Temi di discussione

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WOMEN INVENTORS:
THE LEGACY OF MEDIEVAL GUILDS

by Sabrina Di Addario*, Michela Giorcelli** and Agata Maida***

Abstract

The share of women inventors remains significantly lower than that of men inventors in both developed and developing countries. This paper studies the gender bias in patenting activity, using a unique dataset that matches Italian administrative employer-employee records both to patent data from the European Patent Office (1987-2005) and to municipality-level information on medieval guilds from the Italian Central State Archive.

We empirically verify whether the low female propensity to patent can be explained by the traditional local conception of women's role in society, which we measure with the share of women in guild founders in the Middle Ages. The results indicate that the presence of women in medieval guilds is associated with a higher probability of observing a female inventor and a higher number of yearly patent submissions by women.

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1 Introduction

During the last few decades, the share of women in the labor force has substantially increased in most Western European countries. However, large geographical differences in female labor force participation persist across and within Europe (Ortiz-Ospina et al., 2024). In 2022 the lowest female participation rate among the EU countries was recorded in Italy (Carta et al., 2023), where geographical differences in gender disparities are highly pronounced: the gender gap in employment rates was 14.5 percentage points in the North and 24.8 in the South. The gender gap in women's patenting activity is even greater: between 2010-2019, the women inventor rate was just 14.3 in Italy, against 16.6 and 23.2 percent in France and Spain, respectively (although in Germany it was only 10.0 percent, EPO 2022)[1]. Lowering this gap is important not only for gender diversity but also because it has been proved that if women were to patent at the same rate as men both patents and per capita GDP would sensibly grow (in the US, for instance, patents could increase by 24 percent and GDP by 2.7; Saksena et al., 2022). Although the gender gap in patenting is gradually closing up (in 1987 the women inventor rate in Italy was just 4 percent; Figure 1), the pace at which this occurs is not fast enough. According to Bell et al. (2019), it would take another 118 years to reach gender parity in the fraction of women inventors if the gap continued to shrink at the current US rate (i.e., 0.27 percentage points average increase between 1940 and 1980).

Social norms and attitudes in a conservative society may prevent women from entertaining professional aspirations: women may negatively select into the labor market, and more specifically, into the innovative sectors. The negative selection could occur at an earlier stage: fewer female students may enroll in a STEM (Science, Technology, Engineering, and Math) university, which reduces further the likelihood of entering an R&D lab and thus becoming an inventor, in a sort of "leaking pipeline" mechanism. In Italy, the share of girls among college graduates is above the European average (60 percent in 2021). Still, the percentage of female graduates in a STEM major is just 40, lowering to 27 in ICT and engineering (Bovini et al., 2024). Not surprisingly, the percentage of women in R&D personnel and researchers is around 30 (in 2010-19; EPO, 2022).

This paper investigates whether the innovation gender-gap is historically rooted, using evidence from social norms formed in the Italian medieval municipalities and transmitted across generations in Italy. Most papers on social norms study gender differences across

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[1]The women inventor rate measures the percentage of women inventors among all inventors listed in patent applications in a given year; a woman is an inventor if she has applied for at least one patent during her career.

countries (Giuliano, 2017). However, the belief on the appropriate role of women in society may vary across areas of the same nation. Italy is very interesting in this respect because, between the end of the Roman Empire and Unification in 1861, it experienced a variety of political and economic regimes in different parts of its territory, which led to pronounced differences in social behavior. In this paper, we exploit a territorial variation originating in the Middle Ages to analyze the historical persistence of social attitudes toward women and its effect on female patent production today. More specifically, we collect novel information on the gender of the founders of the main eight medieval guilds in Italian municipalities from the National Archives and we create a new indicator of gender-egalitarian norms. Guilds were medieval institutions that associated artisans and merchants who oversaw the practice of their craft or trade in a particular area. Typically, the key "privilege" of being part of a guild was that only its members could sell their goods or practice their skills within the city.[2] Female participation in guilds was more intense in sectors protected by corporations and several historical records indicate that women in the Middle Ages gained substantial decision-making and economic power through these institutions (Bellavitis, 2002).

We hypothesize that the cities that experienced higher female participation in the labor market since the Middle Ages developed a more gender-egalitarian culture that was transmitted over centuries and generations and that today shapes women's education and labor supply decisions. In the context of this paper, the "culture" of a city is the collection of norms, values, and beliefs associated with female role models, regarding, for instance, whether women are expected to be housewives or work in the labor market, or whether they can freely choose their field of study. In a study on stereotypes conducted on the web, Nosek et al. (2002) obtain that science and career are commonly associated with men, while liberal arts and family are with women. Thus, girls' academic self-concept, their choice of a scientific field of study, and consequently the likelihood of working as an inventor depend on the culture into which they were born and raised. To empirically verify this hypothesis, we construct an indicator classifying Italian municipalities according to their share of women in medieval guilds' founders and test its impact on the current female propensity to invent (proxied by patent applications like for instance, Akcigit et al., 2023) and other female outcomes.

For our analysis to be causal, the municipalities with higher values of women's par-

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[2]Moreover, guilds controlled minimum or maximum prices of final and intermediate goods, hours of trading, and numbers of apprentices, and thus became a tool to certify quality, acting as a brand name (Cerrito, 2017). They regulated disputes, guaranteed trade rules, fought frauds, provided services, and offered credit. These rules made it difficult or impossible for non-members to run businesses in the same sector and helped create functioning markets for craftsmen (Gustafsson, 1987).

ticipation in guild foundations today should exhibit a larger number of female inventors *only because* of women's involvement in the medieval labor market, after conditioning on the observable characteristics. We thus control for historical and geographical characteristics that increase the validity of this exclusion restriction. A first possible concern is that the results are driven by municipalities' geographical characteristics that favored both women in guilds and long-term women's outcomes (the "geography hypothesis"). Even though the geography hypothesis seems unlikely, given that the distribution of the corporations and of the women who participated in their foundation was rather uniform over the Italian territory (see Figures 2 and 3), we also control for time-invariant municipality characteristics, such as altitude, land area, and a dummy for whether the city is located near the coast. A second concern may be that the results are driven by other historical pre-existent characteristics that may have favored female participation in guilds and current female outcomes (the "history hypothesis"). To take into consideration this concern we also control for the presence of a local University founded before the XIII century and for whether the town was close to a commercial route in the Middle Ages, as in these cities merchants' wives acquired reading and writing abilities that were necessary for substituting they husbands during their trade trips (Bertocchi and Bozzano, 2016). Finally, our indicator of women's participation in guilds is computed on information restricted to the Middle Ages: before this historical period guilds did not exist and restrictions to female participation in guilds' activity began to arise later (in the XV century; Bellavitis, 2002 and Rescigno, 2016).[3] Conditional on the observable geographical and historical municipality characteristics, the identifying assumption of our empirical strategy rests on the idea that the proportion of women among guild founders is unrelated to other features that could affect the long-term proportion of women inventors.

Before examining persistence effects on innovation, we undertake a preliminary exercise using the Labor Force Survey (LFS) conducted by the Italian Institute of Statistics (ISTAT) for the years 2002-2003 to analyze the correlation between our historical indicator of female participation in guilds with current education and female labor market outcomes. We find that the women living in the cities that in the past had a higher intensity of female participation in guilds today exhibit higher chances of graduating, especially from a STEM faculty, a higher chance to join the labor force participation, and a lower probability of being housewives. These results suggest that the diffusion of cultural norms

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[3]Between the XV and the XVIII century, female participation in guilds became increasingly limited to widows or spinsters since married women ("femme coverte") were required to have lower public visibility than unmarried ones ("femme sole"). However, the formal exclusion of women from guilds did not mean that women were completely excluded from the labor market. In the second half of the XVIII century, many enlightened monarchs abolished guilds, in the cause of free market principles.

over centuries can affect current female education and labor outcomes.

We then turn to analyze inventors, using INPS-PatStat data, that is data from the Italian National Social Security (INPS) records matched with PatStat, the database of the universe of patent submissions to the European Patent Office (EPO). We are able to compute the Middle Ages effect based on the inventors' municipality of birth to test whether the culture women were raised in matters regardless of where they are living as adults. We find that cities with more intense female participation in medieval guilds exhibit a 0.8 percentage points higher share of female inventors today. In these cities, women are more likely to submit patent applications to the EPO than elsewhere, both on a yearly basis and over their lives. In particular, we find that while on average the yearly contribution of women to patent applications is less frequent than men's, the marginal effect of being born in a city with more gender-egalitarian norms increases women's number of patent applications to the EPO by 1.1. Finally, we find no gender differentials in the patent application quality correlated to the intensity of female participation in guilds.

