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The Productivity Gaps of Female-Owned Firms: Evidence from Ethiopian Census Data

Dennis Essers[a,b], Kelbesa Megersa[a,c], Marco Sanfilippo[a,d*]

[a]Institute of Development Policy (IOB), University of Antwerp (Belgium)

[b]Economics and Research Department, National Bank of Belgium

[c]Centre of Research in the Economics of Development (CRED), University of Namur (Belgium)

[d]Department of Political Sciences, University of Bari (Italy)

*Corresponding author: marco.sanfilippo@uantwerp.be

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Abstract

This paper provides new empirical evidence on the relative productivity disadvantage of female-owned firms compared to male-owned firms in a developing country setting. We rely on a large panel of manufacturing firms based on an annual census run by the Central Statistical Agency of Ethiopia. Our preferred estimation shows a 12% difference in levels of total factor productivity between female- and male-owned firms. Drawing on novel quantile approaches to formally compare productivity distributions, we also dig deeper into some of the potential mechanisms underlying this gender-based firm productivity gap. Our findings suggest that various forces are at work. Most female-owned firms seem to concentrate in certain less productive sub-sectors and only very few succeed in standing out. Moreover, lower productivity of female-owned firms is shown to relate to a combination of observed firm characteristics and unobserved structural factors that varies according to a firm's position in the overall productivity distribution.

JEL Codes: L26; J16

Keywords: Manufacturing firms, productivity distribution, gender gap, Ethiopia

1. Introduction

Closing gender gaps has become an imperative in global development circles. While considerable progress was recorded under the Millennium Development Goals, the recently established Sustainable Development Goals call for renewed efforts to reduce gender discrimination and increase empowerment, with a stronger emphasis on the promotion of a more active role for women as decision makers and owners of economic resources. In many developing countries, including in sub-Saharan Africa (SSA), issues relating to the extent and nature of women's participation in productive activities, to the allocation of women over specific sectors and types of jobs, and to high gender inequalities in the labour market remain pressing (Menon and Rodgers 2009; Hallward-Driemeier 2011; Juhn et al. 2014). Also, much is still unknown about which and how discriminatory practices and institutional constraints to which women are subjected influence their entrepreneurial capabilities.

The literature on gender, entrepreneurship, and firm performance generally shows evidence of significant gender gaps both at market entry (i.e., women are less likely to become entrepreneurs) as well as in several dimensions of female-owned firms' performance (Hellerstein and Neumark 1999; World Bank 2012; Marques 2015). A good part of this literature concerns industrialised rather than low-income countries, and micro- and small entrepreneurs rather than larger enterprises (see Klapper and Parker 2011 for a more complete overview). The evidence for transition and developing countries is mixed (Sabarwal and Terrell 2008; Bruhn 2009), and the few cross-country studies including SSA in their analysis do not observe stark gender-based firm performance differences (Bardasi et al. 2007; Bardasi et al. 2011). Conversely, SSA country-specific evidence suggests considerably lower female firm productivity in Ghana (Jones 2012) and Madagascar (Nordman and Vaillant 2014). The lack of systematic evidence may be due to the type and quality of the data used, as well as to the definition of female ownership adopted (Aterido and Hallward-Driemeier 2011).

Furthermore, there is no conclusive evidence on the underlying factors explaining any gender gaps in firm performance in developing countries and SSA more specifically, although several hypotheses have been advanced (see Campos and Gassier 2017 for a recent survey). In many countries, female businesses are concentrated in sectors characterised by limited economies of scale, low growth, low technology and capital, and intense competition (World Bank 2012; Kucera and Tejani 2014). Also, female entrepreneurs may be disadvantaged in terms of education, experience and other skill-related traits that are positively linked to productivity (Aterido and Hallward-Driemeier 2011). Yet, the empirical study by Nix et al. (2016) on microenterprises based in the Republic of Congo, Ghana, Rwanda, and Tanzania shows that the gender performance gap remains partly unexplained even after controlling for industry, firm, and owners' characteristics. Similar conclusions are reached by Hardy and Kagi (2018a), who focus on the case of Ghana. The importance of adverse external conditions, including access to credit and capital, has been tested in experimental research, which finds that returns to capital grants tend to be positive for male-operated microenterprises but close to zero for women (de Mel et al. 2008, 2009; Fafchamps et al. 2014).[1] Finally, a recent study on Ghana by Hardy and Kagi (2018b) points to the existence of demand-side constraints too. Limited formal employment opportunities for women increase the number of female micro-entrepreneurs, thereby generating lower market-size-to-firm ratios and higher demand scarcity for female-owned firms.

[1] Household capture may help explain this striking finding. Recent work by Bernhardt et al. (2017), using experimental data from India, Sri Lanka and Ghana, shows that returns to capital in female-operated microenterprises receiving grants are lower in multiple-enterprise households but not in single-enterprise households. This suggests that women may be investing the capital in their husbands' enterprises rather than in their own. In line with this, Fafchamps et al. (2014) find that in Ghana the profits of female enterprises respond more positively to in-kind grants, which are less easily diverted to other purposes.

In this paper, we engage with some of above issues and complement the empirical literature on gender-based firm productivity differences. Our overall aim is to contribute to a deeper understanding of the extent, nature and origins of female-owned firms' productivity gaps. We believe that such an understanding is crucial if female-owned firms are to be supported in an effective and cost-efficient manner. We rely on a large panel of Ethiopian manufacturing firms based on an annual census run by Ethiopia's Central Statistical Agency (CSA) over 2003-2009. The case of Ethiopian manufacturing is particularly interesting and relevant for our purposes. Over the last decades, the country has experienced sustained economic growth, spurred by large infrastructural investments, waves of trade liberalization, and industrial policies supporting the growth of the manufacturing sector and the structural transformation of the economy (World Bank 2015), aimed at fostering broader economic participation and enhancing productivity. Importantly, however, large gender gaps remain in the Ethiopian labour market. Female entrepreneurship is still limited in the country because of the existence of higher barriers for women than for men, including in access to finance and education (Alibhai et al. 2017). A few previous studies that have looked into gender-based heterogeneity in firm productivity in Ethiopia, based on survey data, have reported a negative correlation between female business ownership and productivity, especially in rural areas (Rijkers and Costa 2012; Rijkers et al. 2010). The country performs relatively poorly on the World Economic Forum's Gender Gap Index (ranked 115th out of 144 countries in 2017), in part due to low scores on the 'economic participation and opportunity' sub-index, which considers women's labour force participation, gender wage inequality and the prevalence of women in senior professional and technical positions (WEF 2017). A report by the ILO (2015) adds that only 22% of managers in Ethiopia are women, which puts it in the group of worst-performing countries in this specific area. That notwithstanding, other studies have found that recent policy efforts, such as the combined reforms in the family code and in community-based land registration, have already brought measurable improvements in women's economic participation and welfare in Ethiopia (Hallward-Driemeier and Gajigo 2015; Kumar and Quisumbing 2015).

The objective of our empirical analysis is twofold. First, along the lines of existing studies on the topic, we try to find out whether and to what extent female-owned firms in the Ethiopian manufacturing sector exhibit a performance gap compared to their male-owned counterparts. We do so taking total factor productivity (TFP) as our measure of firm performance. Unlike the extant literature on Ethiopia and other developing countries, which mostly relies on survey data and includes large numbers of small and informal firms, we base our analysis on census data (thus avoiding problems of sample representativeness) and consider the universe of formal firms in the Ethiopian manufacturing sector. This marks an important difference with existing studies looking at the gender productivity gap in Ethiopia (Rijkers et al. 2010; Rijkers and Costa 2012), given that they focus primarily on firms based in rural areas, whereas our (larger) firms tend to be based in urban areas.

Though our choice for the census data has the disadvantage of leaving out the majority of firms based in the country, which are small and informal, we are confident about the relevance of our analysis, given that the census firms represent roughly 50% and 90% of total employment and value added in the whole Ethiopian manufacturing sector, respectively. To our knowledge, we are the first to employ firm census data from a SSA country for these purposes. The richness of our dataset allows us to check the robustness of female-male firm productivity differences to alternative definitions of female ownership, based either on capital shares or on the number of female owners, and to control for several observable characteristics likely to affect the productivity gap when estimating regressions. Note however that, above all, our study is of a descriptive nature. Due to the non-experimental set-up, our results should not be interpreted in a causal way.

