they also benefit more from school re-openings[6].

All in all, the evidence seems consistent with the dynamics of the gender production gap: when the gap has widened, the number of female economists decreases, whereas when the production gap has disappeared, the number of female contributors increases.

6 Robustness and additional results

As a first robustness test, I estimate Equation (2) using a Poisson specification rather than a simple OLS model since my dependent variable consists of the daily count of working papers observed for gender i on day t. Table 4 reports the results where the estimated coefficients are expressed in terms of Incidence Rate Ratios (IRR) based on the usual bandwidth sizes around the timing of confinements, as I have done throughout the rest of the paper. The Poisson specification still reports comparable estimates to those of Table 3 in terms of statistical significance, magnitude, and persistence of the negative effects of the lockdown on the gender production gap.

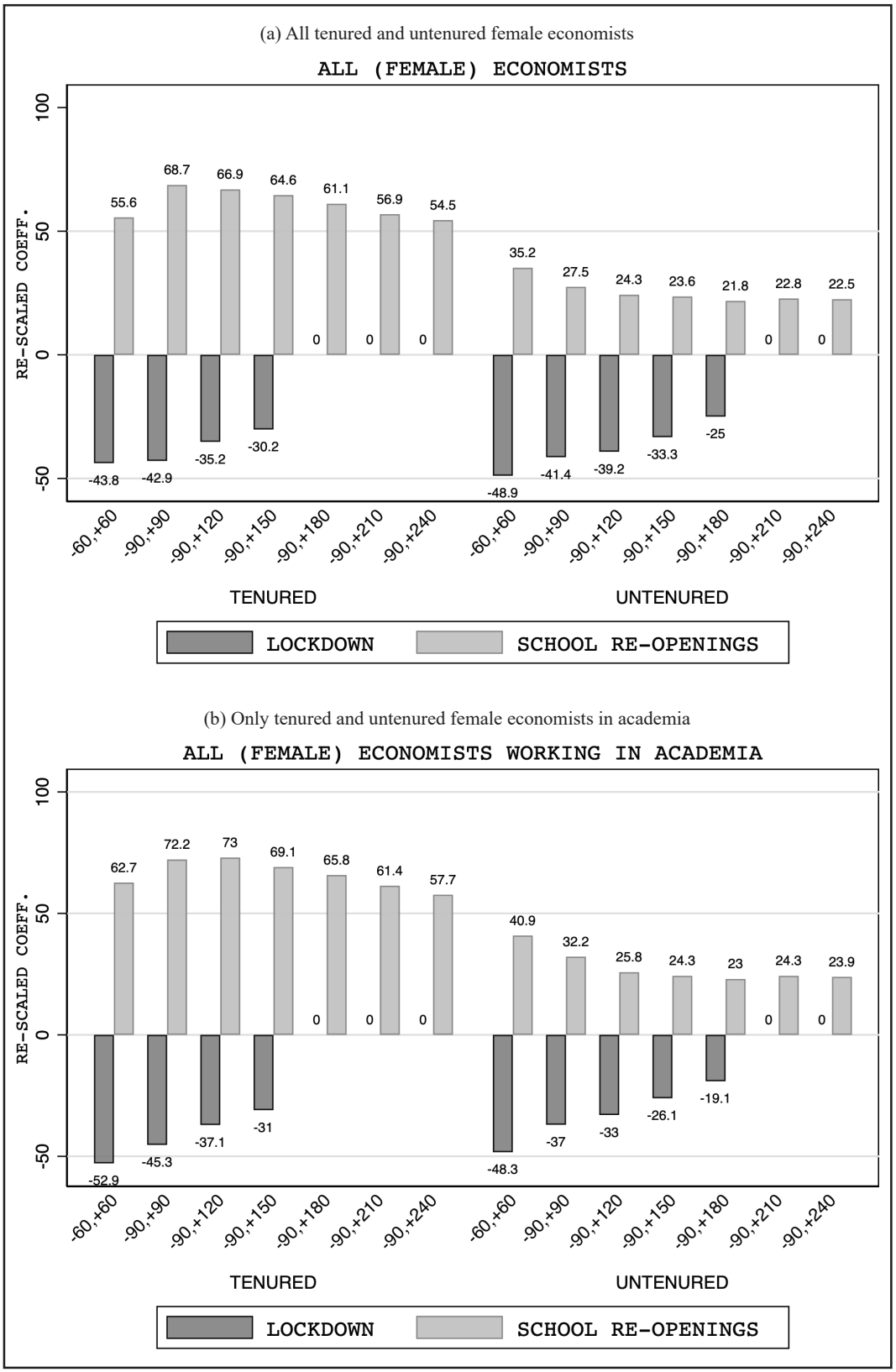
As a second robustness test, I extend the size of my pre-treatment period by considering the 2019 data[7]. One of the main concerns is that a limited pre-treatment period may overestimate the coefficients' magnitude. In this case, I estimate Equation (2) starting with symmetric band-

5 The raw estimates are available in Tables A1 and A2.

6 My findings are confirmed by excluding from the sample of tenured economist researchers, senior researchers and senior research fellows, or if I consider them as untenured rather than tenured (estimates not reported).

7 A detailed description of the 2019 data is available in Appendix B. Table B1 reports the descriptive statistics of the sample. Figures B1-B6 report graphical evidence, as was done with the 2020 sample.

Figure 9 Tenure, lockdowns and school re-openings.



Notes: Panel (a) reports the relative decrease/increase according to estimated coefficients, F*LD and F*SO, of Table A1 in terms of the sample averages for all female economists. Panel (b), replicates Panel (a), but focusing only on academics, according to the baseline estimates available in Table A2.

Table 4 Poisson model based on Eq. (2)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
BW:	±60	±90	−90,+120	−90,+150	−90,+180	−90,+210	−90,+240
F	−0.1350^{+}	−0.1431*	−0.1431*	−0.1431*	−0.1431*	−0.1431*	−0.1431*
	(0.0736)	(0.0641)	(0.0641)	(0.0641)	(0.0641)	(0.0641)	(0.0641)
F*L	−0.1765^{+}	−0.1472^{+}	−0.1431+	−0.1226	−0.1096	−0.0788	−0.0860
	(0.0991)	(0.0846)	(0.0813)	(0.0783)	(0.0768)	(0.0758)	(0.0752)
SO	−1.5999***	−1.2932***	−1.1619***	−1.0714***	−0.9366***	−0.8039***	0.6778***
	(0.2173)	(0.1189)	(0.0937)	(0.0761)	(0.0670)	(0.0592)	(0.0536)
F*SO	−0.3168	−0.1035	−0.1452	−0.0363	0.0041	0.0586	0.0377
	(0.3164)	(0.1767)	(0.1449)	(0.1204)	(0.1086)	(0.0986)	(0.0925)
Days FE	yes	yes	yes	yes	yes	yes	yes
Obs.	258	412	503	609	711	817	923

Notes: Difference-in-Differences estimates on aggregate daily economics working papers based on different bandwidths, measured in days, around the timing of lockdowns (day 0) and a Poisson specification. Estimates are expressed in Incident Rate Ratio (IRR). Robust standard errors in parentheses.

