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Macroeconomic costs of gender gaps in a model with household production and entrepreneurship

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Abstract: This paper examines the quantitative effects of gender gaps in entrepreneurship and workforce participation in an occupational choice model with a household sector. Gender gaps in entrepreneurship affect negatively both income and aggregate productivity, since they reduce the entrepreneurs' average talent and female labor force participation. We estimate the gender gaps for 37 European countries and we find that gender gaps cause an average market output loss of 11.5% when they are considered constant across talent levels. The loss in total output, which also includes household production, varies between 6.4% and 8.7%, depending on the household productivity parameter.

JEL Codes: E2, J21, O40.

Keywords: Gender-specific occupational choice frictions, Entrepreneurhsip talent misallocation, Total output.

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1 Introduction

Gender inequality is present in many socioeconomic indicators around the world in both developed and developing countries. These gaps can be observed in several dimensions: education, earnings, occupation, access to productive inputs, political representation, or bargaining power inside the household.[1] Two important aspects of gender inequality in the labor market are the low female participation in the labor market and the low presence of women in entrepreneurial activities. The consequences of these gender gaps in entrepreneurial activities has not been much studied in the literature, although looking at data on employership and self-employment, we observe that women are largely underrepresented worldwide. On average, in the Middle East and North Africa there is 1 female employer for every 10 male employers, while in Latin America and the Caribbean, Central Asia or South Asia there are approximately 3 female employers for every 10 male employers. In self-employment, the female-to-male ratios are approximately twice the employers' one. In this paper we focus on Europe, where the female-to-male employers' and self-employment ratios are below 0.45 and 0.65 respectively in all regions. The female labor force participation of female is also lower than the male's one, as we can see in Table 1.

Table 1: Gender differences in the labor market, by European region

(female to male ratios)	Employers	Self Employed	Labor force part.
Eastern Europe	0.43	0.61	0.88
Northern Europe	0.34	0.52	0.94
Southern Europe	0.32	0.45	0.76
Western Europe	0.31	0.64	0.84

The main goal of this article is to quantify the aggregate effects of several gender gaps in the labor market on aggregate productivity and income in Europe. To do that we use a general equilibrium occupational choice model based on Cuberes and Teignier (2016) to compute the macroeconomic costs of these gender gaps. In the model, agents are endowed

[1] See the World Development Report 2012 (World Bank, 2012) for a comprehensive review of these and other gender gaps.

with a random skill level, based on which they decide to work as either employers, self-employed, or workers. Women also have the possibility of working in the household sector. An employer in this model produces goods using a span-of-control technology that combines his or her entrepreneurship skills, capital, and workers. This span-of-control element implies that more talented agents run larger firms, as in Lucas (1978). On the other hand, a self-employed agent can produce goods using a similar technology - adjusted by a productivity parameter - but without hiring any workers.

The model assumes that men and women are identical in terms of their skills. However, women have an extra occupational alternative, namely the household sector, and they are subject to several exogenous constraints in the labor market. As a result, fewer women participate in the labor market and, moreover, a fraction of female participants who would like to be employers or self-employed are excluded from these occupations. These restrictions distort the occupational allocation and reduce aggregate productivity and income per capita. The intuition behind the output loss is as follows. When a very talented woman happens to be banned from becoming an employer, a less skilled man will take her position and become the manager of a firm and, as a consequence, firm productivity and aggregate output per worker will fall. One important question is which type of women are excluded from entrepreneurship. When we assume that all women face the same probability of not participating in employership, we are underestimating the actual loss if more talented women are more likely to be excluded, but we are overestimating the actual loss if more talented women are less likely to be excluded.

Several articles in the literature study why economic growth reduces some of the gender gaps, for example, Becker and Lewis (1973), Galor and Weil (1996), Greenwood et al. (2005), Doepke and Tertilt (2009), Fernandez (2009) and Ngai and Petrongolo (2015). Other papers analyze on the reverse effect, i.e. the impact of gender inequality on growth. These theories are, in most cases, based on the fertility and children's human capital channels, as in Galor and Weil (1996), and Lagerlöf (2003). Esteve-Volart (2009), on the other hand, presents a model in which the gender gap in employment leads to a reduction in the stock of talent available in the economy and to distortions in the allocation of talent across different occupations.[2] To our knowledge however, there are only a few papers that quantify the macroeconomic effects of gender gaps in the labor market.The International Labor Organization provides some estimates of the output costs associated with labor gender gaps in the Middle East and Northern Africa but without proposing any specific theoretical model (ILO, 2014).[3] Cavalcanti and Tavares (2016) construct a growth model based on Galor and Weil (1996) with exogenous wage discrimination against women. Calibrating their model using U.S. data, they find very large effects associated with these wage gaps: a 50 percent increase in the gender wage gap in their model leads to a decrease in income per capita of a quarter of the original output. Hsieh et al. (2013) use a Roy model to estimate the effect of the changing occupational allocation of white women, black men, and black women between 1960 and 2008 on U.S. economic growth and find that the improved allocation of talent within the United States accounts for 17 to 20 percent of growth over this period. Finally, Cuberes and Teignier (2016) calculate the macroeconomic effects of gender inequality in the labor market using data from the International Labor Organization for a large sample of countries.