In the second part of the paper we look beyond *average* gender-based firm productivity gaps and investigate differences between the productivity *distributions* of male- and female-owned firms, which sheds some additional light on the potential mechanisms at work. We do this in two ways. First, we apply the Oaxaca-Blinder-type decomposition approach designed by Firpo et al. (2007, 2009). This type of analysis enables us to identify how much of the productivity gap between male- and female-owned firms can be attributed to differences in observable firm characteristics/factors (what we will label as the 'composition effect') and how much by different returns to those factors (the 'structural effect'), at different quantiles of the productivity distribution.[2] Given that the experimental evidence on smaller firms seems to indicate that the gender gaps in performance are mostly explained by lower returns to observables, the evidence we provide here on larger firms complements well existing knowledge on the issue. Second, we draw on another quantile-based methodology originally developed by Combes et al. (2012). Applied to our context, the Combes et al. (2012) approach allows us to evaluate in which ways the shape of the firm productivity distribution varies along the gender of firm owners. We formally distinguish between three 'transformations', i.e., shift, dilation and truncation, in the productivity distribution of female-owned firms relative to that of male-owned firms. More specifically, we look into how much the latter distribution would need to be moved rightwards along the x-axis (captured by the 'shift' parameter), what constant factor each of its observations would need to be divided by ('dilation'), and what share of

[2] Note that we follow Firpo et al. (2007) in using the term 'effect' here. Again, the data at hand do not allow us to draw causal conclusions.

observations would need to be excluded from its left tail ('truncation'), in order to best approximate the former distribution.

Our regression results show a consistent productivity gap for female-owned firms. The size of the average productivity gap varies considerably however, depending on the exact specification and definition of female ownership adopted (with stricter measures of female control over the firm resulting in larger estimated gaps). Our preferred estimation indicates that female-owned firms are, on average, about 12% less productive than male-owned firms, a result which is in line with previous, survey-based findings for large formal firms in other SSA countries (Aterido and Hallward-Driemeier 2011), but lower compared to other studies that include also smaller, informal and rural firms (Rijkers et al. 2010; Jones 2012; Nordman and Vaillant 2014). Our analysis further shows that lower capital intensity and allocation into less productive, more labour-intensive and female worker-dominated industries are among the mechanisms explaining (part of) the female firm productivity gap.

Next, we provide new insights based on a formal comparison of female and male firm productivity distributions. Results from our application of the Firpo et al. (2007, 2009) quantile decomposition suggest that a consistent part of the productivity differences for the firms populating the central section of the productivity distribution can be attributed to structural effects, and mainly to differences in the returns to capital. This echoes existing research based on field experiments with capital grants (de Mel et al. 2008, 2009), suggesting that similar mechanisms may also be at work for more structured firms. Conversely, gender productivity gaps in the upper part of the productivity distribution tend to be related to composition effects, i.e., differences in observed characteristics, and especially in firm size, capital endowments, and the internationalization of firms.

Results based on the Combes et al. (2012) approach provide evidence for a significant leftward shift and significantly lower dilation of the female firm productivity distribution compared to the male distribution. Interestingly, we also uncover that a (though very small) part of the female firm productivity gap can be explained by the female firms' productivity distribution displaying a longer left tail. When we consider a sample confined to firms in the capital region around Addis Ababa, where more than half of all manufacturing establishments are located, the economic significance of the left shift strengthens and also the lower dilation is confirmed. Patterns become more heterogeneous once we split the sample into smaller subgroups and when accounting for sectors and/or other key observable firm characteristics.

How to reconcile these various pieces of evidence? Taken together, our results indicate that female-owned firms are not only systematically less productive but also more homogeneous in terms of productivity than male-owned firms. This homogeneity is likely the result of female firms' concentration in certain (lower-productivity) sectors and sub-sectors. On the one hand, as shown by our decomposition analysis, the productivity differences in the central part of the distribution remain largely unexplained by observable characteristics of the firms. Rather, they seem to be driven by differences in returns to capital, whose origins and motivations have not yet been fully identified by the existing literature (de Mel et al. 2008, 2009; Fafchamps et al. 2014; Bernhardt et al. 2017) and which, unfortunately, we cannot explore further with our data. On the other hand, we find that there is only a very small number of highly productive female firms that coexist with a much larger group of substantially less productive establishments. In the upper tail of the distribution, particular observable characteristics of female firms, such as relatively small size and limited capital, seem to make it harder for them to stand out. All in all, our findings suggest that various forces are at work. Policymakers bound on closing the gender-based firm productivity gap in Ethiopia will need to heed its heterogeneous nature.

The remainder of the paper is structured as follows. Section 2 introduces our data and methodology. We then present the regression results for the average female-male firm productivity gap in section 3, and introduce and implement the two quantile approaches by Firpo et al. (2007, 2009) and Combes et al. (2012) that we use to compare female and male firm productivity distributions in section 4. Section 5 concludes.

2. Data and descriptive analysis

This paper uses manufacturing firm-level data from Ethiopia over the period 2003-2009. Our data are sourced from the annual census of large and medium manufacturing firms run by the CSA, which covers all firms that engage more than ten people and that employ electricity in their production process.[3] All firms need to comply with CSA requirements, and the census therefore represents the universe of more structured, formal manufacturing firms in the country. As mentioned earlier, while our census data has the limitation of excluding the largest part of Ethiopian firms, which are small and informal, it allows us to analyse a group of firms accounting for half of total employment and most of the value added created in Ethiopia's manufacturing sector. Table A1 in Appendix details the industry-level shares of total firm numbers, of total employment, and of total value added that are represented by the census firms in 2008, based on CSA (2009, 2010) reports of the manufacturing census and of the Ethiopian Small Scale Manufacturing Industry Survey (SSIS), a representative survey of manufacturing

[3] Persons engaged include both workers and unpaid working owners.

firms with less than 10 employees.[4] For 2008, the SSIS reports on over 43,000 small firms (53% of which are grain mills), engaging about 139,000 people and generating 1.1 billion birr in value added. The 2008 census, on the other hand, counts around 1,900 firms[5], engaging 134,000 people and producing 9.2 billion birr of value added. As shown in Table A1, census firms account for the lion's share of both employment and value added in nearly all manufacturing industries. Exceptions are the food industry[6], metal products and furniture, industries in which smaller firms dominate in terms of employment numbers (but not value added).

This dataset, in various versions and guises, has been employed in the past to study firm growth, survival and structural change (Bigsten and Gebreeyesus 2007; Shiferaw 2009; Söderbom 2012); the role of exporting and trade liberalisation on productivity (Bigsten and Gebreeyesus 2009; Fiorini et al. 2018); returns to capital in formal vs. informal firms (Siba 2015); job creation, job destruction and skill-biased technological change (Shiferaw and Bedi 2013), and road infrastructure and firm entry (Shiferaw et al. 2015), among other topics. Importantly however, to our knowledge, it has never been used to evaluate gender-based firm productivity differences. We believe the dataset's extensive coverage of larger manufacturing enterprises and rich details on ownership structure make it particularly suitable for our purposes.

The dataset includes detailed information on output, capital, labour and other inputs for all firms. In addition, it provides precise information on the location of firms by their region, zone,

[4] 2008 is the latest year for which the census and the survey were run concurrently.
[5] The small difference with the actual number of firms in our dataset, as reported in Table A2, is due to the fact that some firms did not respond to the census questions.
[6] Note that in the SSIS the food industry is largely characterised by the presence of grain mills. In 2008, they represented over 90% of total firms in that industry, as well as 93% of employment and 89% of value added (CSA, 2010).

district (*woreda*) and town of origin. It also contains data on the industry of firms' activities, up to the 4-digit level of the International Standard Industrial Classification (ISIC - revision 3).