This paper contributes to three strands of the literature. First, we contribute to an increasing body of work studying which background characteristics, especially education, determine individual propensity to innovate. In particular, Akcigit et al. (2017) and Bell et al. (2019) study the characteristics of American inventors by linking patent data to income tax records. Kim and Moser (2021) find that female scientists are more likely to hold a Ph.D. than their male counterparts, while Jensen et al. (2018) show that the acceptance rate of patents submitted by women is lower than that of men. In the context of Italy, Bianchi and Giorcelli (2020) document that university-level scientific education changes the direction of innovation. Finally, recently some literature on historical patents has emerged, using evidence from female inventors in Italy (Martinez, 2024) and France (Merouani and Perrin, 2024) and from local exhibitors in Germany during the Industrial Revolution (Cinnirella et al., 2022). We contribute to this literature by studying to what extent historical and cultural exposure to women inventors in the past can affect women's probability of patenting today.

Second, this paper adds to the literature on the legacy of culture and history on current economic performance. The literature on persistence dates back to Putnam (1993)'s seminal work, which argued that the current efficacy of local governments in Italy depends on the degree of local civic commitment that originated from the political regime prevailing in the Middle Ages. Along these lines, Guiso et al. (2016) show that the higher level of social capital developed in the medieval communes persists today and was transmitted to the population through a more pervasive sense of self-efficacy. Based on these findings, a few

papers analyze the effect of social capital on economic performance, under the hypothesis that the medieval political regime shaped today's degree of local civicness without having other direct effects on current outcomes (de Blasio and Nuzzo, 2009, Alfonzo and Di Addario, 2021). We build upon these studies by arguing that the municipalities in which women had a chance to join guilds in the Middle Ages nurtured a culture more favorable to female work outside the home, and developed more gender-equal norms that persisted until today. The results of this paper add another outcome to this literature: the propensity to innovate, stemming from the historical roots of the inventors' municipality of birth.

Finally, we contribute to the literature on gender norms and persistence. Alesina et al. (2013) show that the agricultural system prevailing in the pre-industrial period determined a production specialization along gender lines that affects contemporary views about gender roles and female labor force participation in the present days. Boelmann et al. (2024) analyze the effect of the cultural norms acquired during childhood and those deriving from the adulthood environment on women's labor supply decisions after childbirth, and find that the East German more egalitarian gender norms (due to socialism) are persistent whereas the more traditional West German ones are not. While it has been shown that gender bias affects women's social and economic outcomes through the labor market (see, among others, also Fernández et al. (2004), Cavapozzi et al. (2021)), to the best of our knowledge, this is the first study examining the effects of cultural norms on innovation and patenting. Moreover, most of the papers that analyze the effect of social attitudes toward women compare different countries (Giuliano, 2017), while we exploit territorial variation within the same country, which allows more precise comparisons as regions have more similar institutions and cultural norms than different countries.

The rest of the paper is structured as follows. Section 2 presents the data and the variables, Section 3 the descriptive statistics, and Section 4 the empirical strategy and the results. Finally, Section 5 concludes.

2   Data

In this paper, we use various data sources, from surveys to administrative data. We also collect original historical information on guilds, which we match to current municipalities.

2.1 Labor Force Survey data

For the analysis of female labor supply, we pool the eight waves of the Labor Force Survey for the years 2002 and 2003.[4] ISTAT conducts this survey quarterly and in two stages, sampling about $1,300$ municipalities in the first stage and more than $75,000$ households in the second step (for a total of about $170,000$ individuals).

LFS is the main source of information on working conditions at the individual level in Italy and includes variables on gender, place of residence (municipality and region), age, education, type of high school, type of college, work condition (employed, unemployed, not in the labor force), type of job (blue collar, white collar, manager, other).

In the paper, we restrict the sample to working-age women (age bracket 15–64).

2.2 INPS-Patstat data

Our main data source is the INPS-PatStat matched database by Depalo and Di Addario (2014), who linked inventor information from PatStat to the longitudinal administrative firm-worker data from INPS.

INPS provides the entire work history of private sector employees and their firms since 1987. The available information regards individual features (gender, age, municipality of residence, and municipality of birth), job characteristics (work status, type of contract, gross yearly earnings), and firm details (size, sector, location, date of plant opening, and closure).

PatStat is the EPO Worldwide Patent Statistical Database. This dataset provides the universe of the patent applications submitted to the EPO since the 1980s. Depalo and Di Addario (2014) used the release of April 2009; we drop the years 2006-2009 because in the last period, PatStat may provide incomplete information on patent grants. Each application contains a detailed description of the patent: the title, the name, and address of residence of all its inventors, the name and location of the submitting firms, the dates of filing, the date the patent was granted (if it was), the abstract, the technological field, etc. Patents can be submitted by individuals, firms, institutes of research, universities, or governments. However, since INPS provides information only on private sector employees, Depalo and Di Addario (2014) selected the patents with one or more firms (resident in Italy) as assignees (thus excluding all the submissions to the EPO by individuals, universities, or public entities); they cleaned and harmonized all the relevant names (i.e.,

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[4]We use the 2002-2003 waves because the information on individuals' municipality of residence is only available in these years (in contrast, place of birth is unavailable).

of inventors, applicants, and locations), assigned VAT codes to firms and Istat codes to municipalities.[5]

Upon request, INPS linked its databases to PatStat in three steps. First, it matched applicant firms to its list of employers based on name and location. Then, it matched the inventors to its employees by name and municipality of residence. Finally, a match is considered valid only if a linked employee was employed in a linked firm in the year of submission. INPS always used an exact matching algorithm (on all the variables or a subset) and returned de-identified records.

In 1987, the first available year from INPS, EPO received $1,330$ Italian patent applications, a number that by 2005, the last year considered in this paper, had risen to $3,557$. The total number of submissions received in 1987-2005 amounted to $44,372$, after excluding the submissions from universities, which cannot be matched because their inventors are not in INPS archives. INPS was able to match at least one inventor per patent for about three-fifths of the applications presented in the same period. The data covers the full work history of the employees working in any of the patenting firms that INPS could match, even if they moved from/to a non-patenting firm.

In this paper, we consider as an "inventor" any individual who contributed to a patent application submitted by firms to the EPO individually or as a coauthor, regardless of whether the application was eventually granted.

2.3   Historical data on guilds

We complement the INPS-Patstat data with information on female participation in medieval guilds. Guilds were associations of craftsmen and merchants formed to promote the economic interests of their members and to provide protection and mutual aid. Guilds were prolific throughout Europe between the 11th and 17th centuries as both business and social organizations.

We leverage the fact that the foundation of a guild required a statute indicating the names of founding members. Most Italian guilds were founded between the 12th and 13th centuries. For instance, the first merchant guild was founded in Pavia in 1159, followed by Genoa, Piacenza, Milan, and Florence.

We collected historical records of such statutes from the Italian Central State Archive in Rome, Italy.[6] We use this information to reconstruct the gender of the founding mem-

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[5]Since a patent reports all the names of coauthors and applicant firms without specifying which is the employer of whom, in the case of multiple applicants the authors associated each inventor name to each applicant and relied on INPS to determine which was the correct match.

[6]We accessed the *Fondi Carte medievali*, buste 112-129, in Summer 2013.

bers for the eight major guilds in various Italian municipalities: wool, silk, spices, furs, goldsmiths, dyers, blacksmiths, and shoemakers.

City borders in the Middle Ages differed from those at present. Using GIS to geo-locate the ancient city of guilds, we overlapped the maps of medieval municipalities collected from the Historical Archives with the 2001 map of municipality borders. We therefore input the guild founders to the specific municipalities based on this cross-walk. In doing so, we were able to match them to virtually all current Italian municipalities.[7]

Since all female inventors in our sample were born in municipalities with all eight guilds, we do not distinguish between guild types. We construct indicators at the municipality level for the number of guilds that existed in the Middle Ages and for the share of women in total founders joining any of the guilds. Figure 2 shows the intensity of guilds distribution, depending on whether the current Italian municipalities coincide with cities that in the Middle Ages contained all eight guilds or just a few of them.[8]

3 Descriptive Statistics

In the period 1987-2005, INPS-PatStat comprises more than $16,000$ inventors (including about $1,400$ women). After disregarding the 600 individuals born abroad (for whom we do not have information on the existence of guilds), we are able to associate all the remaining inventors to at least one medieval guild by their municipality of birth. Our final sample comprehends more than $15,400$ inventors, 9 percent of whom are women.