Statistical significance denoted as follows: $^{+}p < 0.10$, $*p < 0.05$, $**p < 0.01$, $***p < 0.001$.

width sizes up to ±240 days, but I also vary the pre-treatment windows to check the consistency of the estimated effects. These results are available in Table 5, where I only report the relevant interaction terms (F*L and F*SO) for brevity and the respective relative effects. As shown, the variation of the bandwidth size or the extension of the pre-treatment windows does not affect the magnitude of the coefficients delivering estimates fully comparable to those reported in Tables 2 and 3.

A final concern relates to the definition of my gender variable (Fi), which takes value of 1 if, among the authors' group of paper i, there is at least one female economist. I repeat the analysis of Equation (2) by keeping only those working papers whose author group is only composed of female or male economists. The results of this further test are available in Table 6. According to the estimated coefficients, I find that the impact of confinements on female production is more long-lasting relative to the evidence in Table 3, up to +210 days, and the magnitude of the effect almost triples. The same argument also applies to the other term of interest, F*SO. In this case, starting from the specification whose bandwidth size is +90 days, I always find positive and statistically significant coefficients. This evidence favours the main estimates obtained using the less conservative female dummy definition, ruling out an overestimation concern.

7 Falsification tests

As a first falsification test, I examine whether the gender gap (in terms of production and authors) occurred during the pre-implementation of confinements, a period during which COVID-19 began to compare everywhere, but no specific actions were taken. I exploit Equation (1) by designing a placebo lockdown date that splits the 90 days pre-treatment period in 2020 into two symmetric windows of 45 days each. If my results capture seasonality, I should also find significant effects during the placebo lockdown. Table 7 reports the falsification test results. In all cases, the placebo estimates are insignificant, implying that women's productivity and daily

Table 5 Pre-treatment period variation and extension

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
BW:	±60	±90	±120	±150	±180	±210	±240
F*L	−1.4231^{+}	−1.2313^{+}	−1.0972*	−1.0362*	−0.4998	−0.3025	−0.2001
	(0.8386)	(0.6455)	(0.5474)	(0.4954)	(0.4797)	(0.4394)	(0.4092)
	[−26%]	[−22.6%]	[−18.6%]				
F*SO	−0.4641	0.1008	0.1589	0.2803	0.6307	0.7024	0.7405
	(1.5756)	(0.8833)	(0.7065)	(0.6083)	(0.5770)	(0.5108)	(0.4640)
BW:	−240, +60	−240, +90	−240, +120	−240, +150	−240, +180	−240, +210	±240
F*L	−1.2922^{+}	−1.0114^{+}	−0.8779^{+}	−0.7129	−0.4976	−0.2194	−0.2001
F*SO	(0.6617)	(0.5546)	(0.5000)	(0.4703)	(0.4393)	(0.4230)	(0.4092)
	[−23%]	[−18%]	[−15.6%]				
	−0.3332	0.3207	0.3781	0.6036	0.6330	0.7855	0.7405
	(1.4935)	(0.8396)	(0.6879)	(0.5995)	(0.5402)	(0.4962)	(0.4640)
BW:	−210, +60	−210, +90	−210, +120	−210, +150	−210, +180	±210	−210, +240
F*L	−1.3754*	−1.0945^{+}	−0.9611^{+}	−0.7960	−0.5807	−0.3025	−0.2832
F*SO	(0.6807)	(0.5711)	(0.5157)	(0.4867)	(0.4554)	(0.4394)	(0.4257)
	[−24%]	[−19.3%]	[−17%]				
	−0.4164	0.2375	0.2950	0.5204	0.5499	0.7024	0.6573
	(1.5177)	(0.8546)	(0.7015)	(0.6139)	(0.5542)	(0.5108)	(0.4790)
BW:	−180, +60	−180, +90	−180, +120	−180, +150	±180	−180, +210	−180, +240
F*L	−1.2945^{+}	−1.0136^{+}	−0.8802	−0.7151	−0.4998	−0.2216	−0.2023
F*SO	(0.7174)	(0.6004)	(0.5421)	(0.5122)	(0.4797)	(0.4631)	(0.4490)
	[−22%]	[−17%]					
	−0.3355	0.3184	0.3759	0.6013	0.6307	0.7832	0.7382
	(1.5763)	(0.8865)	(0.7278)	(0.6383)	(0.5770)	(0.5331)	(0.5010)
BW:	−150, +60	−150, +90	−150, +120	±150	−150, +180	−150, +210	−150, +240
F*L	−1.6155*	−1.3347*	−1.2012*	−1.0362*	−0.8209^{+}	−0.5427	−0.5234
F*SO	(0.6412)	(0.5552)	(0.5111)	(0.4954)	(0.4697)	(0.4590)	(0.4491)
	[−27%]	[−22.9%]	[−20%]	[−20%]	[−17.8%]		
	−0.6565	−0.0026	0.0548	0.2803	0.3097	0.4622	0.4172
	(1.3819)	(0.8057)	(0.6750)	(0.6083)	(0.5571)	(0.5222)	(0.4961)
BW:	−120, +60	−120, +90	±120	−120, +150	−120, +180	−120, +210	−120, +240
F*L	−1.5115*	−1.2306*	−1.0972*	−0.9321+	−0.7168	−0.4386	−0.4193
	(0.6819)	(0.5924)	(0.5474)	(0.5337)	(0.5076)	(0.4974)	(0.4878)
F*SO	[−25.5%]	[−20.8%]	[−18.6%]	[−16.8%]			
	−0.5525	0.1014	0.1589	0.3843	0.4137	0.5662	0.5212
	(1.4275)	(0.8388)	(0.7065)	(0.6422)	(0.5909)	(0.5573)	(0.5321)

Notes: Diff-in-Diff estimates on aggregate daily economics working papers based on different bandwidths, measured in days, around the timing of lockdowns (day 0) and 2019 and 2020 data. Robust standard errors in parentheses.

Statistical significance denoted as follows: $^{+}p < 0.10$, $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

numerousness did not decline significantly during the 45 days before the lockdown began. This evidence suggests that the seasonality concern seems not motivated.

Furthermore, I also use the 2019 sample by exploiting Equation (2) and anticipating the confinement and school re-opening dates by one year, that is, in 2019. Again, if the 2020 evidence is simply the result of a seasonality effect, I should observe declining gender production levels and number of female economists in 2019. The results are available in Tables 8, 9 and 10.

Table 6 WP written by only female vs. only male economists

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
BW:	±60	±90	−90,+120	−90,+150	−90,+180	−90,+210	−90,+240
F	−5.1667***	−4.7674***	−4.7674***	−4.7674***	−4.7674***	−4.7674***	−4.7674***
	(0.9272)	(0.6873)	(0.6651)	(0.6849)	(0.6827)	(0.6728)	(0.6810)
F*L	−3.3477*	−3.0027**	−2.6595**	−2.4394**	−1.8565*	−1.3938^{+}	−1.0132
	(1.2742)	(0.9184)	(0.8526)	(0.8436)	(0.8165)	(0.7924)	(0.7953)
SO	−8.5540***	−6.3696***	−5.8399***	−5.4741***	−4.6033***	−3.8148***	−3.2368***
	(1.4818)	(0.7204)	(0.5749)	(0.4934)	(0.4316)	(0.3793)	(0.3529)
F*SO	1.1893	3.0321*	3.0088**	2.5761*	2.4934*	2.6909**	2.6319**
	(2.6189)	(1.2929)	(1.1380)	(1.1045)	(1.0422)	(0.9439)	(0.9061)
Days FE	yes	yes	yes	yes	yes	yes	yes
Obs.	144	254	307	376	445	519	585
R^2	0.4915	0.5008	0.5022	0.4733	0.4307	0.3865	0.3392

Notes: Difference-in-Differences estimates on aggregate daily economics working papers, written by only female and male economists, based on different bandwidths, measured in days, around the timing of lockdowns (day 0). Robust standard errors in parentheses.
Statistical significance denoted as follows: $^{+}p < 0.10$, $*p < 0.05$, $**p < 0.01$, $***p < 0.001$.