Crucially, the census includes very granular information on the ownership structure of each firm. Constructing a good gender-based measure of ownership from firm-level data is not trivial. In fact, the definition of what constitutes a 'female business' and the distinction between ownership and control matter a great deal in assessing productivity differences.[7] Most studies have used a generic measure of female participation in the ownership of a firm, i.e., a dummy that equals one if *any* woman can be found among the owners. While this perfectly fits the case of sole-owned firms, it may be a less precise measure of female ownership in firms with multiple owners, including larger ones. Some studies, on the other hand, have had the advantage of using purposely collected survey data including specific questions related to the effective control of women in firms' decision-making process (see Aterido and Hallward-Driemeier 2011 on SSA firms; and Presbitero et al. 2014 on Latin American firms). Unfortunately, our own dataset on the Ethiopian manufacturing sector does not contain information on firms' ultimate decision-makers, to the extent that those are different from the owners. Rather, our data allows us to construct measures of female ownership based on the degree of control exercised by women both in terms of a firm's current capital shares and the composition of the corporate board. Importantly, Sekkat et al. (2015) demonstrate that developing country firms with women among their shareholders are more likely to have a female CEO too. For African firms, it is found that the higher the female ownership share, the stronger its effect on the likelihood of having a female CEO.

[7] For example, combining information from World Bank Enterprise Surveys with follow-up interviews of entrepreneurs in five African countries, Aterido and Hallward-Driemeier (2011) find no significant gender gaps in productivity when the standard 'female participation in ownership' (based on capital shares) is used. However, when the actual primary decision-maker is female, firms do exhibit significantly lower productivity.

Our preferred measure of female ownership is based on a relatively restrictive definition, i.e. whether women hold at least 50% of the current capital of firms. It is on the basis of such definition that we present basic descriptive statistics and run our baseline regressions. Alternative definitions of female ownership will be used to check the robustness of our results further on in the paper.

Whereas the total number of firms increased substantially over the period considered (it more than doubled from 2003 to 2009), the share of female-owned firms remained relatively stable, around 12% (cf. Table A2).[8]

Compared to their male-owned counterparts, female-owned firms are generally more concentrated, both geographically (almost 60% are located in the administrative region of Addis Ababa – which in turn accounts for about 49% of all firm-years in the sample) and, especially, at the sectoral level (more than 60% are found in the food processing and mineral products industries, dominated by bakeries and firms producing concrete, respectively) (cf. Tables A3 and A4 in the Appendix). In addition, and in correspondence with existing evidence from other developing countries, female-owned firms are smaller in size[9], less capital-intensive and less internationalised (i.e., engaged in exporting and/or importing) compared to male-owned firms. Moreover, on average, they employ larger shares of female workers overall and of *skilled* female workers in particular (cf. Table 1).

[8] This share increases to 29% of the total sample if we consider a less restrictive definition (i.e., at least one woman among the owners) and reduces to 7.2% in case female ownership is defined as 100% of capital being held by women.

[9] Figure A1 in Appendix plots the distributions of male- and female-owned firms' size, defined as the log of the number of employees. It shows the relative left shift of the female firm size distribution and the much fatter right tail of the male firm size distribution. The large majority of firms in our dataset, both male- and female-owned, has between 10 (about 2.3 in log terms) and 150 (about 5 in logs) employees.

TABLE 1 HERE

2.1 Productivity estimates

The main indicator we use to measure the relative performance of male- and female-owned firms in this paper is productivity. We focus on TFP, an indicator widely employed in the literature on heterogeneous firms (Melitz 2003; Helpman et al. 2004). The production function is assumed to take the form of a standard Cobb-Douglas specification:

$$Y_{it} = A_{it} L_{it}^{\beta_l} K_{it}^{\beta_k} M_{it}^{\beta_m}, \qquad \beta_l, \beta_k, \beta_m > 0 \qquad (1)$$

where Y_{it} stands for the output of firm *i* in year *t*; L_{it}, K_{it}, M_{it} are the inputs in the form of labour, capital and intermediate inputs; A_{it} is the Hicks-neutral efficiency level, which represents the TFP of firms; and the βs are factor shares. At the firm level, *A* includes not easily measurable factors, such as R&D stocks, technology, quality and marginal efficiency (Del Gatto et al. 2011).

A transformation into logarithms allows us to introduce a linear estimation of the following production function (with small letters representing logs):

$$y_{it} = \beta_0 + \beta_l l_{it} + \beta_k k_{it} + \beta_m m_{it} + v_{it} + \pi_{it} \qquad (2)$$

where β_0 captures the mean efficiency across firms over time, and the error term has two components: v_{it}, which represents the level of productivity of the firm, and π_{it}, the i.i.d.

component that is uncorrelated with input choices.[10] v_{it} is the key variable to be computed after having estimated the production function and solved for ω_{it} as the standard Solow residual:

$$\hat{\omega}_{it} = \hat{v}_{it} + \hat{\beta}_0 = y_{it} - \hat{\beta}_l l_{it} - \hat{\beta}_k k_{it} - \hat{\beta}_m m_{it} \quad (3)$$

Considering that $\hat{\omega}$ is observed by firms and influences their choice of inputs, making the error term correlated with the independent variables and rendering the coefficients of a standard OLS model biased, alternative methods to estimate TFP have been proposed in the literature, including fixed effects and system-GMM estimators (see Del Gatto et al. 2011; Van Beveren 2012 for reviews). More consistent approaches include those adopting semi-parametric estimators using proxies to correct for unobservable productivity shocks and the potential simultaneity bias in the choice of input levels. In what follows, we focus on the approach proposed by Olley and Pakes (1996), which controls not only for the simultaneity bias, but also for the potential selection bias resulting from the relationship between productivity shocks and the probability of firms exiting the market (which would bias the coefficient of capital downward if not properly accounted for). More specifically, the method of Olley and Pakes (1996) solves the simultaneity bias by using investment to proxy for unobserved time-varying productivity shocks, while the selection problems are addressed based on survival probabilities.

We estimate TFP separately for each industry, identified by its 2-digit ISIC code. Output is measured by value added (calculated as total sales minus costs), labour is set equal to the total number of employees, capital is the book value of fixed assets, and intermediate inputs are

[10] While both v_{it} and π_{it} are unobserved, the identification is grounded on the assumption that the former term is a state variable affecting the firm's decision-making process, while the latter, being either a measurement error or an unexpected shock to productivity, has no effect on the firm's decisions (Olley and Pakes, 1996, p. 1274).

proxied by the sum of all costs related to the materials used in the production process. Variables reported in monetary terms have been deflated using Ethiopia's GDP deflator, obtained from the IMF's World Economic Outlook database, with 2005 as the base year.

3. Regression results

First, we are interested in evaluating whether the relative productivity gap of female-owned firms that has been found in most existing studies is also present in our census data on Ethiopian manufacturing firms. We estimate regressions of the following form:

$$\widehat{\omega}_{it} = \gamma female_{it} + \eta' X_{it} + \delta_j + \theta_r + \lambda_t + \varepsilon_{it} \qquad (4)$$

where ω_{it} is log TFP; *female* is our variable of interest, i.e., a dummy identifying female ownership; X_{it} is a vector of control variables (see further); δ_j, θ_r, and λ_t are industry *j* dummies (based on the granular 4-digit ISIC revision 3 classification[11]), region *r* dummies (based on first-order administrative unit classification) and year *t* dummies, respectively; and ε_{it} is the error term. Standard errors are clustered at the firm level. Importantly, our identification strategy is based on within-industry variation in productivity according to the ownership of firms. Within-firm changes in ownership are relatively rare over the period considered and do not provide sufficient variation to properly interpret the effect of a switch from male to female ownership on productivity.[12] Hence our analysis will be mostly descriptive, documenting noteworthy correlations rather than presenting causal evidence.

[11] In practice, at this level of detail, we observe 44 industry categories in our regression samples.
[12] Only about 4% of firms switched from male to female ownership over time, according to our preferred definition.

3.1 Unconditional regression estimates

Table 2 summarises the results of a first set of unconditional regressions linking female ownership to TFP.

TABLE 2 HERE

The results are in line with extant evidence from other developing countries and show that, depending on the specification adopted, the productivity difference between female and male manufacturing firms in Ethiopia ranges from 13% to 40% (calculated as $e^{-0.140}$ - 1 and $e^{-0.513}$ - 1), with a gap of 25% ($e^{-0.292}$ - 1) in a specification including a full set of industry, region and year fixed effects.