The rest of the paper is organized as follows. In Section 2 we present the theoretical framework, while in Sections 3 and 4 we show the numerical results. Section 5 concludes.

2 Theoretical framework

We start by presenting the theoretical framework used to generate the quantitative predictions in Section 3, which is an extension of the model proposed by Cuberes and Teignier (2016). The framework consists a general equilibrium occupational choice model where agents are endowed with a random skill level, based on which they decide to work as employers, self-employed, or workers. Women are now also offered the possibility of becoming household workers. An employer in this model can produce goods using a span-of-control

[2]See Cuberes and Teignier (2014) for a critical literature review of the two-directional link between gender inequality and economic growth.

[3]See also the reports by Goldman Sachs (2007), Aguirre et al. (2012), and McKinsey & Company (2015).

technology that combines his or her talent, capital, and workers. This span-of-control element implies that more talented agents run larger firms, as in Lucas (1978). On the other hand, a self-employed agent can produce goods using a similar technology - adjusted by a productivity parameter - but without hiring any workers.

2.1 Setup description

The economy we consider has a continuum of agents indexed by their skill level x, which is drawn from a cumulative distribution Γ that takes values between B and ∞. We assume the economy is closed and that it has a workforce of size N and K units of capital. Skill-adjusted labor and capital are inelastically supplied in the market by consumers, in exchange for a wage rate per unit of skill, w, and a capital rental rate, r, respectively. These inputs are then combined by firms to produce an homogeneous good.

Men choose to become either firm workers, who earn the equilibrium wage rate w times their skill level x , or entrepreneurs, who earn the profits generated by the firm they manage.[4] Women also have the option of becoming household workers. An agent with talent or productivity level x who chooses to become an employer and hires $n(x)$ units of skill-adjusted labor and $k(x)$ units of capital produces $y(x)$ units of output and earns profits $\pi(x) = y(x) - rk(x) - wn(x)$, where the price of the homogeneous good is normalized to one. As in Lucas (1978) and Buera and Shin (2011), the production function is given by

$$y(x) = x\left(k(x)^{\alpha} n(x)^{1-\alpha}\right)^{\eta}, \tag{1}$$

where $\alpha \in (0,1)$ and $\eta \in (0,1)$. The parameter η measures the *span of control* of entrepreneurs and, since it is smaller than one, the entrepreneurial technology involves an element of diminishing returns. On the other hand, an agent with talent x who chooses to become self-employed uses the amount of capital $\tilde{k}(x)$, produces $\tilde{y}(x)$ units of output and earns profits $\tilde{\pi}(x) = \tilde{y}(x) - r\tilde{k}(x)$. The technology he or she operates is given by

[4] In what follows we will refer to an entrepreneur as someone who works as either an employer or a self-employed.

$$\tilde{y}(x) = \tau x \tilde{k}(x)^{\alpha\eta}, \tag{2}$$

where τ is the self-employed productivity parameter.[5] One interpretation of this parameter is that self-employed workers have to spend a fraction of their time on management tasks, which would imply that τ is equal to the fraction of time available for work to the power $(1-\alpha)\eta$. As explained below, we estimate this parameter to match the average fraction of self-employed in the data. Finally, we assume that a women who chooses to become a household worker, operates the technology

$$y_h = \sigma k_h^{\alpha\eta}, \tag{3}$$

where k_h denotes the level of capital that maximizes profits for a household worker. Profits for this woman are given by $\pi_h = y_h - rk_h$. Note that equation (3) assumes that a woman's producitvty in the household sector does not depend on her talent and that she works alone in this sector.