Table 7 Falsification tests

	No. papers	No. authors			
		All economist		Only academics	
		Tenured	Untenured	Tenured	Untenured
	(1)	(2)	(3)	(4)	(5)
F	−0.9444	−12.2059***	−3.5926***	−11.0645***	−3.0000***
	(0.6609)	(1.5067)	(0.6926)	(1.2912)	(0.6832)
F*PL	0.0873	−1.1751	0.2176	−0.0934	0.3056
	(0.9006)	(2.0268)	(0.8964)	(1.7399)	(0.8819)
Placebo days FE	yes	yes	yes	yes	yes.
Obs.	156	152	134	138	120
R^2	0.3912	0.5968	0.4648	0.5886	0.3891

Notes: Difference-in-Differences estimates based on a bandwidth of 45 days centered around the timing of placebo lockdown policies (day 0). Robust standard errors in paren- theses.
Statistical significance denoted as follows: $^{+}p < 0.10$, $*p < 0.05$, $**p < 0.01$, $***p < 0.001$.

Overall, the results support the main 2020 findings since there is no evidence of a gender production gap widening or a decline in the number of female economists.

Overall, these tests provide strong evidence supporting the robustness of the empirical analysis, suggesting that these results are implausible to be driven by a seasonality effect.

8 Quantity vs. Quality

Having ascertained the decrease in productivity of female economists during the lockdown period and not after school re-openings, one might wonder whether, due to the curfews,

Table 8 Falsification test: Eq. (2) using 2019 data

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
BW:	±60	±90	−90,+120	−90,+150	−90,+180	−90,+210	−90,+240
F	−0.6724	−0.7632+	−0.7632+	−0.7632+	−0.7632+	−0.7632+	−0.7632+
	(0.5010)	(0.4274)	(0.4062)	(0.4153)	(0.3993)	(0.4550)	(0.4431)
F*L	−0.3276	−0.1192	−0.0243	0.0482	0.0634	0.1610	0.1596
	(0.7181)	(0.5882)	(0.5250)	(0.5138)	(0.4799)	(0.5351)	(0.5119)
SO	−3.4788**	−3.7739***	−3.5323***	−2.6631***	−2.2311***	−1.5840***	−1.2626***
	(1.1811)	(0.6379)	(0.4870)	(0.4112)	(0.3511)	(0.3541)	(0.3126)
F*SO	−0.5181	−0.4138	0.2692	−0.1100	−0.0563	−0.3510	−0.2132
	(1.5267)	(0.8897)	(0.7046)	(0.6363)	(0.5680)	(0.6064)	(0.5624)
Days FE	yes	yes	yes	yes	yes	yes	yes
Obs.	242	373	463	564	660	764	876
R^2	0.7580	0.7054	0.6969	0.6462	0.6381	0.5493	0.5333

Notes: Difference-in-Differences estimates on aggregate daily economics working papers based on different bandwidths, measured in days, around the timing of a placebo lockdown (day 0) in 2019. Robust standard errors in parentheses.

Statistical significance denoted as follows: $^{+}p < 0.10$, $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

Table 9 Falsification test: anticipated lockdown and school re-openings on gender production by tenure in 2019

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
BW:	±60	±90	−90,+120	−90,+150	−90,+180	−90,+210	−90,+240
				Tenured:			
F	−14.0175***	−12.3699***	−12.3699***	−12.3699***	−12.3699***	−12.3699***	−12.3699***
	(1.6681)	(1.2907)	(1.2006)	(1.1578)	(1.1010)	(1.1373)	(1.0874)
F*L	4.1119+	2.0973	2.6486+	2.7334+	3.3494*	3.5571**	3.7506**
	(2.4032)	(1.7768)	(1.5532)	(1.4341)	(1.3244)	(1.3396)	(1.2586)
SO	−10.5639**	−11.2136***	−10.3680***	−8.6527***	−7.8347***	−6.6142***	−5.7173***
	(3.7370)	(1.8481)	(1.3497)	(1.0746)	(0.9096)	(0.8435)	(0.7306)
F*SO	7.5916	7.3415*	8.6500***	7.5771***	8.4715***	7.4962***	7.4816***
	(5.9238)	(2.8655)	(2.2115)	(1.8513)	(1.5946)	(1.5348)	(1.3940)
Obs.	233	356	441	537	631	729	835
R^2	0.5145	0.5327	0.5433	0.5302	0.5285	0.4933	0.4934
				Untenured:			
F	−3.2041***	−2.8387***	−2.8387***	−2.8387***	−2.8387***	−2.8387***	−2.8387***
	(0.5746)	(0.4799)	(0.4584)	(0.4527)	(0.4334)	(0.4853)	(0.4883)
F*L	0.7651	0.2207	0.1989	0.3062	0.3771	0.5150	0.6741
	(0.8203)	(0.6580)	(0.5954)	(0.5614)	(0.5222)	(0.5709)	(0.5638)
SO	−3.0459+	−3.9664***	−3.2316***	−2.9651***	−2.6681***	−2.0800***	−1.4164***
	(1.7360)	(0.7555)	(0.5771)	(0.4727)	(0.3832)	(0.3769)	(0.3402)
F*SO	1.5144	1.6968	1.7082*	1.7798*	1.9606**	1.8305**	1.4707*
	(2.2084)	(1.1248)	(0.8629)	(0.7343)	(0.6422)	(0.6714)	(0.6354)
Obs.	202	303	368	450	530	619	715
R^2	0.7091	0.6685	0.6565	0.6260	0.6195	0.5241	0.4851
Days FE	yes	yes	yes	yes	yes	yes	yes

Notes: Difference-in-Differences estimates on the aggregate daily number of authors by tenure based on different bandwidths, measured in days, around the timing of a placebo lockdown (day 0) in 2019. Robust standard errors in parentheses.