The size of the productivity gap is sensitive to the exact definition of female ownership. In fact, the size of the estimated gap (of 25%) using our preferred definition of female ownership based on a majority (50% or more) share of firm capital lies in between the gap for a broader definition based on the presence of at least one woman among the owners (column 3; a gap of 13%), and the gap for the most restrictive definition, i.e., female ownership when all capital is held by women (column 4; a gap of 40%).[13] This is consistent with the relatively wide range of estimates found by other studies, and it seems to confirm that what really matters to identify differences in firm performance is the extent of decision-making power, rather than ownership

[13] Interestingly, using an alternative definition of female majority in ownership based on the number of owners results in an estimated coefficient that is very similar to the coefficient of our preferred (capital-based) female majority ownership measure (column 5; corresponding to an estimated gap of 24%).

per se (see also Aterido and Hallward-Driemeier 2011). While the distinction between ownership and decision-making is less meaningful for studies looking at microenterprises where the two concepts tend to overlap (de Mel et al. 2009; Bernhardt et al. 2017), it becomes more important when considering more structured firms like the ones we study here.

3.2 Conditional regression estimates and potential mechanisms

Having investigated the unconditional relation between female ownership and productivity, we now take the analysis further and try to improve our understanding of the origins of the observed gender productivity gap. First, we add a set of control variables likely to affect productivity levels that are typically used in heterogeneous firm models (Helpman et al. 2004). These include firm size, defined as the log number of total employees (*employees*); the age of the firm, i.e., the log number of years since its first establishment (*age*); capital intensity, measured as the log of the ratio of fixed assets to the number of employees (*cap intensity*); and two dummies controlling for the status of firms as *exporter* and/or *importer*. Second, we attempt a first exploration of the main mechanisms underlying the lower productivity of female-owned firms by interacting our female ownership dummy with a range of firm- and industry-specific factors.

The results of these additional regressions are reported in Table 3. All standard controls behave as expected, in accordance with the provisions of heterogeneous firm models (Helpman et al. 2004): older, larger, more capital-intensive and internationalised firms are marked by higher TFP. Most importantly, the existence of a gender-based productivity gap is again confirmed. As expected, the inclusion of firm-specific controls reduces the size of the gap, the estimated difference in productivity now being close to 12% ($e^{-0.125}$ - 1), but its statistical significance remains high.

TABLE 3 HERE

As demonstrated in Figure 1, the size of our estimated productivity gap compares well with what is found in previous studies, especially with studies involving large-scale, formal firms in other SSA countries.

FIGURE 1 HERE

In the remaining columns (2-7) of Table 3, we explore some of the potential mechanisms at work by adding selected interaction terms. To ease interpretation, we have demeaned variables before interacting them with the female ownership dummy; the coefficient of the dummy can thus be read as the partial correlation between female ownership and log TFP when the interaction variable is evaluated at its average value.

Starting from column 2, where female ownership is interacted with capital intensity, we find that the observed gender gap in productivity increases with the use of capital. Whereas at the average value of (log) capital intensity, the estimated productivity disadvantage of female-owned firms is about 14%, this rises to 24% when (log) capital intensity is increased with one sample standard deviation. This is in line with existing studies demonstrating lower returns to capital for female-owned firms (though all these studies look at household-based microenterprises; see, e.g., de Mel et al. 2008, 2009), and therefore a dimension that deserves more attention. Further results, reported in the remainder of this section and in section 4.1 on the decomposition analysis confirm and help to better qualify this finding.

In columns 3 and 4 we do not find any evidence of mechanisms linking the productivity gap to either the size of the firm or to their access to finance. Our proxy for the latter is a dummy (*interest*) taking the value of 1 if the firm reports positive values of interests paid (as in Shiferaw 2016, who uses the same census data). While we show that firms accessing finance tend to display higher productivity (of about 20%, compared to firms that do not employ credit), the interaction term (column 4) is not statistically significant. This implies that the use of credit neither amplifies nor attenuates productivity differences between male- and female-owned firms.

An important result is the one reported in column (5) where the role of female workers employed by the firm is considered (*female workers,* which measures the ratio of female to male workers within each firm). The interaction term appears to indicate that the productivity gap can partly be attributed to those female-owned firms employing a large share of female workers, a factor that in itself is also found to be negatively correlated with productivity. According to the estimates, a female-owned firm with an average ratio of female to male workers, about 0.6 in the full sample, is characterised by a productivity gap of less than 9%. If that ratio increases to 1, the gap is almost 13%. This result looks consistent with evidence reported by Hellerstein and Neumark (1999) on Israeli's manufacturing firms, but opposite to what Flabbi et al. (2016) find in a panel of Italian manufacturing firms. In their theoretical setting, Flabbi et al. (2016) claim that female executives are better at processing information on female workers, resulting in reduced discrimination (e.g., in wages) and, ultimately, improved firm performance (due to better matching of skilled female workers) when the share of female workers is higher. This does not seem to be the case in Ethiopia. Rather, our result likely derives from the clustering of female workers and owners in lower-productivity activities (Juhn et al. 2014; Kucera and Tejani 2014).

In column (6), an industry-level measure of labour intensity (*lab intensity*, constructed from our census data by calculating each 4-digit ISIC industry's share of total wages over capital) is interacted with female ownership. The positive coefficient of the interaction term is consistent with what we discussed above regarding firms' capital intensity (column 2), as it shows that the productivity disadvantage of female-owned firms tends to be attenuated in more labour-intensive industries.

A last finding from Table 3 relates to the role of competition. When we add a variable measuring competition at the sectoral and regional level by means of an Herfindahl index (*herfindahl*) for firms' sales, we do not see significantly different gender productivity gaps in more competitive markets (column 7); unlike what is suggested by some studies reporting greater aversion of female owners towards competition and risk (Niederle and Vesterlund 2007). Since this is another dimension deserving more attention, we have run a set of additional (probit) regressions looking at gender related differences in the probability of firm exit. The results, reported in Table A5 in the Appendix, show that the probability of exit of female-owned firms is not statistically different from the one of their male counterparts, even after conditioning on observable firm characteristics and accounting for a possible bias due to the use of a representative survey – rather than the usual census – in the year 2005. Further analysis complementing these findings on firm survival is reported in section 4.2.

Finally, results remain consistent if we employ different definitions of the dependent variable. When replacing TFP with labour or capital productivity, as we do in the estimates reported in Table 4, we find that in both cases female-owned firms exhibit a gap. Interestingly, and in line with the remainder of the paper, we find a larger average gap in terms of capital productivity (almost 17%, compared to an average labour productivity gap of less than 9%).

TABLE 4 HERE

4. Results on firm productivity distributions

In this section, we move beyond *average* gender gaps in firm productivity and analyse differences between the respective productivity *distributions* of male- and female-owned firms in our Ethiopian census data. We first apply the quantile decomposition approach developed by Firpo et al. (2007) to distinguish between composition and structural effects in explaining gender productivity gaps at different points of the overall distribution. Next, we employ the methodology developed by Combes et al. (2012) to conduct a formal comparison of the shift, dilation and truncation of productivity distributions between female- and male-owned firms. The two approaches complement each other. Whereas the Combes et al. (2012) approach adds structure to our analysis by testing for very specific and intuitive distributional differences between female and male owned firms' productivity, it may be less informative about potential channels driving such differences. The latter are more explicitly captured by the Firpo et al. (2007) approach, which compares the two distributions on the basis of differences in observable and non-observable factors.

4.1 Decomposition analysis

The decomposition method developed by Firpo et al. (2007) allows us to look at the productivity gap between male- and female-owned firms at different points in the productivity distribution and to identify how much of the gap can be explained by differences in observable characteristics or, alternatively, by differences in returns to those characteristics. Using their terminology, the former is labelled as the 'composition effect' and the latter as the 'structural effect'.