Although the gap is slowly reducing, women are a minority among inventors in Italy and worldwide. In 2019 the percentage of female inventors was 13 in Europe (it was just 2 percent in the late 1970s), 15 in the US, and 9.5 in Japan (EPO, 2022). As Figure 1's Panel A shows, the share of female inventors in our sample increased from 4 percent in 1987 to 10 percent in 2005. However, when examining the yearly share of applications in the number of inventors, we do not find much difference between men and women, and in some years the gap is even in favor of the latter (Figure 1, Panel B). Thus, on average, women are not less innovative than men; however, the gap enlarges when we focus only on the applications that will eventually be granted (Figure 1, Panel C).

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[7]Namely, $7,904$ municipalities, with the only exceptions of Cermes (Bolzano) and Misiliscemi (Trapani). Note that if a municipality's current area spans multiple medieval cities, we impute the sum of all their guild members to the current municipality. If, on the contrary, one medieval municipality corresponds to more than one current city, we attribute the guild members to each of today's cities by dividing them equally among each of them.

[8]Thus, a lighter color may imply a higher specialization in one specific sector rather than the absence of guilds *tout-court*.

Table 1 reports the descriptive statistics of our sample of inventors. Like in other European countries (EPO, 2022), women tend to work in teams and with a higher number of co-authors (Table 1): the share of solo-authored patent applications is 3.8 percent for women and 20 percent for men. Moreover, when focusing on the inventors within the 95th percentile of the patent application distribution, we observe that men have at most 4 coauthors, while women have at most 6.

On average, women inventors are younger than men (35 versus 40 years old), are less likely to be blue-collar workers, more likely to be white-collar, and equally likely to be managers.[9] Among the people who provided information on the type of contract (just about half of the sample), the majority has an open-ended contract irrespective of gender. Finally, male inventors tend to work full-time more than women.

When examining the distribution of inventors by the municipality of birth, we observe that the totality of female inventors in the sample were born in a city that included all the 8 guilds considered in this paper, while the corresponding figure for men is 72.5 percent. Figure 3 reports the share of women in total guild members in the Middle Ages:[10] the map does not exhibit any specific territorial pattern.

Finally, Table 2 shows the distribution of male and female inventors according to the intensity of women's participation in guilds in the Middle Ages. While men are equally distributed among the quartiles of the distribution, female inventors are more concentrated in the cities with a higher female presence in medieval guilds. This is in line with the hypothesis that the cities that in the Middle Ages experienced higher participation of women in guilds developed a culture in favor of women working outside the home and more gender-egalitarian norms in terms of professions undertaken that persist today.

4 Empirical Strategy and results

This paper hypothesizes that the cities in which women had a more active role in the labor market in the Middle Ages (i.e. participated in founding guilds to a greater extent than elsewhere) developed a more gender-egalitarian culture that over the centuries "legitimized" women to study longer, graduate in scientific subjects, undertake careers as inventors, and, more generally, work outside the home.

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[9]Note that we respect to the average employee in INPS data, inventors are more likely to be white-collar workers, are less likely to be blue-collar workers and to have a temporary contract (Di Addario and Wu, 2024).

[10]This share ranges from 0 to 12 percent. The percentiles of the FWG distribution across municipalities are: 0.030 (Q1); 0.039 (Q2); 0.049 (Q3); and 0.074 (Q4).

The data we collected from the National State Archive enable us to compute our variable of interest: the fraction of women in total guilds' members (FWG_c). By exploiting the information on the number and gender of the founders of the eight major medieval corporations (i.e. wool, silk, spices, furs, goldsmiths, dyers, blacksmiths, and shoemakers), we construct the following indicator for each municipality c:

$$FWG_c = \frac{\sum FemaleGuildFounders_c}{\sum TotalGuildFounders_c}, \tag{1}$$

We link FWG_c to INPS-PatStat data by inventors' municipality of birth (Sections 4.2-4.3). The extent to which the place of birth can be considered exogenous (once parents have chosen their location), we can interpret FWG_c as the causal effect of being born in a city with more intense female participation in medieval guilds on the probability of being a female inventor in municipality c. The mechanism would operate through the acquisition of more gender-egalitarian cultural norms through childhood, regardless of whether the person moved elsewhere later (note that linking FWG_c by the municipality of work does not substantially change the results).

In contrast, for the analysis on the course of studies and participation in the labor market, place of birth is not available in the data and we can link our variable of interest only to individuals' municipality of residence (Section 4.1). We are aware that basing our analysis on the city of residence may introduce endogeneity issues since people can choose where to live. For instance, the women who want to work in the labor market may move to the cities with historically more intense female participation in guild founding precisely because these locations are the most emancipated and favorable to female work. Thus, we take the results of Section 4.1 as descriptive.

Another threat to our identification strategy is the presence of geographic or preexisting historical features correlated both to women's involvement in medieval guilds and the propensity to study longer or be in the labor market. To reduce the possibility that female participation in guild foundation is related to other characteristics that can affect the long-term proportion of women inventors, we always control for additional geographical and historical city characteristics. More specifically, to exclude the "geography hypothesis" we control for altitude, land area, and a dummy variable for whether the city is located on a coast, while to exclude "history hypothesis" we control for the presence of a University founded before the XIII century and for proximity to a medieval trade route. Indeed, it might be the case that the presence of a local University in the Middle Ages affected women's propensity to be active in guilds. Thus, we always control for whether

cities hosted one of the 15 universities that had been founded before the XIII century.[11] In addition, Bertocchi and Bozzano (2016) find that the women who were living near a commercial route in the Middle Ages were more educated than those living elsewhere and that the medieval trade patterns were still affecting female education in 1861. Indeed, the increased intensity of international trade in the XIII century made male merchants leave for long periods and forced their wives to take charge of their business while traveling. Thus, in these cities,[12] women had to be able to read and write and had to study math and bookkeeping. It is then possible that the higher education level obtained by women in the trade centers led them to be more involved in guild foundations. Thus, we control for whether the individual's municipality was a commercial center in the Middle Ages, to avoid biased and inconsistent estimates in case the higher female literacy rates in the medieval commercial routes were positively correlated to the share of female college graduates, STEM students, and inventors today.

To show the efficacy of our geographical and historical control variables, we undertake an empirical test. We compute the unconditional correlation between FWG and two non-female specific factors at the municipality level: the total employment rate and the proportion of male graduates in the male population 15-64 (from the LFS). The unconditional correlations are, respectively, 0.455 (significant at 5%) and 0.310 (significant at 1%). However, once we control for LLM fixed-effects and for the city's geographical and historical characteristics none of these correlations remains significant. This test supports the exclusion restriction of our identifying assumption.

Our analysis documents that the municipalities that developed more gender-egalitarian social norms since the Middle Ages, today exhibit a higher probability that women graduate from college, enroll in STEM majors, become inventors, and submit patent applications. It also shows that these cities are characterized by a higher female labor force participation and a lower share of women choosing to be housewives.

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[11]They were located in Bologna, Salerno, Modena, Reggio Emilia, Parma, Pavia, Ivrea, Turin, Cremona, Firenze, Fermo, Verona, Vicenza, Forli, and Lucca.

[12]According to the authors the towns on trade routes were: Novara (Vercelli), Turin, Genoa, Bergamo, Brescia, Como, Cremona, Milan, Pavia, Padua, Udine, Venice, Bologna, Ferrara, Modena, Parma, Piacenza, Arezzo, Florence, Pisa, Siena, Rome, Perugia, Naples, Salerno, Bari, Lecce, Catanzaro, Messina, Siracusa, Palermo, and Sassari.

4.1 Women in guilds and current female outcomes in Italian munic-ipalities

The main objective of this paper is the analysis of the specific labor market of inventors, who are highly specialized workers. It is thus useful to first examine whether the social norms that originated 800 years ago induce women to study longer. In this section, we investigate whether the girls living in the cities with higher female participation in medieval guilds' foundations are also more likely to obtain a college degree and, in particular, a degree from a STEM faculty (i.e. engineering, mathematics, physics, chemistry, biology). Moreover, we study the correlation between living in those cities and the current women's likelihood of joining the labor market, being employees, or housewives.

We use quarterly individual data from the LFS, the primary source of information on working conditions at the individual level in Italy. We estimate the following equation in the sample of working-age women by OLS:

$$Y_{ict} = \beta_1 FWG_{c(i)} + \beta_2 X_{ict} + \beta_3 Z_c + \phi_{LLM} + \gamma_t + \epsilon_{ct}, \tag{2}$$

where the outcome variables are dummies for (alternatively) being a college graduate, having graduated from a STEM faculty, being in the labor force, being a housewife, or a private-sector employee in municipality c at time t. X is a quadratic form of individuals' age, which is important because education or labor supply decisions have changed across cohorts over time; Z includes the geographical and historical variables described in the previous section; ϕ_{LLM} represents LLM-fixed effects,[13] and γ_t contains the year-, the quarter-fixed effects, and their interaction with time, to increase the precision of our estimates. The variable of interest, $FWG_{c(i)}$, is linked to LFS by women's municipality of residence. Standard errors are always clustered at the municipality level.