Statistical significance denoted as follows: $^{+}p < 0.10$, $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

Table 10 Falsification test: *anticipated* lockdown and school re-openings on gender production by tenure in 2019, only academics

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
BW:	±60	±90	−90,+120	−90,+150	−90,+180	−90,+210	−90,+240
				Tenured:			
F	−13.3462***	−11.4478***	−11.4478***	−11.4478***	−11.4478***	−11.4478***	−11.4478***
	(1.5895)	(1.2359)	(1.1532)	(1.1068)	(1.0537)	(1.0755)	(1.0316)
F*L	5.4890*	3.0052+	3.5922*	3.5556**	4.0055**	4.1753**	4.2921***
	(2.2821)	(1.6925)	(1.4858)	(1.3661)	(1.2659)	(1.2670)	(1.1939)
SO	−8.0397*	−9.2466***	−8.3408***	−6.7932***	−6.2408***	−5.1511***	−4.4447***
	(3.4086)	(1.7245)	(1.2571)	(0.9994)	(0.8506)	(0.7772)	(0.6734)
F*S	7.4202	7.2145**	7.4827***	6.7210***	7.6111***	6.8548***	6.9297***
	(5.4120)	(2.7345)	(2.2065)	(1.8469)	(1.5883)	(1.5002)	(1.3560)
Obs.	215	332	410	498	579	666	766
R^2	0.4805	0.4834	0.4904	0.4781	0.4790	0.4467	0.4438
				Untenured:			
F	−2.6585***	−2.4038***	−2.4038***	−2.4038***	−2.4038***	−2.4038***	−2.4038***
	(0.6077)	(0.4866)	(0.4610)	(0.4497)	(0.4309)	(0.4463)	(0.4364)
F*L	0.7547	0.3228	0.2991	0.3932	0.4376	0.5843	0.6641
	(0.8638)	(0.6624)	(0.5984)	(0.5565)	(0.5179)	(0.5233)	(0.5030)
SO	−3.2011+	−2.8491***	−2.6068***	−2.3743***	−2.1180***	−1.5810***	−1.1985***
	(1.6959)	(0.7488)	(0.5642)	(0.4503)	(0.3787)	(0.3493)	(0.3048)
F*SO	0.1670	1.3259	1.5932+	1.5634*	1.7143*	1.5920*	1.3287*
	(2.5361)	(1.2324)	(0.9251)	(0.7494)	(0.6631)	(0.6339)	(0.5758)
Obs.	170	259	311	384	451	528	611
R^2	0.6417	0.6188	0.6140	0.5860	0.5776	0.5244	0.5061
Days FE	yes	yes	yes	yes	yes	yes	yes

Notes: Difference-in-Differences estimates on the aggregate number of authors by tenure, considering only economist with typical academic job positions, based on different band- widths, measured in days, around the timing of a placebo lockdown (day 0) in 2019. Robust standard errors in parentheses.

Statistical significance denoted as follows: $^{+}p < 0.10$, $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

researchers had trade-off quantity (in terms of the number of pre-prints) for quality. If this is the case, I should find an increase in the quality of working papers after the lockdown period.

To answer this question, I gathered data on two proxies that SSRN uses to rank working papers: the number of abstract views and the number of downloads. I test this possibility by estimating Equation (2) using the number of views and downloads on working paper-level data as dependent variables. While I am fully aware that journal ranking is the typical metric to evaluate research quality, I can only use these proxies bearing in mind all the limitations they are subject to.

The results of these tests are available in Table 11. According to the estimates, independently of the bandwidth chosen, none of the interaction terms (F*L and F*S0) is significant, with the only exception for the F*L coefficients using the no. of downloads as the dependent variable and a bandwidth of 120 and 150 days which are positive and statistically significant. These results suggest that research quality remained relatively the same after the lockdown measures,

Table 11 Quantity vs. Quality

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
BW:	±60	±90	–90,+120	–90,+150	–90,+180	–90,+210	–90,+240
				No. of abstract views			
F	–20.3565*	–16.8934*	–16.8934	–16.8934	–16.8934	–16.8934	–16.8934
	(10.3412)	(8.2433)	(11.7902)	(11.8163)	(34.0277)	(32.4696)	(31.2512)
F*L	18.9826	13.4288	13.7892	11.8353	–3.4149	–4.8512	–4.8601
	(13.8169)	(10.8113)	(14.8635)	(14.3658)	(40.6140)	(38.2606)	(36.5031)
SO	13.3143	7.4306	–20.0042	–17.3695	–54.2111	–42.0975	–37.8504
	(30.1371)	(15.1074)	(17.1660)	(13.9815)	(35.6794)	(30.1949)	(26.6631)
F*SO	10.2765	11.0193	28.6878	13.4856	–1.7638	–8.5203	–1.3294
	(43.0945)	(21.9449)	(25.8868)	(21.6636)	(56.5204)	(49.1835)	(44.4585)
Obs.	1735	2487	2883	3415	3806	4216	4580
R^2	0.0397	0.0651	0.0503	0.0410	0.0183	0.0182	0.0180
				No. of downloads			
F	–17.7607**	–14.3489**	–14.3489***	–14.3489***	–14.3489*	–14.3489**	–14.3489**
	(6.0210)	(4.4886)	(4.3221)	(4.0954)	(5.7775)	(5.5434)	(5.3329)
F*L	9.0604	7.7095	9.6104+	10.0929*	9.4804	9.2851	9.3089
	(8.0467)	(5.8879)	(5.4482)	(4.9795)	(6.8962)	(6.5327)	(6.2296)
SO	–8.2468	–4.1042	–4.2123	–3.9210	–9.1922	–7.7112	–6.8707
	(17.5984)	(8.2437)	(6.3024)	(4.8551)	(6.0669)	(5.1636)	(4.5557)
F*SO	19.8543	12.7012	13.6724	11.8854	10.2290	9.3387	10.4645
	(25.1618)	(11.9759)	(9.4922)	(7.5150)	(9.5999)	(8.3939)	(7.5866)
Obs.	1,744	2,499	2,899	3,431	3,824	4,236	4,601
R^2	0.0275	0.0391	0.0392	0.0406	0.0247	0.0249	0.0257
Days FE	yes	yes	yes	yes	yes	yes	yes

Notes: Difference-in-Differences estimates on individual daily economics working papers based on different bandwidths, measured in days, around the timing of lockdown policies (day 0). Robust standard errors in parentheses. Statistical significance denoted as follows: $^{+}p < 0.10$, $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

supporting the idea that my findings are unlikely to be driven by the shifts in research quality at the expense of quantity.

9 Conclusions

This paper investigates the short-run economic (labour market) implications of the COVID-19. The pandemic has caused not only disproportionate declines in economic activity but has also worsened iniquities in labour markets and home production. In particular, I study whether confinements and school closures have negatively affected female economists' scientific production.

According to my estimates, these non-pharmaceutical interventions negatively affect the gender production gap. Around the timing of confinements, the number of working papers written by female economists reduces by about 20 percentage points. This negative effect persists up to four months later the timing of restrictions. However, the decline in female scientific production disappears when schools re-open, suggesting that childcare demand has played a salient role in determining productivity deterioration for female economists. Hence,

this evidence supports the idea that social restriction measures have negatively affected labour market performance because of an extraordinary increase in household chores and childcare demand.

Furthermore, I show that the decline in production is markedly due to a reduction in the number of tenured authors working in academia. Finally, a tentative analysis shows that declines in production are not associated with increases in pre-prints quality.

Taken together, these findings appear to show considerable short-run negative effects on female economists' productivity, which according to my data, appear to dissipate in the medium term. On the policy side, whether or not these short-run impacts would translate into long-run impacts will depend exclusively on the actions Universities will undertake to mitigate the further unequal consequences this crisis has added on pre-existing inequalities within academia. While on the one hand, many Universities recognized the strain this crisis has brought on junior faculties, introducing automatic or opt-in (one-year) contract renewals, they should not ignore these issues while devising career advancement processes to mitigate the negative consequences that emerged during this crisis equally. Finally, governments should also take into account with more emphasis gender inequality issues, especially when planning strategies to lower the virus diffusion. If, as the record suggests, there is no optimal and unique strategy for effectively combating such epidemics, the explicit policy message that emerges from this study is that lockdown policies should balance the need to reduce infection spread with the need not to amplify gender inequalities, at least by lightening and mitigating the negative effects implied by the surge in childcare demand.