More specifically, this methodology generalises the standard Oaxaca-Blinder decomposition to different quantiles of the distribution, following a three-step procedure.[14] First, the productivity (log TFP) distribution of male-owned firms is reweighted so that the just-mentioned composition effect is controlled for. If we label this reweighted distribution as Ω_c and use Ω_m and Ω_f to indicate the original male and female distributions, this implies that the productivity gap between male- and female-owned firms, say at the median, can be written as:

$$\Delta_{0.5} = [\Omega_m(0.5) - \Omega_c(0.5)] - [\Omega_c(0.5) - \Omega_f(0.5)] \qquad (5)$$

where the first term represents the composition effect and the second term the structural effect, evaluated at the median. In a next step, 'recentered influence functions' (RIFs) are computed for each quantile of the three distributions Ω_m, Ω_f and Ω_c. As the name suggests, a RIF of a distributional statistic, such as a quantile, represents the influence an individual observation has on that distributional statistic and is constructed in such a way that its mean corresponds to the statistic of interest. More formally, in the case of quantiles:

[14] Our presentation of the methodology follows that of Nix et al. (2016).

$$RIF(\Omega; Q_\tau) = Q_\tau + \frac{\tau - I\{\omega \leq Q_\tau\}}{f_\Omega(Q_\tau)} \tag{6}$$

where I is an indicator function, f_Ω the marginal density of Ω, and Q_τ is the population τ^{th} quantile of the unconditional distribution Ω. Then, RIF quantile regression models are fitted, based on a specification similar to equation (4) in section 3 and also using OLS, but where the dependent variable is replaced by the corresponding RIF for the quantile of interest. Finally, in the third and last step, the gender-based firm productivity gap at each quantile is decomposed in a standard Oaxaca-Blinder fashion. For the median, we obtain:

$$\hat{q}_{0.5}(\Omega_m) - \hat{q}_{0.5}(\Omega_f) = \underbrace{\sum_j E[X_{j,m}](\hat{\eta}_{j,m} - \hat{\eta}_{j,c}) + R_{0.5}^S}_{\hat{\Delta}_S = structural\ effect} + \underbrace{\sum_j E[X_{j,m}]\hat{\eta}_{j,c} - \sum_j E[X_{j,f}]\hat{\eta}_{j,f} + R_{0.5}^C}_{\hat{\Delta}_C = composition\ effect} \tag{7}$$

where X and η represent the covariate vector and vector of coefficients as in equation (4), and the Rs are approximation errors due to the structural and composition effects (as the RIF regressions involve first-order approximations).

A more detailed and technical description of the methodology can be found in Firpo et al. (2007; 2009), whereas Nix et al. (2016) provide an application of the methodology to a research question similar to ours. This latter study shows that a significant part of the performance gap of female-owned microenterprises in four SSA countries can be explained by structural effects.

The main results of applying the decomposition analysis to our data are summarised in Figure 2. Figure 2 shows differences in firm productivity across gender, and decomposes them into composition and structural effects at each decile of the productivity distribution. It demonstrates that differences in productivity increase when moving towards the upper tails of the distribution (where female-owned firms are less represented), and that in the tails composition effects have the highest explanatory power. Conversely, structural effects are largely responsible for the productivity differences observed in the central part of the distribution, i.e., from the 3rd to the 6th decile. No clear differences among the two types of effects are observed in the bottom deciles.

FIGURE 2 HERE

The Firpo et al. (2007) approach also makes it possible to disentangle the contribution of the individual variables (see Table A6 in Appendix). Importantly, over the central quantiles of the distribution the role of capital appears to be crucial. Returns to capital account for most of the unobserved part of the productivity differences; often it is the only significant component of the structural effect. On the other hand, observable characteristics related to the size, capital intensity and internationalization of firms are the main factors accounting for the larger male-female productivity differences linked to the composition effect that we observe when moving towards the upper tails of the distribution.

4.2 Differences in productivity distributions

Combes et al. (2012) study the positive correlation between city size and firm productivity and present a quantile-based approach to discriminate empirically between two common explanations, i.e., firm selection and agglomeration economies. Supported by a theoretical model incorporating both firm entry/exit and between-firm interactions, they show that stronger firm selection in larger cities should result in a left truncation of the productivity distribution of firms active there; whereas stronger agglomeration effects should lead to a right-shifted and, if more productive firms are also better able to exploit such agglomeration economies, more dilated productivity distribution. Since making proper inference about relative shift, dilation and truncation by eye-balling the differences in shape of two distributions can be difficult, Combes et al. (2012) translate their theoretical framework into a quantile-based estimator that allows them to formally identify and test shift, dilation and truncation parameters.[15] It is this estimator that we transplant to our specific context. As pointed out by Kondo (2017), the Combes et al. (2012) quantile approach can be applied more generally, outside the fields of urban economics and economic geography, to compare any two (productivity) distributions.[16]

The main value added of the Combes et al. (2012) approach over the traditional regression results we presented in section 3 is that it provides additional insights beyond the average productivity gap of female-owned firms based on very specific distributional parameters. For example, are productivity gaps systematically observed over the whole distribution, and/or are they reinforced by differences between the top-performing female- and male-owned firms? And to what extent are productivity gaps also explained by gender differences in the relative heterogeneity of firms? Unlike the decomposition methodology of Firpo et al. (2007), which considers the influence of covariates at different quantiles of the distribution, the Combes et al. (2012) methodology summarises the differences in productivity distributions of male- and

[15] In general terms, the estimation approach minimises the errors in matching the quantiles of the two distributions concerned and relies on a two-step-iterated numerical optimization (with iterations over the truncation parameter and over combinations of the shift and dilation parameters). For more technical details, see Combes et al. (2012) and Kondo (2017).

[16] That notwithstanding, most papers employing the Combes et al. (2012) methodology stay close to the original set-up of comparing firm productivity between larger and small cities (see, e.g., Kondo 2016). We are not aware of other studies using it to compare firm productivity along gender dimensions.

female-owned firms in three intuitive transformation parameters (shift, dilation and truncation), thus providing a complementary perspective.

To better understand the gist of Combes et al.'s (2012) approach, let us consider two cumulative distributions, F_f for female-owned firms and F_m for male-owned firms, with some common underlying distribution F. Further assume that F_f (F_m) can be obtained by shifting F rightward by a constant A_f (A_m), dilating F by a factor D_f (D_m), and left-truncating a share S_f (S_m) ϵ [0, 1[of F; or mathematically:

$$F_f(\omega) = max\left\{0, \frac{F\left(\frac{\omega - A_f}{D_f}\right) - S_f}{1 - S_f}\right\}$$

and (8)

$$F_m(\omega) = max\left\{0, \frac{F\left(\frac{\omega - A_m}{D_m}\right) - S_m}{1 - S_m}\right\}$$

where ω again stands for productivity or, more specifically, log TFP. Moreover, if we define $D \equiv \frac{D_f}{D_m}$, $A \equiv A_f - DA_m$, and $S \equiv \frac{S_f - S_m}{1 - S_m}$, then it is relatively straightforward to show that the following relationship between F_f and F_m holds[17]:

[17] The simple proof of this relation can be found in Appendix C of Combes et al. (2012, p. 2589-90).

$$F_f(\omega) = max\left\{0, \frac{F_m\left(\frac{\omega - A}{D}\right) - S}{1 - S}\right\} \; if \; S_f > S_m$$

$$F_m(\omega) = max\left\{0, \frac{F_f(D\omega + A) - \frac{-S}{1-S}}{1 - \frac{-S}{1-S}}\right\} \; if \; S_f < S_m \tag{9}$$

This relation indicates that one distribution, say F_f, can be obtained as a transformation of the other, say F_m, without having to specify the common underlying distribution F. Combes et al. (2012) translate the above expressions in quantile functions that can be estimated to derive parameters A, D, and S, i.e., respectively, the relative shift, relative dilation, and relative left truncation that need to be applied to F_m to approximate F_f.

Given our previous regression results on the average productivity gap, we expect the TFP distribution of female-owned firms to be *left*-shifted relative to the male distribution ($A<0$). Besides such a general productivity disadvantage, we may also expect relatively stronger homogeneity in productivity among female firms, due to their concentration in lower-productivity industries, their smaller scale and lower capital intensity. Ceteris paribus, this should be reflected in a less dilated TFP distribution for female- than for male-owned firms ($D<1$). Finally, we do not have very strong priors on the relative truncation parameter, especially since we do not find significant gender differences in firm exit (cf. Appendix Table A5).

Table 5 presents the parameters for relative shift (A), dilation (D) and truncation (S) for the female- vs. male-owned firm productivity distributions, estimated using Combes et al.'s (2012) quantile approach.[18] Productivity is here defined as log TFP averaged for each firm over the available (maximum 7) years of data. The reported standard errors are obtained using 500 bootstrap replications and significance is based on two-sided z-tests of the respective null hypotheses that A=0, D=1, and S=0.[19]

TABLE 5 HERE

As can be seen in the first row of Table 5, when we consider our full sample of female- and male-owned firms we find a negative value for A of about -0.140, which is also highly significant. This means that to move from the male to the female average TFP distribution one needs to shift the former distribution leftwards (cf. Figure 3) and, on its own (without considering dilation and truncation), implies a decrease in mean productivity of just over 13% ($e^{-0.140}$ - 1). Moreover, in the full sample, D<1, meaning that the female firms' TFP distribution is less dilated than the male distribution. This is a relevant property, since it reflects the relative homogeneity of female-owned firms, which appear to be less likely to succeed in achieving high productivity than male firms. Finally, we also find evidence of some (statistically significant but economically small) truncation differences in the full sample. More specifically,

[18] As in Combes et al. (2012), we trim the extreme (bottom/top 1%) values of firm-level TFP, separately for female- and male-owned firms, to obtain more reliable and unbiased estimates of the parameters A, D and S.