Table 3 exhibits the results. In the first two columns, the dependent variable is the college dummy, while in the last two, it is the STEM dummy. The results in (3.1) indicate that a one percentage point increase in medieval guilds' female ratio is associated with a 1.3 percentage points higher probability that a female student graduates from college (at the 1 percent statistical level). When adding the historical and geographical characteristics of the municipality of residence (specification (3.2)), the probability lowers to 0.8 percentage points but remains positive and statistically significant at the 1 percent level. In terms of standard deviations, the increase is very large: it amounts to 2.8. Moreover,

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[13]In 2001 Italy counted 686 LLMs, partitioning the entire country; they are "self-contained" labor markets since the National Institute of Statistics singles them out based on workers' daily commuting flows from place of residence to place of work (Istat, 2005).

female students are 0.3 percentage points more likely to graduate from a STEM faculty (conditionally on graduating from college) for each percentage point increase in the share of female guild founders in the Middle Ages. When controlling for city characteristics (column (3.4)) the coefficient slightly lowers (to 0.2); in terms of standard deviations, the increase is 0.9.

Table 4 reports the results on the labor market outcomes. In the first two columns, the dependent variable is a dummy equal to 1 if the woman works or is unemployed in municipality c at time t, zero otherwise. Our preferred specification's results, including the geographical and historical variables, indicate that a one percentage point increase in medieval guilds' female ratio is associated with a 0.4 percentage points higher female labor force participation today (at the 5 percent statistical level; column (3.2)). An increase of one standard deviation in medieval guilds' female ratio corresponds to a 0.7 percentage point increase in current female labor force participation. In columns (3.3)-(3.4) the outcome variable is a dummy equal to 1 if the person is a housewife. We obtain that a one percentage point increase in the share of women in municipality c's guild members 800 years ago is associated with a 0.9 percentage points lower chance of being a housewife in the same city (statistically significant at the 1 percent level), or a 1.9 reduction in terms of standard deviation, in line with the idea that higher female involvement in medieval corporations continues to be associated with a lower propensity to work in the home today. In contrast, specification (3.4) shows that a one percentage point higher share of female guild members is associated with a 0.5 percentage points greater share of the city's female employees in total employed women (at the 1 percent statistical level), but this result is no longer significant once we add the geographical and historical city characteristics (in the last column).

4.2   Women in guilds and female inventors in Italian municipalities

We now turn to examine the labor market of inventors, using INPS-PatStat. The dataset contains information on individuals' municipality of birth, which we use to match our variable of interest, FWG_c, to inventors.[14] The extent to which the place of birth can be considered exogenous (once parents have chosen their location), we can interpret the FWG_c coefficient as the causal effect of being born in a city with more intense female participation in medieval guilds on the current share of female inventors in municipality

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[14]Matching our variable of interest to individuals' municipality of work does not change the results substantially (available upon request).

c. More specifically, we estimate the following equation in the sample of inventors:

$$Y_{ict} = \beta_1 FWG_{c(i)} + \beta_2 X_{ict} + \beta_3 Z_{c(i)} + \phi_{LLM} + \gamma_t + \epsilon_{ct}, \qquad (3)$$

where Y_{ict} is a dummy variable equal to one if the inventor is a woman. To increase the precision of our estimates, we also control for X_{ict}, including workers' age, work status, and type of contract; for firm size, since large companies tend to employ more inventors and also more women, which could be correlated with FWG; ϕ_{LLM} represents LLM-fixed effects and γ_t year fixed-effect, capturing the average probability of observing a female inventor in year t. In addition, to ensure that our variable of interest is not capturing other characteristics of the municipality of birth that could have an impact on the outcome, we add cities' geographical and historical features ($Z_{c(i)}$). Observations are weighted by municipality size (measured by the number of workers) and standard errors are clustered at the municipality level.

The results indicate a positive impact of cities' gender-egalitarian rules on the share of women inventors today (Table 5). Column (5.1) reports the outcomes obtained after controlling for the individual characteristics and for year-fixed effects, while specification (5.2) adds LLM fixed-effects, and column (5.3) includes the geographical and historical characteristics at the municipality level. We obtain that a one percentage point increase in city c's share of women founders in medieval guilds is associated with a 1.5 percentage points higher share of female inventors in that city at the beginning of the 21st century (column (5.1)). After controlling for LLM-fixed effects, the estimated coefficient of interest almost halves (column 5.2), while adding the geographical and historical variables at the municipality level stabilizes the impact at 0.8 percentage points (column 5.3). In terms of standard deviations this increase is very large (2.8).

4.3 Women in guilds and current patent applications of female inventors

We now examine whether the positive effect of a more gender-egalitarian culture in medieval cities on the current share of women inventors translates into a more intense patent activity by the female inventors in these municipalities. In this section, we thus focus on inventors' "productivity" in terms of patent applications and we estimate the following OLS model (in the sample of inventors):

$$Patent_{ijt} = \beta_1 Female_i + \beta_2 FWG_{c(i)} + \beta_3 Female*FWG_{c(i)} + \beta_4 X_{it} + \beta_5 Z_{c(i)} + \delta_j + \gamma_t + \epsilon_{ijt},$$

$$(4)$$

where $Patent_{ijt}$ is the number of patent applications submitted to the EPO by inventor i working in firm j in year t, or, alternatively, the subset of these applications that will eventually be granted in our observational period. To raise estimates' precision, we add a vector of individual observable characteristics (X_{it}), such as age and features of the employee's job in firm j: work status and type of contract (whether full-time or part-time and whether open-ended or short-term). We also control for the number of patent-coauthors, year dummies γ_t (capturing the average yearly variation in patenting activity among all the inventors), the geographical and historical municipality characteristics $Z_{c(i)}$, and for firm-fixed effects δ_j, because in our context the decision to apply for a patent is taken by the company, not by the employee, and not all firms have the same propensity to patent. Observations are weighted by municipality size. Errors ϵ_{ijt} are always clustered at the municipality level.

Since in equation (4) patents can also be submitted by men, our variable of interest is now the interaction between the $Female$ dummy and $FWG_{c(i)}$ ($Female*FWG_{c(i)}$ from now on), after controlling for gender and the medieval intensity of women's participation in guilds in inventor i's municipality of birth. In this case, the coefficient of interest β_3 represents the marginal effect of applying for a patent for a woman born in a municipality that experienced higher female participation in medieval guilds.

We first estimate equation (4) using the number of yearly patent submissions as the dependent variable. Panel A of Table 6 reports the results. As it is apparent from the first column, controlling for the covariates at the worker-, firm- and year-level, on average each year women apply for patents less intensively than men; however, the marginal effect of being born in a city with more gender-egalitarian norms ($Female*FWG_c$) increases women's number of patent applications to the EPO by 0.7 (the effect is significant at the 10 percent level). Adding all the covariates raises the effect of interest to 1.1 more patent submissions (at the 1 percent statistical significance level), which corresponds to a 1.5 percent increase in terms of standard deviations.

We now examine whether these results are confirmed in terms of quality. To this aim, we run the same regressions reported in Panel A after substituting the dependent variable with the number of patent applications that have been granted, which represent the highest-quality applications (Griliches, 1990). Note that almost 60 percent of the $27,000$ applications presented overall in our sample have been granted between 1987 and 2009.

The results are reported in Table 6's Panel B (columns (6.5)-(6.8)). The coefficient of our variable of interest $Female * FWG_c$ is significant only in the first specification: when we control for firm fixed-effects it loses significance. These results suggest that higher female participation in medieval economic life favored the development of gender norms that currently enable women to undertake scientific careers and to contribute to patent applications more often than elsewhere. However, while these norms affect female behavior they do not have an impact on the probability of being granted a patent, which does not statistically differ from men's once we take into account unobserved firm characteristics.

Finally, in Table 7 we test three other sets of specifications, in which the dependent variable is the overall productivity of inventors ($Patent_i$), computed either in terms of the total number of patents that each individual submits to the EPO over the entire observational period (columns (7.1)-(7.3)), or, alternatively, in terms of the sum of granted patents that they ever obtain (columns (7.4)-(7.6)). The number of observations drops from over $210,000$ to about $15,400$ because we can keep only one observation per individual (we select the observation relative to the first year the individual appears in the dataset). In all specifications, we control for the number of years the employee is present in the dataset, in addition to firm size, region-, sector-, and time dummies. In line with Jensen et al. (2018), the female dummy is always negative and significant at the 1-5 percent statistical level, while FWG_c is positive and significant only after we control for the LLM fixed effect. More importantly, our variable of interest, $Female * FWG_c$, has always a large, positive, and highly significant effect on the number of applications. In contrast, there are no gender differences in the number of granted patents.