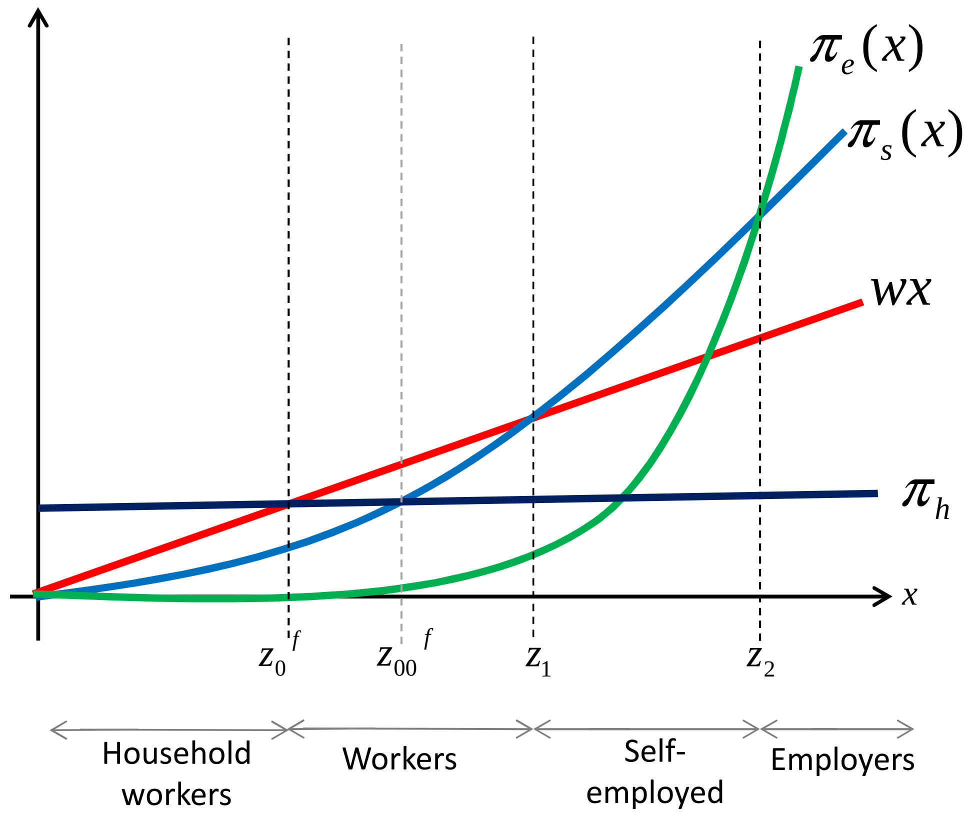
2.2 Equilibrium

Figure 1 displays the payoff of the three occupations at each talent level and shows the optimal occupational choices in equilibrium. Agents with the highest skill level (those with talent above z_2) become employers, whereas those with intermediate skill levels become self-employed. Men with a level of talent lower than z_1 become market workers, while women become market workers if their talent is between z_0^f and z_1. Women with talent below z_0^f become household workers.

In this economy, aggregate (market) production per capita is the sum of output by male

[5]The consumption good produced by the self-employed and the capital they use is the same as the one in the employers' problem. However, it is convenient to denote them $\tilde{y}$ and $\tilde{k}$ to clarify the exposition.

Figure 1: The occupational map



employers and self-employed, as well as output by female employers and female self-employed:

$$\frac{Y}{N} = \left[\int_{z_2}^{\infty} y(x) d\Gamma(x) + \int_{z_1}^{z_2} \tilde{y}(x) d\Gamma(x) \right],$$

where$\Gamma(x)$ denotes the talent cumulative density function. The first term in brackets represents the production by male and female employers, whereas the second one is the corresponding term byself-employed.

Some production of this economy takes place at home by women:

$$\frac{Y_h}{N} = \frac{1}{2} \int_{B}^{z_0^f} y_h d\Gamma(x),$$

where $y_h = \sigma k_h^{\alpha\eta}$ denotes the household production. We will refer to total production as the sum of market and household production:

$$Y_T = Y + Y_h.$$

2.3 Introducing gender gaps into the framework

The model assumes that men and women are identical in terms of their innate skills. However, women are subject to some exogenous constraints in the labor market, namely a fraction of women see their occupational choices limited.[6] These restrictions reduce female participation in the market and alter the occupational, which results in lower aggregate output and incomes. When access to entrepreneurship is restricted, there are general equilibrium implications that reduce the average talent of entrepreneurs and the aggregate productivity. The intuition behind the output and productivity loss is as follows. Assume a very skilled woman does not participate in employership. The model then implies that a less skilled man will take her position and become the manager of a firm. But note that, if this man has a lower talent level than the woman who is not allowed to become a manager, he will run a smaller and less productive firm. This would then reduce output, wages and firms' profits.

The first constraint we impose is that females face a probability μ of being allowed to be an employer and a probability$1-\mu$ of being excluded from employership. Out of the group of women not allowed to be employers, some have have the possibility of becoming self-employed while the rest are also excluded from self-employment. In particular, women excluded from employership have a probability μ_o of being allowed to be self-employed and a probability $(1-\mu_o)$ of not being allowed to be self-employed. As a result a fraction $(1-\mu)(1-\mu_o)$ of women are shut out from entrepreneurship, i.e. both employership and self-employment, and can only become workers, if allowed.[7] Finally, the third friction we

[6] As in Cuberes and Tegnier (2016), we only consider participation constraints and we abstract from gender wage gaps.

[7] Note that, in this setup, we are not allowing for the possibility of women being excluded from self-employment but not from employership, since we think that whichever are the barriers women face to become

introduce is that only a fraction λ of women are allowed to participate in the labor market, while a fraction $(1-\lambda)$ of randomly selected women are excluded from all the possible occupations in the labor market.[8] This friction may reflect discrimination, or other *demand factors*, but it might also reflect differences in optimal choices of women, or other *supply factors*. In this setup, women who do not participate in the formal labor market become household producers and, hence, the income loss due to the λ gender gap estimated by our model depends on the household productivity parameter σ.