[19] To produce these results, we have used the *estquant* command in Stata developed by Kondo (2017). As a robustness check, we have also performed the same analysis using the original SAS code of Combes et al. (2012). Both codes yield nearly identical point estimates for A, D and S. However, the latter requires much longer computational time for larger numbers of bootstrap iterations. To deal with the small subsample of female firms (about 250), bootstrap sampling is stratified on the gender of ownership and bootstrap samples where less than 50% of the original female firms are represented are discarded. This ensures that our bootstrap samples include a sufficient number of unique female firms. Further stratification of bootstrap sampling on sectors or regions is employed in view of large sectoral/regional heterogeneity in productivity. See notes below Table 5 for details. As in Combes et al. (2012), we also report in Table 5 a measure of explanatory power, which is calculated as

$$R^2 = 1 - \frac{M(\hat{A}, \hat{D}, \hat{S})}{M(0,1,0)}$$

where M is the criteria function minimised by Combes et al.'s (2012) estimator. In other words, this pseudo R^2 indicates how much of the mean-squared quantile difference between the female and male firm productivity distributions is explained by the three parameters.

we uncover an S<0, suggesting that, overall, female firms are somewhat more likely to stay in the market even at lower productivity levels, compared to male firms. While it is not possible to identify the exact underlying mechanisms with the data at hand, one possible interpretation could be a relatively more cautious approach to business by female owners (Niederle and Vesterlund 2007). Another interpretation is that the high gender discrimination in the Ethiopian labour market perhaps provides an extra incentive for women to keep running their own businesses, even when they are comparatively unproductive.

FIGURE 3 HERE

Overall, these results very well complement and further qualify those of the decomposition analysis, especially for what concerns the tails of the distribution. In Table A7 in the Appendix we report some descriptive statistics on the firms populating the top and bottom 10% of the overall productivity distribution differentiating by gender of the owners. Male- and female-owned firms at the bottom of the productivity distribution look relatively similar as far as main endowments are concerned. This is consistent with the moderate compositional effects at the first decile we observe in Figure 2. Two notable exceptions are that female-owned firms employ much more female workers and that they are operating at a lower scale of activity. At the top 10% of the distribution, on the contrary, marked gender differences are observed in almost all observable firm characteristics, including in the number of employees, capital endowments and internationalization status, again consistent with the findings of the decomposition analysis (cf. Figure 2). The few female-owned firms that do make it to the top 10% of most productive firms, do so in spite of large differences in the observables. The very small number of such 'outstanding' female-owned firms likely explains part of the lower distribution dilation (relative to male-owned firms) that we have documented using the Combes et al. (2012) approach.

4.2.1 Further results based on differences in productivity distributions

The second row of Table 5 shows our estimates for the three transformation parameters of the TFP distributions when considering only firms based in the neighbourhood of the capital, Addis Ababa (cf. Figure A2 in Appendix). Our choice to look into Addis Ababa separately is motivated by the very strong presence of manufacturing firms in the Addis region (about half of our sample) and by the literature emphasizing the specific productivity advantages of being located in larger agglomerations (e.g., Combes et al. 2012; Kondo 2016), including in SSA (Sanfilippo and Seric 2016).[20] The relative left shift in the female productivity distribution is economically more significant in Addis Ababa than in the full sample (implying a 26% lower TFP at the mean) and also the lower dilation is again clear. On the other hand, however, the truncation parameter is no longer statistically significant. We thus conclude that there are no strong survival differences between Addis Ababa-based female- and male-owned firms.

In rows 3 and 4 of Table 5, we list our results for the TFP distributions of firms operating within the food processing and mineral products industries, respectively (cf. Figures A3 and A4 in Appendix). These are two manufacturing industries where female owned-firms are relatively well represented, even if female-owned firms in no way dominate these industries (see the last

[20] For the specific case of Ethiopia, Rijkers et al. (2010) carry out a rural–urban comparison of manufacturing firms and find that the benefits associated with agglomeration are ‘concavely’ related to city sizes. They argue that firms in remote rural areas are much less productive than firms located elsewhere, but fail to uncover big productivity differences between rural towns and major urban areas. On the other hand, Siba et al. (2012) study the effect of firm clustering on output prices and productivity in Ethiopia and find a positive and statistically significant relationship between the density of firms that produce a given product and productivity.

column of Table 5 as well as Table A4).[21] As in the full sample, we again observe, in both sectors, relative left shifts and lower dilation for the female versus male firm productivity distributions. Yet, there is considerable heterogeneity, as the shift is particularly strong for the labour-intensive food processing industry, while dilation (and, to a lesser extent, truncation) is most evident in the mineral products sector. The finding that male-owned firms on average outperform female-owned firms also within these two sectors (especially so in food processing) could have various reasons. It may be due, for instance, to an engagement in different, more profitable or capital-intensive subsector activities: in the food processing industry, female-owned business are almost exclusively bakeries, whereas male-owned firms are also flour and edible oil manufacturers; within mineral products, female firms produce mostly concrete, while male firms produce mostly concrete and 'other non-metallic' products.

Finally, we perform two additional exercises on the full sample: we regress log TFP on either (i) 4-digit ISIC industry dummies or (ii) industry dummies, firm size (log number of employees) and capital intensity, and then apply the Combes et al. (2012) approach to the regression residuals. The results are shown in rows 5 and 6 of Table 5 (cf. also Figures A5 and A6 in Appendix). We again find a significant relative left shift of the female firms' productivity distribution, moreover one that is economically larger than in the unconditional full-sample estimates of row 1. The earlier truncation differences disappear. And, interestingly, once sectoral composition is controlled for, the productivity distribution of female firms is actually slightly *more* dilated than that of their male counterparts (i.e., D>1). This seems to suggest that

[21] Despite the over-representation of female-owned firms in these sectors, there are also many male-owned firms found there, not only as a share of all male-owned firms (cf. Table A4) but also in absolute terms (with still many more male-owned than female-owned firms operating in these sectors, in fact). In other words, even if female business owners are heavily concentrated in these sectors (representing more than 60% of all female-owned firms), food processing and mineral product production are not 'dominated' by female-owned firms.

the relative homogeneity (smaller dispersion) in female firms' productivity overall relates to their concentration in certain lower-productivity sectors.

5. Concluding remarks

In this paper, we have investigated whether and how productivity differs between female- and male-owned firms in Ethiopia. Using census data on manufacturing firms over the 2003-2009 period, we provide robust evidence of a productivity disadvantage for female-owned firms, which can be plausibly linked to factors such as their size, endowments (of capital in particular), differences in returns to those endowments (again, primarily returns to capital), and specialization/sorting into less productive sub-sectors.

Our findings underline the importance of moving beyond standard analysis based on the average productivity gap. The various methodologies we apply demonstrate how there might be different gaps, diverse mechanisms leading to them, and hence different explanations for their existence. For instance, based on formal comparisons of productivity distributions, we show that one important mechanism underlying the gender-based firm productivity gap is a higher homogeneity in terms of productivity, coupled with the relative lack of highly productive female-owned firms.

One issue that also emerges from our distributional analyses is that, whereas much of the gaps recorded at the upper tail of the productivity distribution seems to be linked to observed firm-level characteristics such as firm size and capital intensity, non-negligible productivity differences found in the more central part of the distribution tend to derive from other factors, in particular returns to capital, that are more difficult to capture with our data. Further research, including more in-depth, qualitative work, is therefore needed to get a fuller understanding of the key factors explaining the performance gaps of female-owned firms in Ethiopia.