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APPENDIX A: The role of tenure: baseline estimates

Table A1 Impact of lockdown and school re-openings on gender production by tenure

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
BW:	±60	±90	−90,+120	−90,+150	−90,+180	−90,+210	−90,+240
Tenured:							
F	−13.4643***	−12.8553***	−12.8553***	−12.8553***	−12.8553***	−12.8553***	−12.8553***
	(1.3518)	(1.1284)	(1.1403)	(1.1652)	(1.1403)	(1.1460)	(1.1547)
F*L	−5.1392**	−4.7010**	−3.8589**	−3.3123*	−2.3072+	−1.4809	−0.6299
	(1.8951)	(1.5492)	(1.4769)	(1.4433)	(1.3730)	(1.3521)	(1.3407)
SO	−26.9446***	−18.9611***	−17.8135***	−15.9379***	−13.6780***	−11.5667***	−9.7381***
	(2.4337)	(1.4470)	(1.2051)	(1.0429)	(0.9102)	(0.8215)	(0.7610)
F*SO	8.2262*	9.9220***	9.6618***	9.3303***	8.8231***	8.2283***	7.8812***
	(3.9539)	(2.2514)	(1.9527)	(1.7700)	(1.6132)	(1.5238)	(1.4719)
Obs.	248	387	472	574	668	770	869
R^2	0.6238	0.6049	0.5875	0.5672	0.5504	0.5152	0.4814
Untenured:							
F	−3.5385***	−3.4627***	−3.4627***	−3.4627***	−3.4627***	−3.4627***	−3.4627***
	(0.7257)	(0.6048)	(0.5853)	(0.5764)	(0.5633)	(0.5636)	(0.5593)
F*L	−3.1282**	−2.5331**	−2.3980**	−2.0367**	−1.5308*	−1.1854+	−0.8951
	(1.0035)	(0.8110)	(0.7480)	(0.7066)	(0.6722)	(0.6607)	(0.6463)
SO	−11.2053***	−7.7262***	−6.9591***	−6.4456***	−5.4061***	−4.6897***	−3.9675***
	(1.4573)	(0.8010)	(0.6236)	(0.5090)	(0.4447)	(0.4030)	(0.3660)
F*SO	3.4633+	2.5661*	2.2724*	2.2065**	2.0342**	2.1325**	2.1043**
	(1.8344)	(1.1204)	(0.9419)	(0.8385)	(0.7677)	(0.7320)	(0.6976)
Obs.	239	363	440	537	627	714	808
R^2	0.4302	0.4307	0.4529	0.4610	0.4353	0.3933	0.3674
Days FE	yes	yes	yes	yes	yes	yes	yes

Notes: Difference-in-Differences estimates on the aggregate daily number of authors by tenure based on different bandwidths, measured in days, around the timing of lockdowns (day 0). Robust standard errors in parentheses. Statistical significance denoted as follows: $^{+}p < 0.10$, $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

Table A2 Impact of lockdown and school re-openings on gender production by tenure, only academics

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
BW:	±60	±90	−90,+120	−90,+150	−90,+180	−90,+210	−90,+240
				Tenured:			
F	−11.0577***	−11.1159***	−11.1159***	−11.1159***	−11.1159***	−11.1159***	−11.1159***
	(1.2349)	(1.0417)	(1.0418)	(1.0420)	(1.0327)	(1.0360)	(1.0336)
F*L	−4.8370**	−3.9748**	−3.2610*	−2.7236*	−1.8506	−1.1733	−0.5515
	(1.7077)	(1.4059)	(1.3348)	(1.2768)	(1.2313)	(1.2129)	(1.1933)
SO	−21.9452***	−15.5738***	−14.8460***	−13.1898***	−11.2039***	−9.5284***	−8.2193***
	(2.2113)	(1.3029)	(1.0740)	(0.9032)	(0.7956)	(0.7150)	(0.6579)
F*SO	7.4712*	8.4323***	8.5301***	8.0742***	7.6896***	7.1690***	6.7433***
	(3.5829)	(2.1524)	(1.8386)	(1.5936)	(1.4634)	(1.3842)	(1.3259)
Obs.	237	364	441	543	635	730	819
R^2	0.5939	0.5735	0.5639	0.5507	0.5223	0.4864	0.4608
F	−2.7872***	−2.8167***	−2.8167***	−2.8167***	−2.8167***	−2.8167***	−2.8167***
	(0.6356)	(0.5170)	(0.5046)	(0.4965)	(0.4783)	(0.4775)	(0.4721)
F*L	−2.3914**	−1.8232**	−1.6260*	−1.2837*	−0.9420+	−0.6592	−0.4086
	(0.8722)	(0.6837)	(0.6384)	(0.6027)	(0.5660)	(0.5561)	(0.5436)
SO	−8.3581***	−5.8054***	−4.8132***	−4.5461***	−3.8981***	−3.3293***	−2.8135***
	(1.2751)	(0.6990)	(0.5488)	(0.4382)	(0.3766)	(0.3404)	(0.3073)
F*SO	3.0761+	2.3025*	1.8481*	1.7402*	1.6482*	1.7420**	1.7088**
	(1.7055)	(0.9790)	(0.8353)	(0.7392)	(0.6640)	(0.6301)	(0.5966)
Obs.	219	334	401	493	575	652	734
R^2	0.3786	0.4108	0.4084	0.4112	0.4006	0.3590	0.3388
Days FE	yes	yes	yes	yes	yes	yes	yes

Notes: Difference-in-Differences estimates on the aggregate number of authors by tenure, considering only economist with typical academic job positions, based on different bandwidths, measured in days, around the timing of lockdowns (day 0). Robust standard errors in parentheses.

Statistical significance denoted as follows: $^{+}p < 0.10$, $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

APPENDIX B: 2019 Data

2019 pre-print data have always been scraped from the SSRN website. As for the 2020 data, they refer to the *Economics Departments Research Papers* and *Economics Research Centers Papers* working paper series. The total number of papers extracted and uploaded for the first time during January and December 2019 equals 4,235. Of these, the 44.8% has been written by at least of female economist. Overall, the number of authors involved in drafting the working papers totals 7,735 distinct researchers (27.4% women and 72.6% men). Also, I hand-collected the authors' employment status in 2019, recovering detailed information for the 96.8% of the sample. In addition, the comparison between the 2019 data and the 2020 sample suggests that they are very similar along many dimensions (*i.e.* country of affiliation, distribution by position and tenure) as Table B1 and the subsequent figures show (Figures B1-B6).