A key question to understand the magnitude of the income loss due to entrepreneurship gender gaps is the type of women who are not allowed to work in this occupation. In Cuberes and Teignier (2016) we assume that the probability of facing this exclusion is independent of their level of talent. This loss, however, would be significantly larger if more talented women faced a higher probability of being excluded from entrepreneurship since this would imply a bigger drop in the average talent of firm managers. On the other hand, the actual aggregate income loss due to entrepreneurship gender gaps would be smaller than the one estimated in Cuberes and Teignier (2016) if it was the case that more talented women faced a lower probability of being excluded, since this would imply a smaller drop in the average talent of firm managers. In terms of equation (**??**), the former case ($\widetilde{\mu}'(x) < 0$) corresponds to the lower part of the equation, and the latter one ($\widetilde{\mu}'(x) > 0$) corresponds to the upper part of the equation.

3 Numerical results

3.1 Talent Distribution

To simulate the model, we use a Pareto function for the talent distribution, as in Lucas

self-employed, they should apply even more strongly to become an employer. In terms of the parameters of the model, if $\mu = 1$, then the value of μ_o does not affect the occupational choices of women.

[8]We say that women excluded from the labor force are randomly selected because their talent is drawn from the same distribution as the rest of the population.

(1978) and Buera et al. (2011), so the cumulative distribution of talent is given by

$$\Gamma(x) = 1 - B^{\rho} x^{-\rho},\ x \geq 0, \tag{4}$$

where $\rho, B > 0$.

3.2 Model Parametrization

Table 2 shows the values used for the parameters that are constant across countries. The parameter B of the talent distribution is normalized to 1, while the parameter η is set to 0.79 as in Buera and Shin (2011).[9] The capital-output elasticity parameter α is set to 0.114 in order to match the 30% capital income share observed in the U.S. data.[10] The parameter ρ of the talent distribution is set to 6.57 to minimize the distance between the actual and the predicted fraction of employers in the OECD countries, which is 4.5% on average. Similarly, the self-employed relative productivity parameter τ takes a value of 0.83 to match the fraction of self-employed workers in the OECD countries, which is 10.8% on average.

The household sector productivity parameter, σ, is not so straightforward to calibrate. If σ takes a high value, the estimated frictions in female labor force participation and its economic costs will be lower since women would now produce some output even if they did not participate in the formal labor market. The approach we follow here is to present our results for three possible values. One of the values is the lower bound $\sigma = 0$, as if there was no household sector in the model. Another value is given by the upper bound for the OECD sample, i.e. the highest possible value that keeps the labor force frictions non-negative in all countries. In other words, if σ was higher than 0.83, the parameter λ would take a value above 1 in the country with the smallest gender gap in labor force participation

[9] Buera and Shin (2011) choose η to match the top five percent income share in the U.S., which is 30%. This is a reasonable approximation given that the top earners are entrepreneurs both in the model and the U.S. data.

[10] Entrepreneurs' profits are considered capital income, thus we set $\alpha\eta + (1 - \eta)$ equal to 30%.

Table 2: Common parameter values

Parameter	Value	Explanation
B	1	Normalization
η	0.79	From Buera and Shin (2011)
α	0.114	To match capital share: $\alpha\eta + (1-\eta) = 0.3$
ρ	6.57	To match employer's share OECD countries (4.5%)
τ	0.68	To match self-employed share OECD countries (10.8%)
	0	No household sector
σ	0.49	Relative output per worker U.S. household sector
	0.83	Highest possible value OECD sample ($\lambda^{SWE} = 1$)

in our sample, namely Sweden, implying a meaningless negative value for $1-\lambda$. Finally, we also use an intermediate value of $\sigma = 0.49$, which is the value that matches the U.S. value added per worker at the household sector relative to the market value added per worker.[11] The gender gaps (μ, μ_o, λ), which are country specific, are described in section 3.4.

3.3 Potential effects of gender gaps

Tables 3 and 4 present the effects of introducing the highest possible gender gaps into the model for the cases $\sigma = 0.83$ and $\sigma = 0$ respectively. The parameter values are taken from Table 2.The first two columns show the output effects of excluding all women from employership when they can still participate in the labor market and in self-employment. In other words, the effect of changing μ from 1 to 0, when $\mu_o = \lambda = 1$. Similarly, the third and fourth row show the effects of excluding all women from entrepreneurship (i.e., changing both μ and μ_o from 1 to 0) when they are all allowed to participate in the labor market (i.e. $\lambda = 1$). Finally, the last two columns show the effect of excluding all women from the labor force participation (i.e., changing λ from 1 to 0) when they were initially allowed into all occupations (i.e. $\mu = \mu_o = 1$).

When computing the numerical results, we distinguish between the short run and the long run. In the short run, capital is taken as constant and, therefore, not affected by the

[11] The value of the household production is taken from Bridgman, Duernecker and Herrendorf (2015).