Still, we believe our findings so far provide valuable policy lessons for a country like Ethiopia, currently embarked on a process of structural transformation, in which productivity growth in the manufacturing sector will be crucial. The literature on resource misallocation shows that persistent productivity gaps across manufacturing firms result in lower aggregate productivity (Hsieh and Klenow 2009), suggesting that there are gains to be made from shutting down unproductive firms and reallocating their resources to other, more productive firms. In our context, bluntly applying such logic of improving allocative efficiency would imply leaving many female-owned firms behind. However, the promotion of an active role for women as decision makers and owners of economic resources, including through the encouragement of female-owned firms, seems an important goal in itself and a key ingredient of any inclusive, broad-based process of structural transformation. Supporting female-owned firms while limiting the cost of allocative inefficiencies, requires a deeper understanding of the extent, nature and origins of their productivity gaps vis-à-vis male-owned firms. This is indeed what the current paper attempts to contribute to. Above all, our paper demonstrates that in Ethiopia heterogenous forces are at work behind the average male-female firm productivity gap. Arguably, closing productivity gaps that relate to the limited use of capital or smaller firm size will require different kinds of interventions than addressing gaps that result from lower returns to capital, or yet another source, such as the concentration in particular sub-sectors. It also makes a difference whether one targets a much-constrained female-owned firm at the lower end of the productivity distribution or, alternatively, a moderately productive firm that misses some key inputs to really stand out. We hope future research will shed further light on the various mechanisms this paper has briefly documented, in order to inform the design of appropriate policy packages.

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TABLE 1— BASIC CHARACTERISTICS OF FIRMS, BY OWNERSHIP

Variable	**Male-owned**	**Female-owned**
Number of employees	86.116	35.679
Sales (log)	13.849	13.045
Value added (log)	13.776	12.958
Fixed assets to number of employees (log)	9.401	8.894
Female/male workers (ratio)	0.566	0.816
Female/male skilled workers (ratio)	0.545	0.824
Exporter (dummy)	0.0504	0.018
Importer (dummy)	0.676	0.595

***Source*:** Authors' elaborations on CSA manufacturing census data.

TABLE 2—RESULTS, UNCONDITIONAL OLS REGRESSIONS

VARIABLES	(1) 50% female ownership of capital	(2) 50% female ownership of capital	(3) Any women among owners	(4) 100% female ownership of capital	(5) 50% women among owners
female	-0.213**	-0.292***	-0.140***	-0.513***	-0.280***
	(0.104)	(0.0676)	(0.0464)	(0.0926)	(0.0681)
Constant	10.19***	10.21***	10.24***	10.21***	9.994***
	(0.0502)	(0.0767)	(0.0776)	(0.0769)	(0.0801)
Observations	7,727	7,726	7,726	7,726	6,811
R-squared	0.001	0.655	0.654	0.657	0.632
Industry fixed effects	NO	YES	YES	YES	YES
Region fixed effects	NO	YES	YES	YES	YES
Year fixed effects	NO	YES	YES	YES	YES

Notes: *** p<0.01, ** p<0.05, * p<0.1. Standard errors are clustered at the firm level. Dependent variable is log TFP. Independent variable of interest is a dummy taking a value 1 if female-owned capital is larger than 50% of total in columns (1)-(2); a dummy taking a value 1 if there is at least 1 woman among the owners in column (3); a dummy taking a value 1 if female-owned capital is 100% in column (4); and a dummy taking a value 1 if there is a majority (50%) of women among the owners of the firm in column (5).

TABLE 3—RESULTS, OLS REGRESSIONS WITH CONTROLS AND INTERACTION TERMS

VARIABLES	(1) baseline	(2) Interaction with capital intensity	(3) Interaction with firms' size	(4) Interaction with access to finance	(5) Interaction with share of female workers	(6) Interaction with industry's labour intensity	(7) Interaction with competition
female	-0.125**	-0.154**	-0.115*	-0.122	-0.0911	-0.124**	-0.120*
	(0.0615)	(0.0647)	(0.0586)	(0.0762)	(0.0629)	(0.0544)	(0.0614)
age	0.103**	0.101**	0.104**	0.103**	0.0745*	0.110***	0.111***
	(0.0413)	(0.0412)	(0.0412)	(0.0411)	(0.0415)	(0.0383)	(0.0414)
employees	0.392***	0.390***	0.389***	0.370***	0.404***	0.384***	0.395***
	(0.0224)	(0.0222)	(0.0220)	(0.0228)	(0.0226)	(0.0202)	(0.0225)
cap intensity	0.0547***	0.0689***	0.0550***	0.0473***	0.0504***	0.0520***	0.0558***
	(0.0120)	(0.0132)	(0.0119)	(0.0120)	(0.0118)	(0.0113)	(0.0120)
exporter	0.342***	0.342***	0.344***	0.353***	0.329***	0.341***	0.360***
	(0.111)	(0.110)	(0.111)	(0.111)	(0.110)	(0.106)	(0.111)
importer	0.271***	0.268***	0.270***	0.265***	0.267***	0.245***	0.265***
	(0.0424)	(0.0423)	(0.0423)	(0.0421)	(0.0422)	(0.0402)	(0.0424)
female*cap intensity		-0.0563**					
		(0.0228)					
female*employees			0.0281				
			(0.0703)				
female*interest				-0.000862			
				(0.113)			
interest				0.185***			
				(0.0399)			
female*female workers					-0.109**		
					(0.0512)		
female workers					-0.0683**		
					(0.0328)		
female*labintensity						0.143**	
						(0.0682)	
lab intensity						-0.238***	
						(0.0654)	
female*herfindahl							0.157
							(0.206)
herfindahl							-0.407***
							(0.102)
Constant	7.887***	8.407***	9.175***	7.961***	7.947***	7.971***	7.904***
	(0.175)	(0.130)	(0.181)	(0.176)	(0.174)	(0.169)	(0.176)
Observations	7,546	7,546	7,546	7,546	7,530	7,544	7,546
R-squared	0.719	0.720	0.719	0.721	0.722	0.751	0.720

Notes: *** p<0.01, ** p<0.05, * p<0.1. Standard errors are clustered at the firm level. Dependent variable is log TFP. All regressions include industry, region and year fixed effects. Apart from the interest payments dummy (*interest*), variables interacted with female ownership have been first demeaned.

TABLE 4— RESULTS, OLS REGRESSIONS WITH ALTERNATIVE PRODUCTIVITY MEASURES

VARIABLES	(1) Labour productivity	(2) Capital productivity
female	-0.0909*	-0.182**
	(0.0528)	(0.0740)
age	0.208***	0.166***
	(0.0416)	(0.0560)
employees	0.0636***	-0.00465
	(0.0204)	(0.0235)
cap intensity	0.197***	-0.556***
	(0.0127)	(0.0277)
exporter	0.152	0.0282
	(0.0969)	(0.112)
importer	0.244***	0.219***
	(0.0404)	(0.0581)
Constant	7.616***	5.694***
	(0.179)	(0.322)
Observations	7,725	7,700
R-squared	0.441	0.449

Notes: *** p<0.01, ** p<0.05, * p<0.1. Standard errors are clustered at the firm level. Dependent variable in column 1 is the log of labour productivity (the ratio of sales to employment) and in column 2 the log of capital productivity (the ratio of sales to capital). All regressions include industry, region and year fixed effects.

TABLE 5—RESULTS, COMPARISON OF PRODUCTIVITY DISTRIBUTIONS

#	Category/sector	Shift (A)	Dilation (D)	Truncation (S)	R^2	Obs.	% female-owned firms
1	Female-owned vs male-owned, full sample	-0.140***	0.855***	-0.0115***	0.867	2465	10.14%
		(0.0089)	(0.0037)	(0.0012)			
2	Female-owned vs male-owned, Addis Ababa only	-0.306***	0.872***	0.00213	0.902	998	13.63%
		(0.0126)	(0.0049)	(0.0012)			
3	Female-owned vs male-owned, food and beverages sector only (ISIC 15)	-1.232***	0.973	0.00425	0.990	561	16.22%
		(0.1525)	(0.0676)	(0.0886)			
4	Female-owned vs male-owned, mineral products sector only (ISIC 26)	-0.105***	0.857***	-0.0174*	0.500	682	13.64%
		(0.0165)	(0.0207)	(0.0083)			
5	Female-owned vs male-owned, full sample (Residual distribution, controlling for sectors)	-0.386***	1.098***	0.00442	0.894	2465	10.14%
		(0.0152)	(0.0205)	(0.0039)			
6	Female-owned vs male-owned, full sample (Residual distribution, controlling for sectors, number of employees and capital intensity)	-0.226***	1.102***	-0.00345***	0.949	2446	10.14%
		(0.0065)	(0.0043)	(0.0010)			

Notes: *** p<0.01, ** p<0.05, * p<0.1.Results are based on the quantile approach developed by Combes et al. (2012) (see main text) and use average log TFP as productivity measure. Bootstrapped standard errors (using 500 replications) in parentheses. Bootstrap sampling is stratified on gender of ownership and on either sector (lines 1 and 2) or region (lines 3, 4, 5 and 6) and uses only samples where at least 50% of the original female-owned firms are represented.