Table B1 Economics working papers summary statistics

	Mean	SD	min.	Max.	Obs.
All observations:					
Tot. authors	2.596	1.195	1	16	4,235
No. of downloads	38.209	129.07	0	4,659	4,235
No. of views	334.953	467.683	61	14,047	4,203
No. of pages	47.513	21.338	1	316	4,201
Female author	0.448	0.497	0	1	4,235
Tot. no. of female	0.629	0.851	0	8	4,235
Intensity female	0.231	0.306	0	1	4,235
At least one female author:					
Tot. authors	3.011	1.294	1	16	1,896
No. of downloads	35.776	135.188	0	4,659	1,896
No. of views	319.142	451.648	61	14,047	1,882
No. of pages	48.087	21.163	1	316	1,881
Tot. no. of female	1.406	0.726	1	8	1,896
Intensity female	0.517	0.247	0.125	1	1,896
Only male authors:					
Tot. authors	2.26	0.988	1	7	2,339
No. of downloads	40.18	123.883	0	3,126	2,339
No. of views	347.773	480.007	65	9,376	2,321
No. of pages	47.048	21.473	4	212	2,320

Notes: Sample period goes from January to December 2019.

Figure B1 Number of working papers by month in 2019.

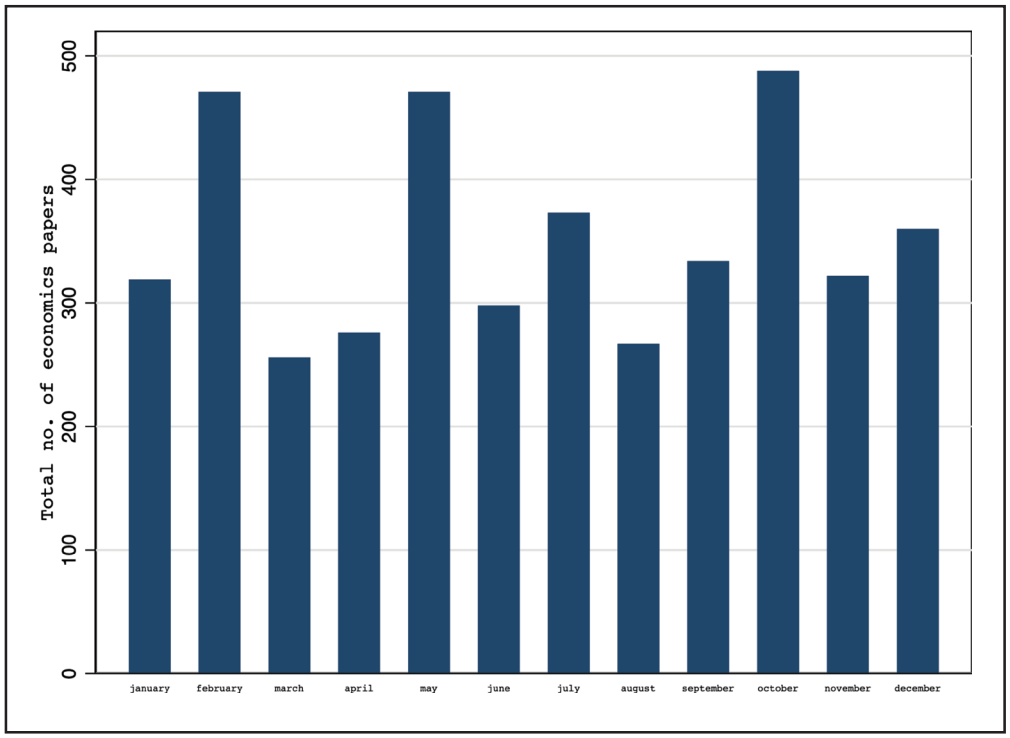


Figure B2 Distribution of authors by gender and country of affiliation in 2019.

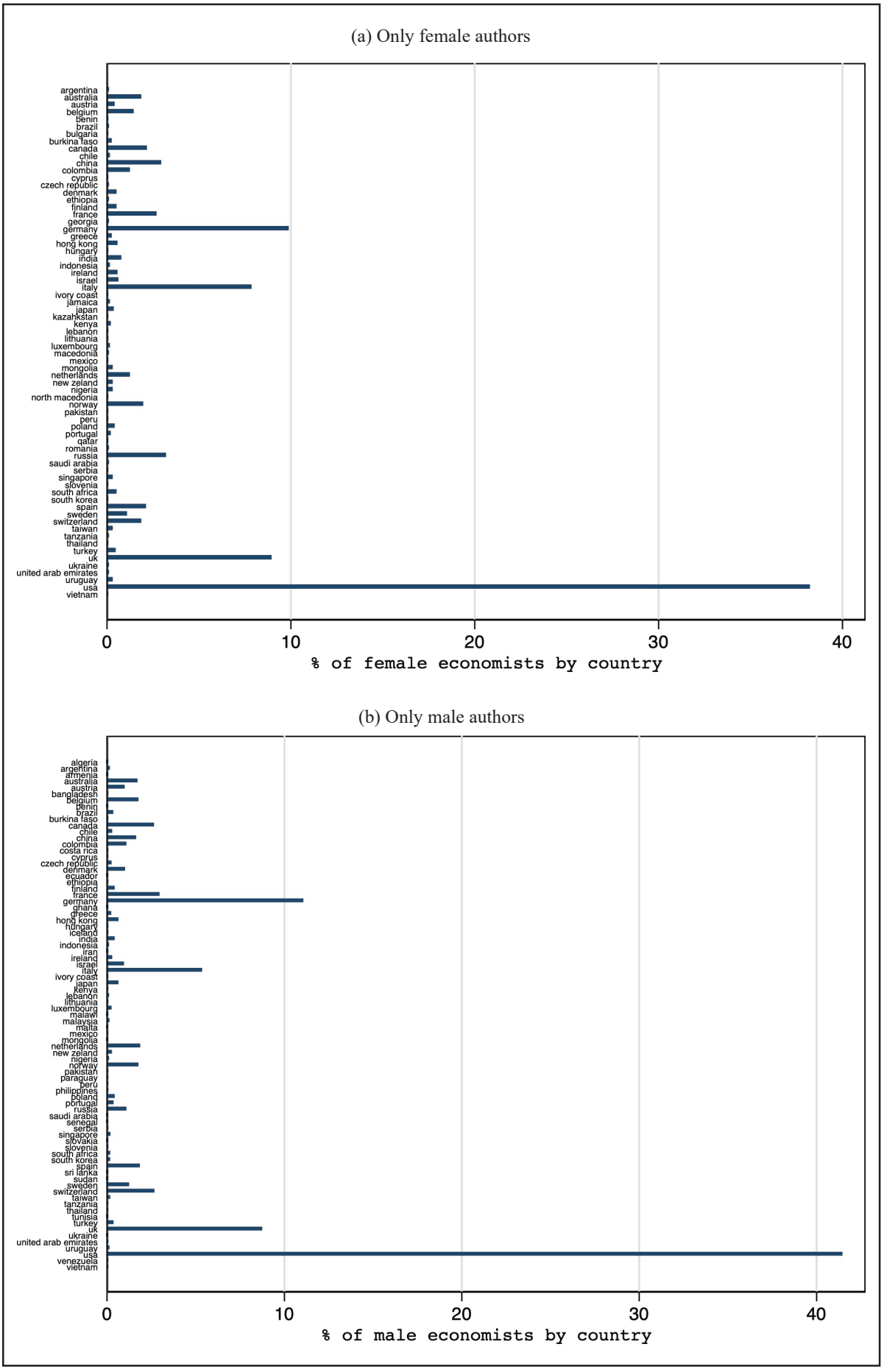


Figure B3 Distribution of authors by gender and position in 2019.