5 Conclusions

Our work sheds new light on the determinants of the gender gap in innovation. Innovation is widely viewed as a central driver of economic growth and many countries use a variety of policy measures to spur it. A crucial aspect for these policies to be successful is to understand who becomes an inventor.

Our paper focuses on the specific channel of a historically transmitted gender bias that may encourage women to patent. In particular, we test whether the municipalities that in the Middle Ages experienced higher participation of women in guilds developed a more gender-egalitarian culture that persists today and encourages women to work outside the home and innovate. We are able to single out the cultural effect by tracing its origin to a historical period whose formal political and economic institutions have long disappeared.

We find that female participation in market-based economic activities persists over time across Italian municipalities. A city's higher share of women in medieval guilds today is associated with a higher percentage of women with a college degree, especially from STEM faculties. Moreover, the cities with more intense participation of women in guilds today exhibit a greater female labor force participation and a lower share of housewives. Finally, a more gender-egalitarian culture increases the share of female inventors and their propensity to submit patent applications to the EPO. However, more gender-egalitarian norms affect women's behavior but not the acceptance rate of their patent applications, which does not differ from that of observationally equivalent men. Our findings are robust to controlling for geographical city characteristics and two alternative historical variables that could in principle be relevant (i.e. proximity to a medieval trade route, and the presence of a University founded before the XIII century), making the geography and alternative history hypotheses lose ground.

Our results align with the hypothesis that social norms on the role of women in society are, at least partly, historically rooted, and are persistent over centuries. Policies should thus aim at targeting female students to enroll in STEM faculties and at encouraging female participation to innovation, especially in the areas more permeated by traditional social norms.

Figure 1: **Women Inventor Rates, patent applications and granted patents by gender**
Source: European Patent Office, years 1987–2005. Notes: The Women Inventor Rate
measures the percentage of female inventors in all inventors listed in each year's patent
applications.

Figure 2: **Distribution of guilds in the Middle Ages.** Source: Our elaboration on data from the Central State Archive in Rome. Notes: The darkest blue means that all the Medieval guilds considered in this paper (wool, silk, spices, furs, goldsmiths, dyers, blacksmiths, and shoemakers) are present in the current municipal territory. The lightest shade means that no guilds or just one of them was present.

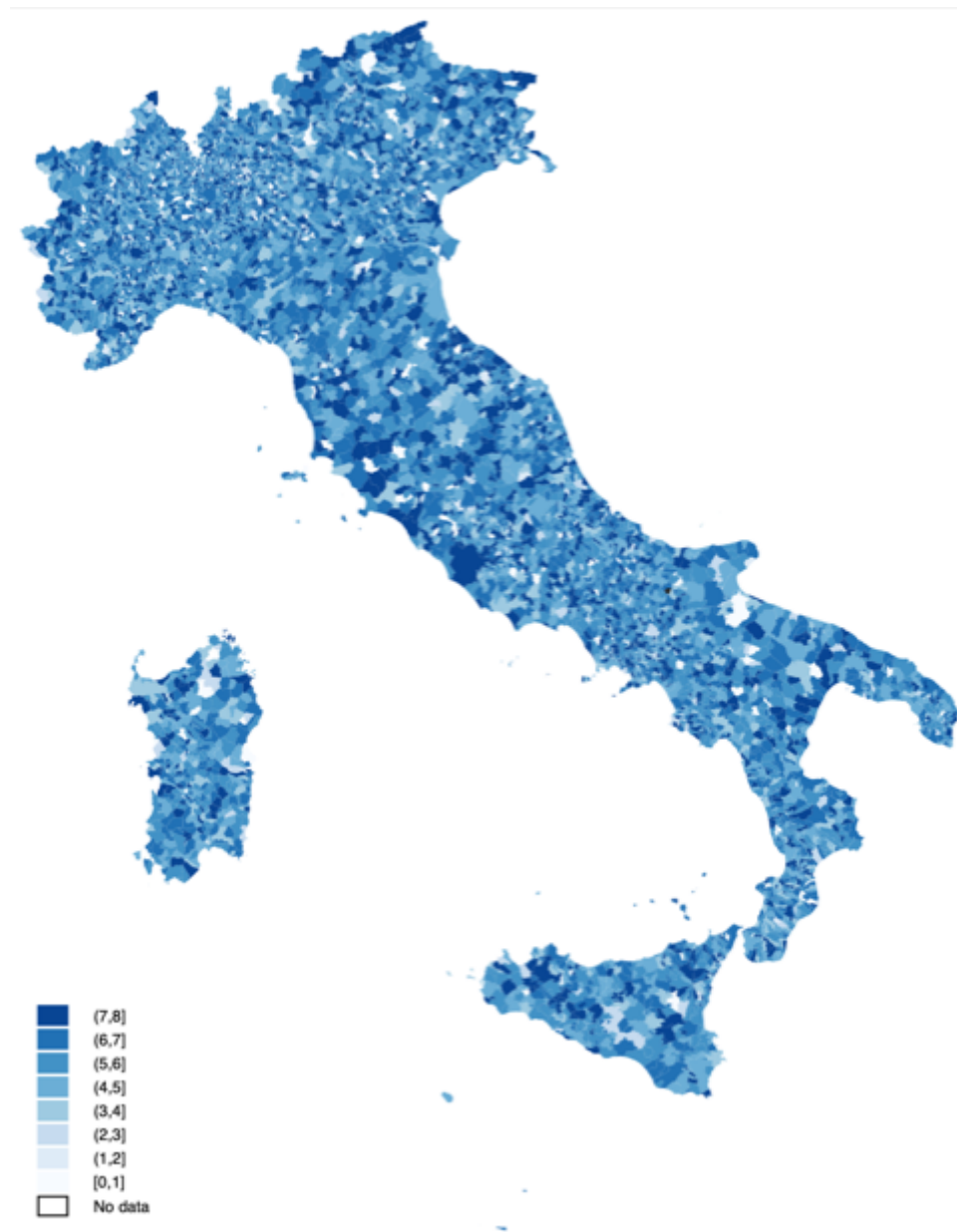Figure 3: **FWG: Female share in Medieval guild founders.** Source: Our elaboration on data from the Central State Archive in Rome. Notes: The darkest red means that the city (at current Italian borders) exhibited the highest share of women in any of the 8 Medieval guilds considered in this paper (wool, silk, spices, furs, goldsmiths, dyers, blacksmiths, and shoemakers).

5-12%
4.1-5%
3-4%
>0-3%
No data

Table 1:   **Descriptive statistics on inventors**

	Men		Women		Whole sample	
	Mean	Std. Dv.	Mean	Std. Dv.	Mean	Std. Dv.
Individual-level variables						
Age	39.631	9.506	34.854	7.178	39.270	9.437
Full-time	0.995	0.069	0.959	0.198	0.993	0.086
Blue-collar	0.052	0.221	0.016	0.124	0.049	0.216
White-collar	0.612	0.487	0.726	0.446	0.620	0.485
Manager	0.003	0.057	0.003	0.057	0.003	0.057
Other work status	0.333	0.471	0.255	0.436	0.327	0.469
Seasonal contract	0.018	0.132	0.053	0.224	0.020	0.141
Open-end contract	0.430	0.495	0.499	0.500	0.435	0.496
Patent's no. of authors	0.372	1.111	0.616	1.642	0.390	1.160
No. of patent applications per year	0.210	0.735	0.227	0.694	0.211	0.732
Overall no. of patent applications	4.030	7.266	3.686	5.337	4.005	7.142
No. of patent grants per year	0.069	0.380	0.064	0.326	0.069	0.376
Overall no. of patent grants	2.232	4.930	1.860	3.291	2.205	4.829
Firm characteristics						
Industry	0.942	0.234	0.912	0.283	0.940	0.238
Services	0.002	0.046	0.002	0.046	0.002	0.046
Public	0.020	0.141	0.034	0.181	0.021	0.144
Handcraft	0.007	0.085	0.002	0.046	0.007	0.083
Agriculture and Fishing	0.001	0.030	0.001	0.026	0.001	0.029
Credits and Insurance	0.000	0.017	0.001	0.025	0.000	0.017
Retail	0.027	0.163	0.048	0.214	0.029	0.168
Firm-size (log)	5.921	2.235	6.296	2.054	5.941	2.224
Municipality-level variables						
FWG_c	0.049	0.054	0.054	0.015	0.050	0.016
Altitude	160.765	172.839	138.590	148.471	160.765	172.839
Coastal dummy	0.817	0.386	0.757	0.429	0.812	0.390
Municipality size (km^2)	147.036	239.861	198.737	307.923	150.847	245.894
Medieval trade route dummy	0.609	0.487	0.666	0.472	0.613	0.487
Pre-XIII century university dummy	0.162	0.368	0.152	0.359	0.161	0.36

Source: INPS-Patstat, years 1987–2005; Central State Archive (Rome). Note: FWG_c is the fraction of women in total Medieval guild founders.