Table 3: Effects of highest possible gender gaps ($\sigma = 0.83$)

(%)	Employership gap		Entrepreneurship gap		LFP gap	
	Short Run	Long Run	Short Run	Long Run	Short Run	Long Run
(Market) Output per worker	5.1	5.8	6.0	6.9	-1.6	0
(Market) Output per capita	12.4	13.0	17.8	18.6	49.2	50
Total Output capita (Market + Household)	7.11	7.8	9.11	10.0	14.51	15.8
Female labor force participation	15.4	15.4	25.1	25.1	100	100

introduction of the gender gaps (μ, μ_o, λ); in the long run, on the other hand, the capital stock takes its steady-state value and, therefore, is negatively affected by the introduction of the gender gaps.[12] To compute the steady-state capital stock, we assume a gross interest rate of 0.125, which is consistent with a depreciation rate of 0.075 and an intertemporal discount factor of 0.05 in a continuous-time model.[13] Not surprisingly, the long-run effects are stronger, since capital is adjusted downwards. However, since the output elasticity to the capital stock is only $\alpha\eta = 0.09$, the long-run results do not differ much to the short-run ones.

The introduction of the μ and μ_o-gender gaps generates both a reduction in output per worker as well as a reduction in female labor force participation. As we can see in Figure 2, when some women get excluded from entrepreneurship, the equilibrium wage rate falls since either labor demand decreases (μ-gap effect) or labor supply increases (μ_o-gap effect). As a result, both thresholds z_1 and z_2 fall, which leads to reduction in the average talent of entrepreneurs. Moreover, there is an increase in the z_0^f threshold, which means that some women switch from employees to household producers and, hence, female participation in the formal labor market falls. Both effects lead to decrease in (market) output per capita.

[12]The value for the stock of capital used in the short run is irrelevant, since the income loss predicted by the model due to the introduction of gender gaps is not affected by its value.

[13]The intertemporal discount factor we use is similar to the one proposed by Cooley and Prescott (1995), while the value for the depreciation rate is roughly an average of values found in the literature; for example, 0.048 in Cooley and Prescott (1995) and 0.1 in Christiano et al. (2005).

Table 4: Effects of highest possible gender gaps ($\sigma = 0$)

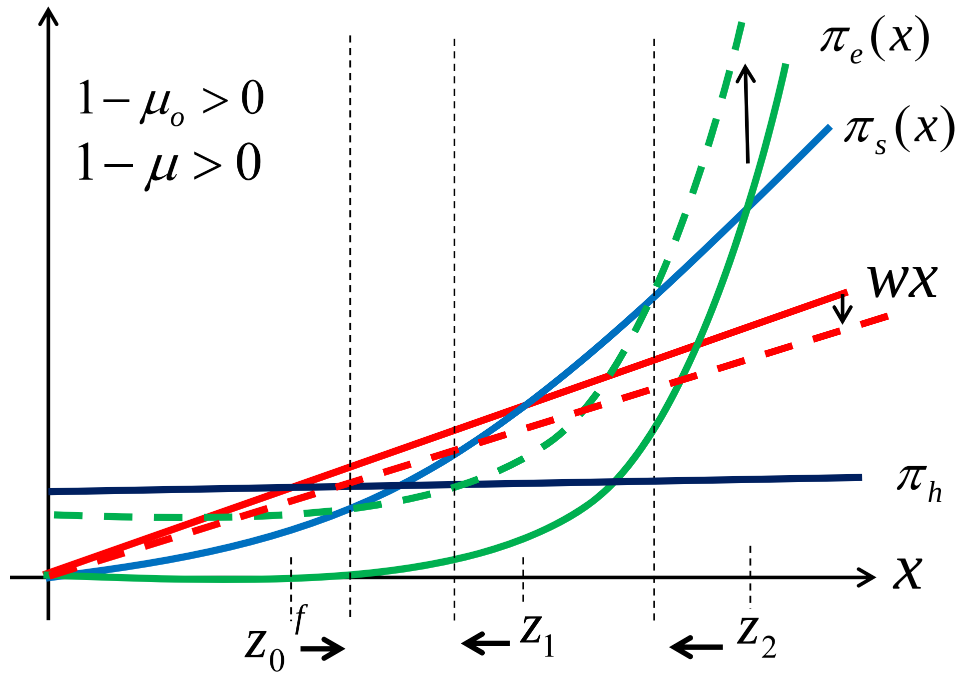
(%)	Employership gap		Entrepreneurship gap		LFP gap	
	Short Run	**Long Run**	**Short Run**	**Long Run**	**Short Run**	**Long Run**
(Market) Output per worker	7.2	7.9	9.36	10.24	-6.44	0
(Market) Output per capita	7.2	7.9	9.36	10.24	46.8	50
Total Output capita (Market + Household)	7.2	7.9	9.36	10.24	46.0	50
Female labor force participation	0	0	0	0	100	100

When we take into account the production that takes place in the household, the predicted fall in total output is significantly smaller.

The introduction of the λ-gap (the gender gap in labor force participation) in the last two columns, on the other hand, has a mechanical effect on market output in the long run: output per worker is not affected, output per capita falls by 50% when female labor force participation falls by 100%. In the short run, the effects are slightly different because capital is kept at its initial level. It is worth noting that the drop in total output per capita is much smaller, less than 1/3 of the drop in market output per capita, given that women now have the option to produce at home.