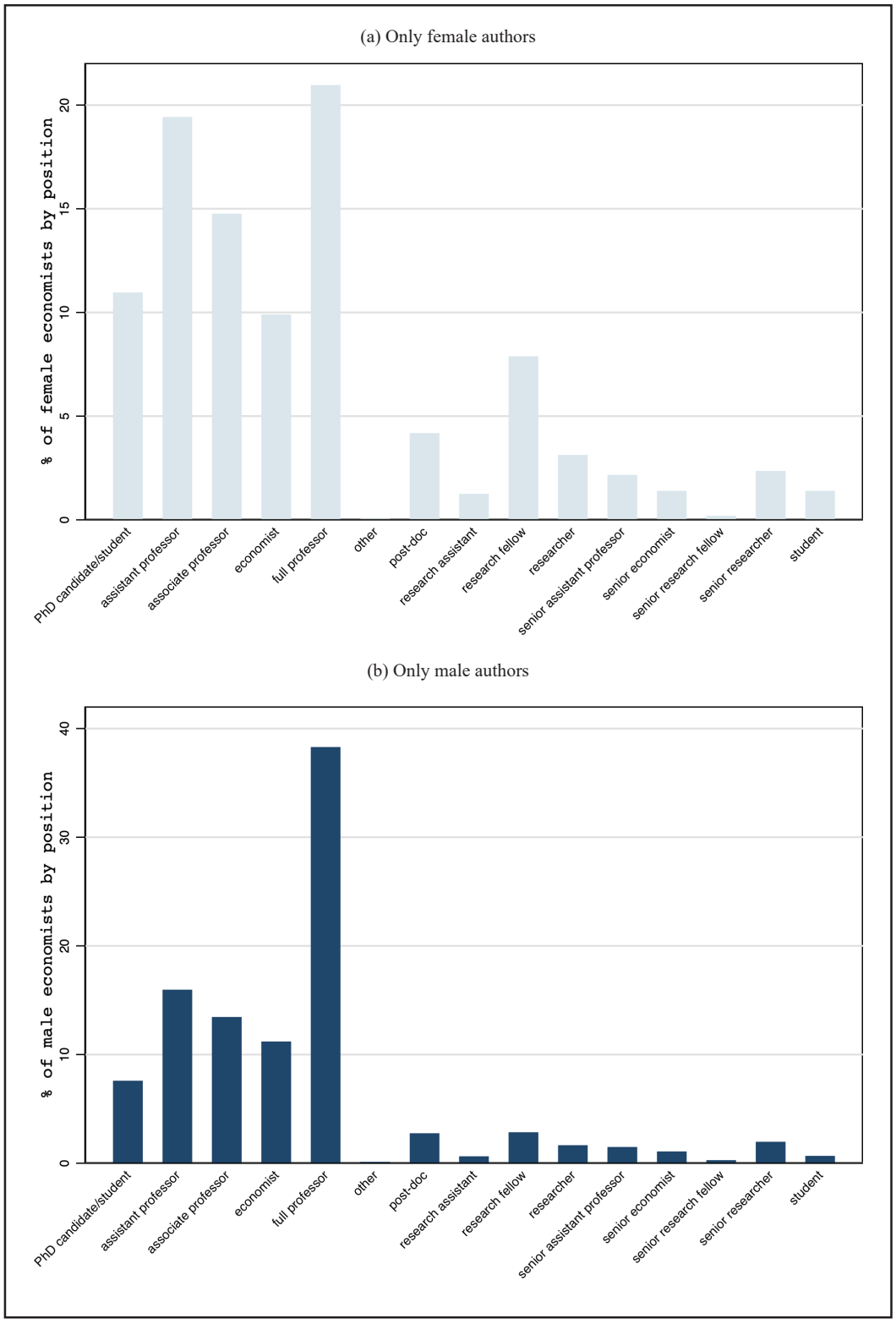


Figure B4 Distribution of authors by gender and tenure in 2019.