Table 2:   **Distribution of male and female inventors by FWG_c quartiles**

	Male inventors	Female inventors	FWG_c
1st quartile	25.55	17.42	0.037
2nd quartile	24.89	22.38	0.050
3rd quartile	24.68	27.48	0.059
4th quartile	24.88	32.73	0.077

Source: INPS-Patstat, years 1987–2005; Central Archive of the State (Rome). Note: FWG_c is the fraction of women in total guild founders.

Table 3:   **Female participation in Medieval guilds and current female study outcomes**

	College		STEM	
	(3.1)	(3.2)	(3.3)	(3.4)
FWG_c	1.2890 ***	0.7891 ***	0.2987 ***	0.1714 ***
	(.1203)	(.1166)	(.0567)	(.0543)
Municipality-level covariates	NO	YES	NO	YES
Mean of dep. var.	.087		.040	
Std. dev. of dep. var.	.281		.197	
No. obs.	497,267		220,931	

Source: Labor Force Survey, years 2002-2003, quarterly data; Central State Archive (Rome). Note: Additional control variables include age, age squared, LLM fixed-effects, year, quarter fixed-effects, and quarters x year. The control variables at the municipality level are the city's altitude and surface, a dummy for being near the coast, a dummy for whether the city was located near a Medieval trade route, and a dummy for the presence of a University before the 13th century. Standard errors, in parentheses, are clustered at the municipality level. Note: ***[**](*) denotes significance at the 1[5](10)% confidence level.

Table 4: **Female participation in Medieval guilds and current female labor outcomes**

	LFP		% of housewives		% of employees	
	(4.1)	(4.2)	(4.3)	(4.4)	(4.5)	(4.5)
FWG_c	0.8122 ***	0.3703 **	-1.1734 ***	-0.8737 ***	0.5112 ***	0.1596
	(.1915)	(.1724)	(.2389)	(.2447)	(.1660)	(.1718)
Municipality-level covariates	NO	YES	NO	YES	NO	YES
Mean of dep. var.	.481		.313		.780	
Std. dev. of dep. var.	.500		.464		.414	
No. obs.	489,945		293,716		203,545	

Source: Labor Force Survey, years 2002-2003, quarterly data; Central State Archive (Rome). Note: Additional control variables include age, age squared, LLM fixed-effects, year, quarter fixed-effects, and quarters x year. The control variables at the municipality level are the city's altitude and surface, a dummy for being near the coast, a dummy for whether the city was located near a Medieval trade route, and a dummy for the presence of a University before the 13th century. Standard errors, in parentheses, are clustered at the municipality level. Note: ***[**](*) denotes significance at the 1[5](10)% confidence level.

Table 5: **Female participation in Medieval guilds and share of women inventors**

	Share of female inventors		
	(5.1)	(5.2)	(5.3)
FWG_c	1.536 ***	0.797 ***	0.784 ***
	(0.272)	(0.207)	(0.221)
Worker- and firm-level covariates	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes
LMM fixed-effects	No	Yes	Yes
Municipality-level covariates	No	No	Yes
Mean of dep. var.	.089	.089	.089
Std. dev. of dep. var.	.284	.284	.284
No. obs.	15,423	15,423	15,423

Source: INPS-Patstat; Central State Archive (Rome). Note: Worker- and firm-level co-variates include the worker's age, work status, type of contract, a full-time dummy, the log of firm size, the log of firm average wage, and industry dummies. The control variables at the municipality level are the city's altitude and surface, a dummy for being near the coast, a dummy for whether the city was located near a Medieval trade route, and a dummy for the presence of a University before the 13th century. Observations are weighted by municipality size (measured by the number of employees). Standard errors, in parentheses, are clustered at the municipality level. ***[**](*) denotes significance at the 1[5](10)% confidence level.

Table 6: **Yearly number of patent applications and grants**

	(6.1)		(6.2)		(6.3)		(6.4)	
Panel A: Yearly number of patent applications								
Female x FWG_c	0.708	*	1.036	***	1.127	***	1.124	***
	(0.392)		(0.360)		(0.322)		(0.321)	
FWG_c	-0.840	*	-0.828	*	0.254		0.183	
	(0.474)		(0.451)		(0.201)		(0.346)	
Female	-0.098	***	-0.098	***	-0.105	***	-0.104	***
	(0.030)		(0.030)		(0.028)		(0.028)	
Mean of dep. variable	.211		.213		.213		.213	
Std. dev. of dep. variable	.731		.736		.736		.736	
Panel B: Yearly number of patent grants								
	(6.5)		(6.6)		(6.7)		(6.8)	
Female x FWG_c	0.425	***	-0.159		-0.131		-0.130	
	(0.123)		(0.183)		(0.182)		(0.183)	
FWG_c	0.342		-0.105		0.101		0.271	**
	(0.340)		(0.175)		(0.128)		(0.142)	
Female	-0.026	***	-0.013		-0.015		-0.015	
	(0.008)		(0.011)		(0.011)		(0.011)	
Worker- and firm-level covariates	Yes		Yes		Yes		Yes	
Year fixed-effects	Yes		Yes		Yes		Yes	
Firm fixed-effects	No		Yes		Yes		Yes	
LMM fixed-effects	No		No		Yes		Yes	
Municipality-level covariates	No		No		No		Yes	
Mean of dep. variable	.069		.069		.069		.069	
Std. dev. of dep. variable	.376		.378		.378		.378	
No. obs.	214,074		211,065		211,065		211,065	

Source: INPS-Patstat; Central State Archive (Rome). Note: Worker- and firm-level co-variates include worker's age, work status, type of contract, a full-time dummy, number of patent coauthors, the log of firm size, the log of firm average wage, and industry dummies. The control variables at the municipality level are the city's altitude and surface, a dummy for being near the coast, a dummy for whether the city was located near a Medieval trade route, and a dummy for the presence of a University before the 13th century. Observations are weighted by municipality size (measured by the number of employees). Standard errors, in parentheses, are clustered at the municipality level. ***[**](*) denotes significance at the 1[5](10)% confidence level.

Table 7: **Overall number of patent applications and grants**

Panel A: Overall number of patent applications

	(7.1)		(7.2)		(7.3)	
Female x FWG_c	18.213	***	13.969	***	13.947	***
	(4.574)		(4.352)		(4.347)	
FWG_c	-0.298		3.717		14.152	**
	(15.249)		(6.464)		(6.214)	
female	-1.265	***	-1.013	**	-1.011	**
	(0.373)		(0.400)		(0.400)	
Mean of dep. variable	3.80		3.80		3.80	
Std. dev. of dep. variable	4.52		4.52		4.52	

Panel B: Overall number of patent grants

	(7.4)		(7.5)		(7.6)	
Female x FWG_c	6.976	*	4.274		4.252	
	(3.940)		(3.015)		(3.021)	
FWG_c	1.191		4.229		7.845	**
	(9.746)		(3.156)		(3.550)	
Female	-0.581	***	-0.415	***	-0.413	***
	(0.213)		(0.159)		(0.159)	
	15423					
Worker- and firm-level covariates	Yes		Yes		Yes	
Year fixed-effects	Yes		Yes		Yes	
LMM fixed-effects	No		Yes		Yes	
Municipality-level covariates	No		No		Yes	
Mean of dep. variable	2.03		2.03		2.03	
Std. dev. of dep. variable	6.69		6.69		6.69	
No. obs.	15,423		15,423			

height

height

Source: INPS-Patstat; Central State Archive (Rome). Note: Worker- and firm-level covariates include worker's age, work status, type of contract, a full-time dummy, number of patent coauthors, the log of firm size, the log of firm average wage, and industry dummies. The control variables at the municipality level are the city's altitude and surface, a dummy for being near the coast, a dummy for whether the city was located near a Medieval trade route, and a dummy for the presence of a University before the 13th century. Observations are weighted by municipality size (measured by the number of employees). Standard errors, in parentheses, are clustered at the municipality level. ***[**](*) denotes significance at the 1[5](10)% confidence level.

6 References

Akcigit, U., S. Baslandze, and F. Lotti (2023). Connecting to power: political connections, innovation, and firm dynamics. *Econometrica 91*(2), 529–564.