Comparing the models with and without household sector ($\sigma = 0.83$ vs. $\sigma = 0$), in Tables 3 and 4, we observe some interesting differences. First, the loss in market output per worker due to the employership and entrepreneurship gender gaps is larger under $\sigma = 0$. The reason is that, under the presence of the household sector, the least skilled workers move to the household sector, which mitigates the productivity loss caused by the drop in entrepreneurs talent. Second, the loss in market output per capita is larger when $\sigma = 0.83$, since the introduction of the entrepreneurship gender gaps generate a reduction in the labor force participation of women. At the same time, not surprisingly, the loss in total output per capita due to these gaps is smaller when $\sigma = 0.83$ given that, when it exists, the household sector becomes the optimal choice for some individuals after the fall in average firm

Figure 2: Qualitative effect of entrepreneurship gaps



productivity. Finally, the introduction of the labor force participation gender gap generates a smaller increase in the short-run market output per worker and a larger drop in market output per capita when $\sigma = 0.83$ (since female household workers also demand some capital and, hence, capital per market worker increases less), as well as a higher drop in the total output per capita both in the short and the long run (since non-participant females still produce at home).

3.4 Numerical results for European countries

Using data on employers, self-employed, and labor force participants for 37 European countries for the latest available year from the International Labor Organization, we estimate the country specific parameters (μ, μ_o, λ). Table 5 shows the average value for the employership, entrepreneurship, and labor force participation gender gaps when $\sigma = 0.83$. On average, the largest gender gaps are in employership, with 59% of women getting excluded, followed by entrepreneurship with 44%, and labor force participation with 13%. There is substantial variation across European countries but all of them have positive gender gaps

Table 5: Summary statistics of gender gaps in Europe ($\sigma = 0.83$)

	Parameter	Mean	Max	Min
Employership gender gap	$(1-\mu)$	0.59	0.80	0.38
Entrepreneurship gender gap	$(1-\mu)(1-\mu_0)$	0.44	0.71	0.04
Labor force part. gender gap	$1-\lambda$	0.13	0.46	0

in employership and entrepreneurship.

The numerical long-run results for the sample of European countries are presented in Tables 6 and 7, as well as in Figure 3. Table 6 shows that in the models with household production, the introduction of entrepreneurship gender gaps cause an average fall in income per capita of 6.18% when $\sigma = 0.83$, and 4.97% when $\sigma = 0.49$. These effects are larger than the ones of a model without household production ($\sigma = 0$), since in that model some women can switch to home production when equilibrium wages are low. The market output loss due all gender gaps is similar for the 3 values of sigma, between 10.5% and 11% in the short run, and around 11.5% in the long run. The total output loss, however, is very different in the two models. In a model where $\sigma = 0$, the fall in total output is the same as the fall in market output, while in a model with $\sigma > 0$, women have an outside option when not participating in the labor force and, hence, the estimated (total) output loss in a model with household production is much lower. Moreover, in a model with household production, the entrepreneurship gender gaps are responsible for almost all the fall in total income, while in a model without household production, they are responsible for less than half. Table 7 shows that, on average, the largest losses due to gender gaps take place in Southern Europe, while the lowest ones take place in Northern Europe.

As Figure 3 shows, the long-run fall in per capita income is above 25% in Malta and below 5% in Latvia. In Italy or Serbia the losses are above 15%, while in Poland, Spain, Germany or the United Kingdom, the losses are between 10% and 15%. Under the current parametrization, gender gaps in entrepreneurship are responsible for almost all the income

Table 6: Average losses due to the gender gaps in Europe

(%)	Short run			Long run		
	$\sigma = 0.83$	$\sigma = 0.49$	$\sigma = 0$	$\sigma = 0.83$	$\sigma = 0.49$	$\sigma = 0$
Fall in (market) output per capita due to entrepreneurship gaps	5.75	4.53	4.53	6.18	4.97	4.97
Fall in (market) output per capita due to all gender gaps	10.97	10.75	10.51	11.49	11.48	11.48
Fall in total output per capita due to all gender gaps	5.83	7.96	10.51	6.39	8.71	11.48

Table 7: Long-run average losses due to the gender gaps, by European region

	Market output per capita loss			**Total output per capita loss**		
	$\sigma = 0.83$	$\sigma = 0.49$	$\sigma = 0$	$\sigma = 0.83$	$\sigma = 0.49$	$\sigma = 0$
Eastern Europe	9.73	9.73	9.73	5.58	7.42	9.73
Northern Europe	8.77	8.67	8.67	5.98	7.32	8.67
Southern Europe	15.65	15.59	15.59	7.40	11.07	15.59
Western Europe	11.97	12.10	12.10	6.67	9.15	12.10