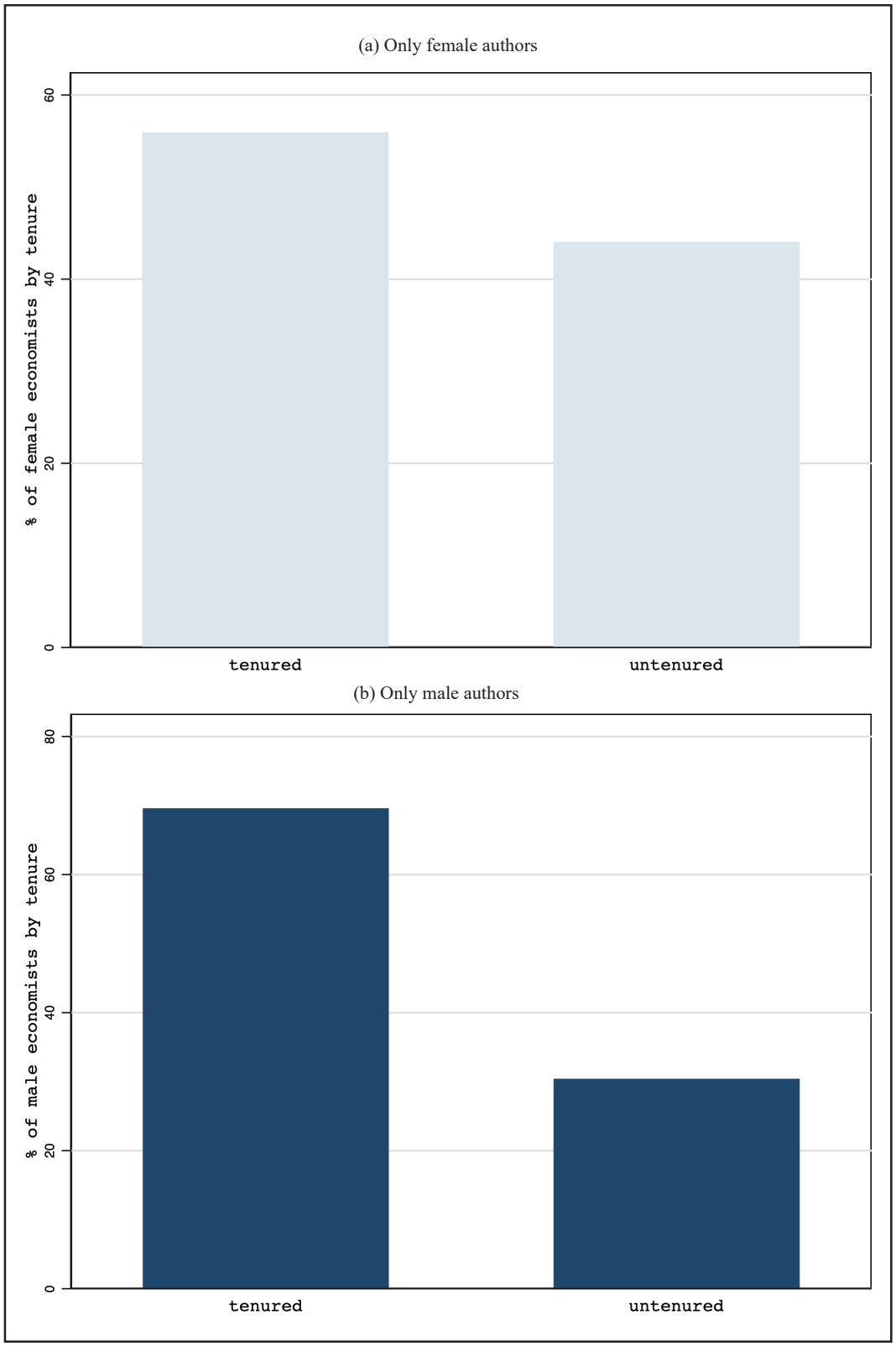
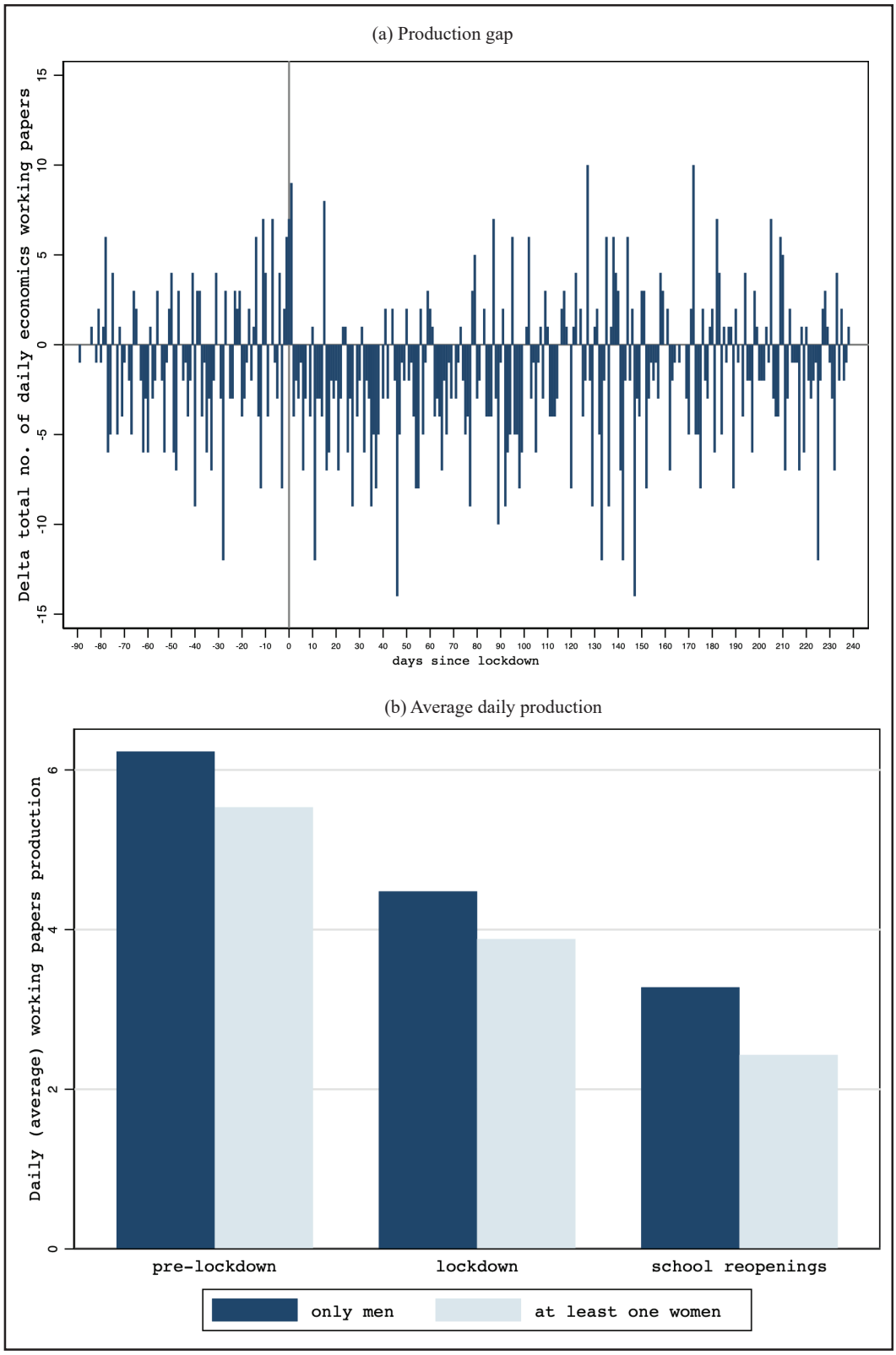
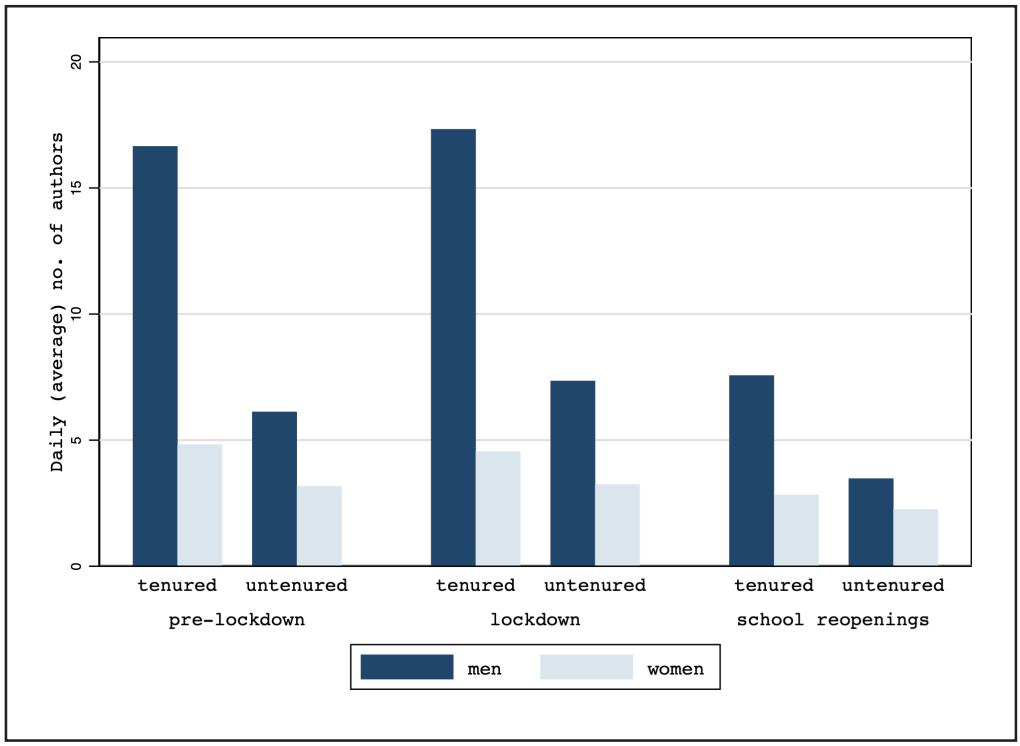


Figure B5 Aggregate number of papers by gender in 2019.



Notes: Sample period goes from January to November 17, 2019. Lockdown and school reopening dates are brought forward by one year.

Figure B6 Average no. of authors by period, gender and tenure in 2019.



Notes: Sample period goes from January to November 17, 2019. Lockdown and school re-opening dates are brought forward by one year.