Akcigit, U., J. Grigsby, and T. Nicholas (2017). The rise of american ingenuity: Innovation and inventors of the golden age. *American Economic Review: Papers and Proceedings 107*(5), 327–331.

Alesina, A., P. Giuliano, and N. Nunn (2013, May). On the Origins of Gender Roles: Women and the Plough. *Quarterly Journal of Economics 128*(2), 469–530.

Alfonzo, C. and S. Di Addario (2021). The Legacy of Medieval Communes on Italian Entrepreneurship Today. mimeo.

Bell, A., R. Chetty, X. Jaravel, N. Petkova, and J. V. Reenen (2019, Winter). Who Becomes an Inventor in America? The Importance of Exposure to Innovation. *Quarterly Journal of Economics 134*, 647–713.

Bellavitis, A. (2002). Donne, cittadinanza e corporazioni tra Medioevo ed eta' moderna: ricerche in corso. In T. P. M. Filippini and A. Scattigno (Eds.), *Corpi e storia. Donne e uomini dal mondo antico all'eta' contemporanea*, pp. 87–104. Viella.

Bertocchi, G. and M. Bozzano (2016). Women, Medieval Commerce, and the Education Gender Gap. *Journal of Comparative Economics 44*, 496–521.

Bianchi, N. and M. Giorcelli (2020, Winter). Scientific Education and Innovation: from Technical Diplomas to University STEM Degrees. *Journal of European Economic Association 18*(5), 2608–2646.

Boelmann, B., A. Raute, and U. Schönberg (2024). Wind of Change? Cultural Determinants of Maternal Labor Supply. *American Economic Journal: Applied Economics Forthcoming*.

Bovini, G., M. De Philippis, and L. Rizzica (2024). The Origins of the Gender Pay Gap: Education and Job Characteristics. Temi di discussione 1470, Bank of Italy.

Carta, F., M. De Philippis, L. Rizzica, and E. Viviano (2023). Women, Labour markets and Economic growth. Workshops and Conferences June, Bank of Italy.

Cavapozzi, D., M. Francesconi, and C. Nicoletti (2021). The Impact of Gender Role Norms on Mothers' Labor Supply. CESifo Working Papers 8983, CESifo.

Cerrito, E. (2017). Guilds, Competition, Growth. In A. Gigliobianco and G. Toniolo (Eds.), *Concorrenza, mercato e crescita in Italia: il lungo periodo*, Volume 3 of *Collana storica della Banca d'Italia*, Chapter 3, pp. 83–115. Marsilio.

Cinnirella, F., E. Hornung, and J. Koschnick (2022). Flow of Ideas: Economic Societies and the Rise of Useful Knowledge. CEPR Discussion Papers DP17442, CEPR.

de Blasio, G. and G. Nuzzo (2009). Historical Tradition of Civicness and Local Economic Development. *Journal of Regional Science 50*(4), 883–857.

Depalo, D. and S. Di Addario (2014). Shedding Light on Inventors' Returns to Patents. Development Studies Working Papers 375, Centro Studi Luca d'Agliano.

Di Addario, S. and A. Wu (2024). Who Becomes an Inventor in Italy? The Role of Talent Discovery. mimeo.

EPO (2022). Women's Participation in Inventive Activity. Technical report, European Patent Office.

Fernández, R., A. Fogli, and C. Olivetti (2004). Mothers and Sons: Preference Formation and Female Labor Force Dynamics. *The Quarterly Journal of Economics 119*(4), 1249–1299.

Giuliano, P. (2017). Gender: an Historical Perspective. NBER Working Papers 23635, NBER.

Griliches, Z. (1990, December). Patent Statistics as Economic Indicators: A Survey. *Journal of Economic Literature 28*(4), 1661–1707.

Guiso, L., P. Sapienza, and L. Zingales (2016, December). Long-term Persistence. *Journal of the European Economic Association 14*(6), 1401–1436.

Gustafsson, B. (1987). The Rise and Economic Behaviour of Medieval Craft Guilds. An Economic Theoretical Interpretation. *The Scandinavian Economic History Review and Economy and History XXXV*(1).

Istat (2005). Distretti industriali e sistemi locali del lavoro 2001. Technical report, Istat.

Jensen, K., B. Kovacs, and O. Sorenson (2018, Winter). Gender Differences in Obtaining and Maintaining Patent Rights. *Nature Biotechnology 36*(4), 307–309.

Kim, S. D. and P. Moser (2021). Women in Science. Lessons from the Baby Boom. NBER Working Papers 29436, NBER.

Martinez, M. (2024). Women Inventors in Italy, 1861-1939. *Business History forthcoming*.

Merouani, Y. and F. Perrin (2024). Women Inventors: On the Origins of the Gender Patenting Gap. Lund Papers in Economic History 255, Lund University.

Nosek, B. A., M. R. Banaji, and A. G. Greenwald (2002). Harvesting implicit group attitudes and beliefs from a demonstration website. *Group Dynamics: Theory, Research, and Practice 6*(1), 101–115.

Ortiz-Ospina, S. Esteban, Tzvetkova, and M. Roser (2024). Women's Employment. Workshops and Conferences June, Our World in Data.

Putnam, R. D. (1993). *Making Democracy Work: Civic Traditions in Modern Italy*. Princeton University Press.

Rescigno, G. (2016). *Lo "Stato dell'Arte". Le corporazioni nel Regno di Napoli dal XV al XVIII secolo*. Ministero dei Beni e delle Attivita' Culturali e del Turismo.

Saksena, M., N. Rada, and L. Cook (2022). Where are U.S. Women Patentees? Assessing Three Decades of Growth. Office of the Chief Economist IP Data Highlights 6, USPTO.

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2023

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BALTRUNAITE A., G. BOVINI and S. MOCETTI, *Managerial talent and managerial practices: are they complements?,* Journal of Corporate Finance, v. 79, Article 102348, **WP 1335 (April 2021).**

BARTOCCI A., A. NOTARPIETRO and M. PISANI, *Non-standard monetary policy measures in non-normal times,* International Finance, v. 26, 1, pp. 19-35, **WP 1251 (November 2019).**

CAPPELLETTI G. and P. E. MISTRULLI, *The role of credit lines and multiple lending in financial contagion and systemic events,* Journal of Financial Stability, v. 67, Article 101141, **WP 1123 (June 2017).**

CECI D. and A. SILVESTRINI, *Nowcasting the state of the Italian economy: the role of financial markets,* Journal of Forecasting, v. 42, 7, pp. 1569-1593, **WP 1362 (February 2022).**

CIAPANNA E, S. MOCETTI and A. NOTARPIETRO, *The macroeconomic effects of structural reforms: an empirical and model-based approach,* Economic Policy, v. 38, 114, pp. 243-285, **WP 1303 (November 2020).**

CORNELI F., *Sovereign debt maturity structure and its costs,* International Tax and Public Finance, v. 31, 1, pp. 262-297, **WP 1196 (November 2018).**

DAURICH D, S. DI ADDARIO and R. SAGGIO, *The macroeconomic effects of structural reforms: an empirical and model-based approach,* Review of Economic Studies, v. 90, 6, pp. 2880–2942, **WP 1390 (November 2022).**

DI ADDARIO S., P. KLINE, R. SAGGIO and M. SØLVSTEN, *The effects of partial employment protection reforms: evidence from Italy,* Journal of Econometrics,v. 233, 2, pp. 340-374, **WP 1374 (June 2022).**

FERRARI A. and V. NISPI LANDI, *Toward a green economy: the role of central bank's asset purchases,* International Journal of Central Banking, v. 19, 5, pp. 287-340, **WP 1358 (February 2022).**

FERRIANI F., *Issuing bonds during the Covid-19 pandemic: was there an ESG premium?,* International Review of Financial Analysis, v. 88, Article 102653, **WP 1392 (November 2022).**

GIORDANO C., *Revisiting the real exchange rate misalignment-economic growth nexus via the across-sector misallocation channel,* Review of International Economics, v. 31, 4, pp. 1329-1384, **WP 1385 (October 2022).**

GUGLIELMINETTI E., M. LOBERTO and A. MISTRETTA, *The impact of COVID-19 on the European short-term rental market,* Empirica, v. 50, 3, pp. 585-623, **WP 1379 (July 2022).**

LILLA F., *Volatility bursts: a discrete-time option model with multiple volatility components,* Journal of Financial Econometrics, v. 21, 3, pp. 678-713, **WP 1336 (June 2021).**

LOBERTO M., *Foreclosures and house prices,* Italian Economic Journal / Rivista italiana degli economisti, v. 9, 1, pp. 397-424, **WP 1325 (March 2021).**