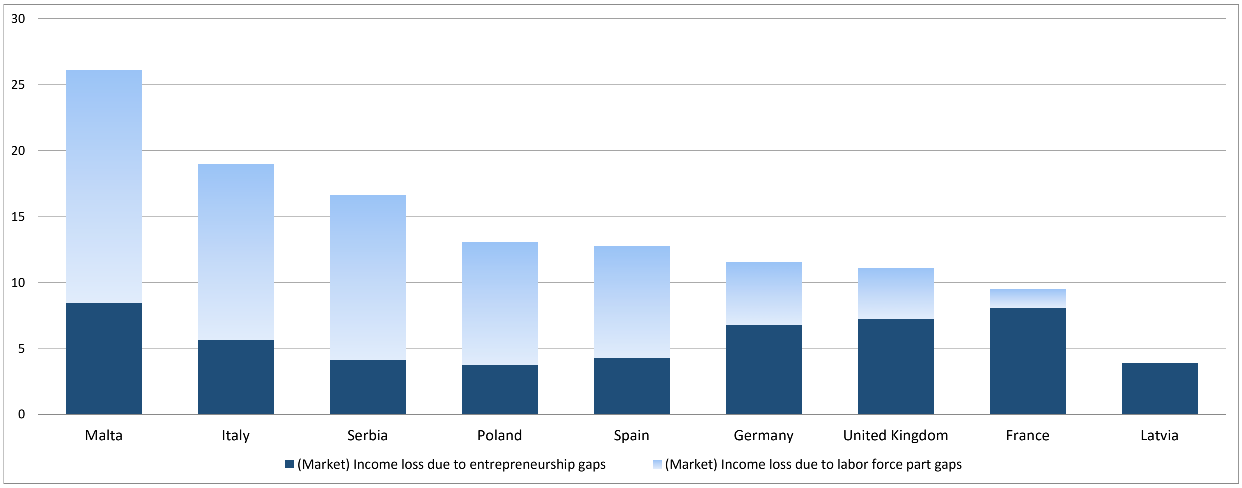
loss in countries like Latvia, while they are responsible for less than one third of the total loss in countries like Malta, Italy or Spain.

4 Conclusions

This paper uses a general equilibrium, occupational choice model with a household sector to examine the quantitative effects of gender gaps in entrepreneurship and workforce participation. The introduction of the household sector increases the estimated loss in market output, but it decreses the estimated loss in total (market plus household) output.

Our simulations also show that gender gaps in entrepreneurship have very large negative effects both income and aggregate productivity, since they reduce the entrepreneurs' average talent as well female labor force participation when we consider the possibility of working in the household sector. In particular, the expected (market) income loss from from excluding 5% of women from the market would generate a market income loss of more than 10% if they were all employers. If they were randomly selected, on the other hand, the ex-

Figure 3: Market output losses due to gender gaps, some European countries ($\sigma = 0.83$)



pected loss in market income would be of 2.5%, while the expected loss in total income would be less than 1%.

We then estimate the gender gaps for 37 European countries and we find that gender gaps cause an average market output loss of 11.5% . The loss in total output, which also includes household production, varies between 6.4% and 8.71%, depending on the household productivity parameter.

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A Model details

A.1 Agents' optimization

A.1.1 Employers

Employers choose the units of labor and capital they hire in order to maximize their current profits π. The optimal number of workers and capital stock, $n(x)$ and $k(x)$ respectively, depend positively on the productivity level x, as equations (5) and (6) show:

$$n\left(x\right) = \left[x\eta(1-\alpha)\left(\frac{\alpha}{1-\alpha}\right)^{\alpha\eta}\frac{w^{\alpha\eta-1}}{r^{\alpha\eta}}\right]^{1/(1-\eta)}, \tag{5}$$

$$k\left(x\right) = \left[x\eta\alpha\left(\frac{1-\alpha}{\alpha}\right)^{\eta(1-\alpha)}\frac{r^{\eta(1-\alpha)-1}}{w^{\eta(1-\alpha)}}\right]^{1/(1-\eta)}. \tag{6}$$

A.1.2 Self-employed

When we solve for the problem of a self-employed agent with talent x who wishes to maximize his or her profits, we find

$$\tilde{k}(x) = \left(\frac{\tau x\alpha\eta}{r}\right)^{\frac{1}{1-\alpha\eta}}. \tag{7}$$

A.1.3 Household workers

The optimization problem of household workers does not depend on their talent. They choose their household capital to maximize their earnings, which gives

$$k_h = \left(\frac{\sigma\alpha\eta}{r}\right)^{\frac{1}{1-\alpha\eta}}$$

A.1.4 Occupational choice

Figure (1) displays the shape of the profit functions of employers $(\pi_e(x))$ and self-employed $(\pi_s(x))$ along with wage function earned by employees and the household-workers earnings as a function of talent x.[14] The figure also shows the relevant talent cutoffs for the occupational choices. Here we present the equations that define the three thresholds: the first one, z_0^f, defines the talent level at which women are indifferent between being household workers of market worker:

$$\sigma k_h^{\alpha\eta} - rk_h = wz_0^f$$

When their talent is below z_0^f, women maximize their earnings as household workers, while above z_0^f their earnings are maximized as market workers. The second threshold, z_1, determines the earnings such that agents are indifferent between becoming workers or self-employed and it is given by

$$wz_1 = \tau z_1 \tilde{k}\left(z_1\right)^{\alpha\eta} - r\tilde{k}\left(z_1\right). \tag{8}$$

If $x \leq z_1$ agents choose to become workers, while if $x > z_1$ they become self-employed or employers. Finally, the third cutoff, z_2, determines the choice between being a self-employed or an employer and it is given by

$$\tau z_2 \tilde{k}(z_2)^{\alpha\eta} - r\tilde{k}(z_2) = z_2 x \left(k(z_2)^{\alpha} n(z_2)^{1-\alpha}\right)^{\eta} - rk\left(z_2\right) - wn(z_2) \tag{9}$$

so that if $x > z_2$ an agent wants to become an employer.

A.2 Competitive Equilibrium in a model with household sector

We assume that women represent half of the population in the economy and that there is no unemployment. Moreover, any agent in the economy can potentially participate in the labor market, except for the restrictions on women described above. Under these assump-

[14] In order to construct this figure we are implicitly using values for the parameters $\sigma,\ \tau,\ \alpha$, and η, such that the three occupations are chosen in equilibrium.

tions, in equilibrium, the total demand of capital by employers and self-employed must be equal to the aggregate capital endowment (in per capita terms) k:

$$\begin{aligned} k &= \frac{1}{2}\left[\int_{z_2}^{\infty} k(x)d\Gamma(x) + \int_{z_1}^{z_2} \tilde{k}(x)d\Gamma(x) + (1-\theta)\int_{B}^{z_1} \tilde{k}(x)d\Gamma(x)\right] \\ &+ \frac{\lambda}{2}\left[\int_{z_2}^{\infty} \mu k(x)d\Gamma(x) + \int_{z_1}^{z_2} (\mu + (1-\mu)\mu_0)\,\tilde{k}(x)d\Gamma(x) + \int_{z_2}^{\infty}(1-\mu)\mu_0\tilde{k}(x)d\Gamma(x)\right] \\ &+ \frac{\lambda}{2}\left[(1-\theta)\int_{z_{00}^{f}}^{z_1} (\mu + (1-\mu)\mu_0)\,\tilde{k}(x)d\Gamma(x) + k_h\Gamma(z_o^f)\right] + \frac{1-\lambda}{2}k_h. \end{aligned}$$

The upper term is the demand for capital by men and the two lower terms are the women's demand for capital. The demand for capital by male-run firms has three components: the first one represents the capital demand by employers, while the second and third terms represent the demand by self-employed. i.e. those who have the right ability to be self-employed plus those who become self-employed because they do could not find a job as workers.[15] These *out-of-necessity* self-employed demand the optimal amount of capital given their talent or ability.

The demand of capital by female-run firms has five components, each of them multiplied by the fraction of women in the labor force, $\frac{\lambda}{2}$. The first one represents the capital demand by female employers, i.e. those with enough ability to be employers and who are allowed to be so, while the second term represent the capital demand by women who have the right ability to be self-employed and are allowed to work.[16] The third term shows the capital demand by women who become self-employed because they are excluded from employership. The fourth term shows the fraction of females who would like to be market workers but, since they are "excluded" from this occupation, they choose to become *out-of-necessity*

[15] As explained in section 3, a fraction $(1-\theta)$ of both males and females with ability below z_1 become self-employed because they would like to be workers but are not allowed to do so and choose their second-best option.

[16] Note that here we are allowing for the possibility that μ depends on x, so the probability to be excluded from employership changes with the level of talent.

self-employed if their talent is above z_{00}^{f} are not excluded from entrepreneurship.[17]

Similarly, the labor market-clearing condition is given by

$$\frac{1}{2}\left[\int_{z_2}^{\infty} n(x)d\Gamma(x)\right] + \frac{\lambda}{2}\left[\int_{z_2}^{\infty} \mu\left(x\right) n(x)d\Gamma(x)\right] =$$

$$\frac{1}{2}\int_{B}^{z_1} xd\Gamma(x) + \frac{\lambda}{2}\left[\int_{z_0^f}^{z_1} xd\Gamma(x) + \int_{z_1}^{\infty} \left(\left(1-\mu\right)\left(1-\mu_0\right)\right) xd\Gamma(x)\right],$$

where the first line represents the aggregate labor demand and the second line represents the aggregate labor supply. The first term is the skill demand by male employers and the second one corresponds to the skilled demand by female employers, i.e. those women with enough ability to be employers who are allowed to choose their occupation freely. The first term of the labor supply shows the skill supply of men who choose to become workers, while the second and third show the skill supply of female workers. This latter terms is composed by the skill supply of females who, given their talent, want to be workers plus the skill supply of females who have enough ability to be employers or self-employed but are excluded from both occupations. For these group of women, the only option is to try to become workers.

A competitive equilibrium in this economy is a pair of cutoff levels (z_1, z_2), a set of quantities $\left[n\left(x\right), k\left(x\right), \tilde{k}\left(x\right)\right]$,$\forall x$, and prices (w, r) such that entrepreneurs choose the amount of capital and labor to maximize their profits, and labor and capital markets clear.

[17]Note that this setup implies that, for each talent level x, a fraction $\left(1-\theta\right)\left(1-\mu\right)\left(1-\mu_o\right)$ are excluded from all employment categories and, hence, they are forced to become household workers.