LOMBARDI M. J., M. RIGGI and E. VIVIANO, *Worker's bargaining power and the Phillips curve: a micro-macro analysis, and wages,* Journal of the European Economic Association, v. 21, 5, pp. 1905–1943, **WP 1302 (November 2020).**

MODENA F., S. PEREDA-FERNANDEZ and G. M. TANZI, *On the design of grant assignment rules,* Politica economica/Journal of Economic Policy, v. 1/2023, pp. 3-40, **WP 1307 (December 2020).**

NERI S., *Long-term inflation expectations and monetary policy in the Euro Area before the pandemic*, European Economic Review, v. 154, Article 104426, **WP 1357 (December 2021).**

ORAME A., *Bank lending and the European debt crisis: evidence from a new survey*, International Journal of Central Banking, v. 19, 1, pp. 243-300, **WP 1279 (June 2020).**

RIZZICA L., G. ROMA and G. ROVIGATTI, *The effects of shop opening hours deregulation: evidence from Italy,* The Journal of Law and Economics, v. 66, 1, pp. 21-52, **WP 1281 (June 2020).**

TANZI G. M., *Scars of youth non-employment and labour market conditions,* Italian Economic Journal / Rivista italiana degli economisti, v. 9, 2, pp. 475-499, **WP 1312 (December 2020).**

2024

BALTRUNAITE A. and E. KARMAZIENE, *Fast tracks to boardrooms: director supply and board appointments,* Journal of Corporate Finance, v. 88, Article 102642, **WP 1278 (June 2020).**

BARTOCCI A., A. CANTELMO, P. COVA, A. NOTARPIETRO and M. PISANI, *Monetary and fiscal policy responses to fossil fuel price shocks,* Energy Economics, v. 136, Article 107737, **WP 1431 (December 2023).**

BENCHIMOL J. and L. PALUMBO, *Sanctions and Russian Online Prices,* Journal of Economic Behavior & Organization, v. 225, pp. 483-521, **WP 1468 (October 2024).**

BRANZOLI N., R. GALLO, A. ILARI and D. PORTIOLI, *Central banks' corporate asset purchase programmes and risk-taking by bond funds in the aftermath of market stress,* Journal of Financial Stability, v. 72, Article 101261, **WP 1404 (March 2023).**

BRANZOLI N., E. RAINONE and I. SUPINO, *The role of banks' technology adoption in credit markets during the pandemic,* Journal of Financial Stability, v. 71, Article 101230, **WP 1406 (March 2023).**

BUONO I, F. CORNELI and E. DI STEFANO, *Capital inflows to emerging countries and their sensitivity to the global financial cycle,* International Finance, v. 27,2, pp. 17-34, **WP 1262 (February 2020).**

CANTELMO A., N. FATOUROS, G. MELINA and C. PAPAGEORGIOU, *Monetary policy under natural disaster shocks,* International Economic Review, v.65, 3, pp. 1441-1497, **WP 1443 (March 2024).**

DEL PRETE S, G. PAPINI and M. TONELLO, *Gender quotas, board diversity and spillover effects. Evidence from Italian banks,* Journal of Economic Behavior & Organization, v. 221, pp. 148-173, **WP 1395 (December 2022).**

DE MARCHI R. and A. MORO, *Forecasting fiscal crises in emerging markets and low-income countries with machine learning models,* Open Economies Review. v. 35, 1, pp. 189-213, **WP 1405 (March 2023).**

FERRARI A. and V. NISPI LANDI, *Whatever it takes to save the planet? Central banks and unconventional green policy,* Macroeconomic Dynamics, v. 28, 2, pp. 299-324, **WP 1320 (February 2021).**

FLACCADORO M., *Exchange rate pass-through in small, open, commodity-exporting economies: lessons from Canada,* Journal of International Economics, v. 148, Article 103885, **WP 1368 (May 2022).**

GAUTIER E., C. CONFLITTI, R. FABER, B. FABO, L. FADEJEVA, V. JOUVANCEAU, J.-O. MENZ, T. MESSNER, P. PETROULAS, P. ROLDAN-BLANCO, F. RUMLER, S. SANTORO, E. WIELAND and H. ZIMMER, *New facts on consumer price rigidity in the euro area,* American Economic Journal: Macroeconomics, v. 16, 4, pp. 386-431, **WP 1375 (July 2022).**

LATTANZIO S., *Schools and the transmission of Sars-Cov-2: evidence from Italy,* Economics & Human Biology, v. 52, Article 101342, **WP 1453 (February 2023).**

MORO A. and V. NISPI LANDI, *The external financial spillovers of CBDCs,* Journal of Economic Dynamics and Control, v. 159, Article 104801, **WP 1416 (July 2023).**

PORRECA E. and A. ROSOLIA, *Immigration and unemployment. Do natives get it right?,* Journal of Economic Behavior & Organization, v. 225, pp. 522–540, **WP 1273 (April 2020).**

RAINONE E., *Real-time identification and high frequency analysis of deposits outflows,* Journal of Financial Econometrics, v. 22, 4, pp. 868–907, **WP 1319 (December 2017).**

ROSOLIA A., *Do firms act on their inflation expectations? Another look at Italian firms,* Journal of Political Economy Macroeconomics, v. 2, 4, pp. 651-686, **WP 1353 (October 2021).**

ZAGHINI A., *Unconventional Green,* Journal of Corporate Finance, v. 85, Article 102556, **WP 1453 (April 2024).**

2025

BERNARDINI M. and A. DE NICOLA, *The market stabilization role of central bank asset purchases: high-frequency evidence from the COVID-19 crisis,* Journal of International Money and Finance, v. 152, Article 103257, **WP 1310 (December 2020).**

LOSCHIAVO D., F. TULLIO and A. DI SALVATORE, *Measuring households' financial fragilities: an analysis at the intersection of income, financial wealth, and debt,* Review of Income and Wealth, v. 71, 1, e12691, **WP 1452 (April 2024).**

MISTRETTA A., *Synchronization vs transmission: the effect of the German slowdown on the Italian business cycle,* International Journal of Central Banking, v. 21, 1, pp. 331-386, **WP 1346 (October 2021).**

FORTHCOMING

BALTRUNAITE A., M. CANNELLA, S. MOCETTI and G. ROMA, *Board composition and performance of state-owned enterprises: quasi experimental evidence,* The Journal of Law, Economics, and Organization, **WP 1328 (April 2021).**

BENVENUTI M. and S. DEL PRETE, *The evolution of banking competition in italian credit markets using a profit elasticity approach,* Italian Economic Journal / Rivista italiana degli economisti, **WP 1237 (October 2019).**

BOTTERO M. and S. SCHIAFFI, *Firm liquidity and the transmission of monetary policy,* International Journal of Central Banking, **WP 1378 (July 2022).**

"TEMI" LATER PUBLISHED ELSEWHERE

CIANI E., A. GROMPONE and E. OLIVIERI, *Jobs for the long-term unemployed: place-based policies in depressed areas,* Italian Economic Journal / Rivista italiana degli economisti, **WP 1249 (November 2019).**

CUCINIELLO V. and N. DI IASIO, *Determinants of the credit cycle: a flow analysis of the extensive margin,* Journal of Money, Credit and Banking, **WP 1266 (March 2020).**

CUCINIELLO V., C. MICHELACCI and L. PACIELLO, *Subsidizing business entry in competitive credit markets,* Journal of Political Economy, **WP 1424 (October 2023).**

DESTEFANIS S. and V. DI GIACINTO, *The heterogeneous effects of EU structural funds: a spatial VAR approach,* Journal of Regional Science, **WP 1409 (April 2023).**

FLACCADORO M., *Exchange rate pass-through in small, open, commodity-exporting economies: lessons from Canada,* Journal of International Economics, **WP 1365 (April 2022).**

FRATTOLA E., *Parental retirement and fertility decisions across family policy regimes,* Review of Economics of the Household, **WP 1417 (July 2023).**

GNOCATO N., *Energy price shocks, unemployment, and monetary policy,* Journal of Monetary Economics, **WP 1450 (March 2024).**

MICHELANGELI V. and E. VIVIANO, *Can internet banking affect households' participation in financial markets and financial awarness?,* Journal of Money, Credit and Banking, **WP 1329 (April 2021).**

MORO A., *Optimal policies in a small open economy with an environmental externality and shallow foreign exchange markets,* Portuguese Economic Journal, **WP 1348 (October 2021).**

RAINONE E., *Reservation rates in interbank money markets,* Journal of Money, Credit and Banking, **WP 1160 (February 2021).**

ROPELE T., Y. GORODNICHENKO and O. COIBION, *Inflation expectations and misallocation of resources: evidence from Italy,* American Economic Review: Insights, **WP 1437 (December 2023).**