Appendix

TABLE A1—CENSUS FIRMS' SHARE OF TOTAL NUMBER OF FIRMS, EMPLOYMENT AND VALUE ADDED IN 2008, BY INDUSTRY

		Number of firms		Persons engaged		Value added	
Industry	**ISIC rev. 3**	**Total (N)**	**% census firms**	**Total (N)**	**% census firms**	**Total (mln birr)**	**% census firms**
Food*	15	25073	1.93%	116452	35.79%	4416.09	87.84%
Tobacco	16	1	100%	1254	100%	344.34	100%
Texiles	17	1391	1.80%	14887	81.25%	215.89	90.91%
Wearing apparel	18	3136	1.24%	14225	53.67%	175.28	65.44%
Leather, footwear	19	129	64.34%	8817	98.11%	367.92	99.60%
Wood and cork	20	160	43.75%	3581	90.23%	57.24	94.63%
Paper and printing	21-22	901	15.87%	10668	83.81%	478.91	98.43%
Chemicals	24	86	93.02%	7815	99.53%	531.37	99.96%
Rubber and plastic	25	82	100%	8751	100%	446.03	100%
Other non-metallic mineral	26	945	51.64%	20185	87.62%	1764.04	96.81%
Basic iron and steel	27	15	100%	1329	100%	280.16	100%
Fabricated metal products	28	4456	2.27%	20538	25.50%	620.66	71.31%
Machinery and equipment	29	4	100%	206	100%	9.35	100%
Motor vehicles	34	15	100%	1727	100%	168.45	100%
Furniture; Manufacturing n.e.c.	36	8874	3.37%	42189	17.71%	440.29	36.89%
Total		**45268**	**4.26%**	**272624**	**49.03%**	**10316.03**	**88.93%**

***Source*:** Authors' elaborations on CSA manufacturing census data and CSA (2010)
Notes: Industries are here reported at the 2-digit level of the ISIC classification (revision 3). Industries 30-31 are not reported by CSA official documents given the very small number of firms covered. *The food sector includes grain mills.

TABLE A2—DISTRIBUTION OF FIRMS PER YEAR, BY OWNERSHIP

Year	**Number of firms**	**% female owned**
2003	795	12.70%
2004	857	13.42%
2005	715	9.79%
2006	1,007	11.92%
2007	1,206	11.86%
2008	1,577	12.43%
2009	1,792	12.22%

Source**:** Authors' elaborations on CSA manufacturing census data.
Notes: In 2005 (Ethiopian year 1997), the Census was run as a representative survey. Ownership based on whether or not female-owned capital is larger than 50% of total.

TABLE A3—DISTRIBUTION OF FIRMS BY REGION AND OWNERSHIP (% OF TOTAL)

	Male-owned	**Female-owned**	**All**
Tigray	10.25	4.47	9.55
Afar	0.52	0.42	0.50
Amhara	9.36	9.24	9.35
Oromia	16.94	14.75	16.67
Somali	0.59	0.31	0.55
Benshangul	0.23	0.10	0.21
S.N.N.P.R.*	11.11	5.71	10.46
Gambela	0.24	0.52	0.28
Harari	1.26	2.18	1.37
Addis Ababa	47.69	59.92	49.17
Dire Dawa	1.82	2.39	1.89

Source: Authors' elaborations on CSA manufacturing census data.
Notes: * SNNPR stands for Southern Nations, Nationalities and Peoples. Ownership based on whether or not female-owned capital is larger than 50% of total.

TABLE A4—DISTRIBUTION OF FIRMS BY INDUSTRY AND OWNERSHIP (% OF TOTAL)

ISIC rev. 3	Industry	Male-owned	Female-owned	Total
15	Manufacturing of food products and beverages	24.41	34.85	25.68
26	Manufacturing of other non-metallic mineral products	18.91	26.24	19.80
22	Publishing, printing and reproduction of recorded media	6.18	8.51	6.47
36	Manufacturing of furniture; manufacturing n.e.c.	15.93	8.09	14.98
20	Manufacturing of wood and of products of wood and cork, except furniture	2.06	3.53	2.24
25	Manufacturing of rubber and plastics products	5.11	3.53	4.92
19	Tanning and dressing of leather; manufacturing of luggage, handbags, saddlery, harness and footwear	5.97	3.11	5.62
28	Manufacturing of fabricated metal products, except machinery and equipment	6.40	3.11	6.00
24	Manufacturing of chemicals and chemical products	5.21	2.70	4.91
17	Manufacturing of textiles	2.93	2.28	2.86
18	Manufacturing of wearing apparel; dressing and dyeing	2.69	1.45	2.54
29	Manufacturing of machinery and equipment n.e.c.	0.46	1.14	0.54
21	Manufacturing of paper and paper products	1.06	1.04	1.06
27	Manufacturing of basic metals	1.17	0.21	1.06
34	Manufacturing of motor vehicles, trailers and semi-trailers	1.26	0.21	1.13
16	Manufacturing of tobacco products	0.10	0.00	0.09
30	Manufacturing of office, accounting and computing machinery	0.01	0.00	0.01
31	Manufacturing of electrical machinery and apparatus	0.11	0.00	0.11

Source: Authors' elaborations on CSA manufacturing census data.

Notes: Industries are here reported at the 2-digit level of the ISIC classification (revision 3), but are originally at the 4-digit level in the data. Ownership based on whether or not female-owned capital is larger than 50% of total.

TABLE A5— RESULTS, PROBIT REGRESSIONS FOR FIRM EXIT

VARIABLES	(1) Exit	(2) Exit (excl. 2005)	(3) Exit	(4) Exit (excl. 2005)
female	0.0582	0.0785	0.0698	0.0873
	(0.0570)	(0.0600)	(0.0658)	(0.0705)
tfp			-0.0449**	-0.0384*
			(0.0191)	(0.0212)
age			-0.401***	-0.407***
			(0.0548)	(0.0596)
employees			-0.147***	-0.143***
			(0.0250)	(0.0269)
cap intensity			-0.0319***	-0.0364***
			(0.0108)	(0.0120)
exporter			0.0277	-0.0333
			(0.167)	(0.179)
importer			-0.0342	-0.0342
			(0.0581)	(0.0616)
Constant	-1.237***	-1.255***	0.902	-2.885***
	(0.0213)	(0.0225)	(0.550)	(0.322)
Observations	7,949	7,234	5,730	5,034
Industry FE	NO	NO	YES	YES
Region FE	NO	NO	YES	YES
Year FE	NO	NO	YES	YES

Notes: *** p<0.01, ** p<0.05, * p<0.1. Standard errors are clustered at the firm level. The dependent variable is a dummy variable taking value of 1 if the firm leaves the sample, and 0 otherwise. The samples of the estimations in columns 2 and 4 exclude 2005, since in that year a representative survey was run instead of the full census.

TABLE A6 —RESULTS, EFFECTS OF FIRM CHARACTERISTICS ON THE PRODUCTIVITY GAP, BY QUANTILE Q

Composition effects	q10	q20	q30	q40	q50	q60	q70	q80	q90
age	0.005	0.000	-0.000	-0.001	-0.000	-0.000	-0.001	-0.002	-0.003
	(0.007)	(0.003)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.004)	(0.005)
employees	-0.090***	-0.091***	0.120***	0.136***	0.151***	0.203***	0.229***	0.251***	0.273***
	(0.034)	(0.028)	(0.014)	(0.015)	(0.017)	(0.021)	(0.024)	(0.026)	(0.031)
cap intensity	0.003	0.016	0.018*	0.032***	0.047***	0.058***	0.123***	0.097***	0.096***
	(0.013)	(0.011)	(0.010)	(0.011)	(0.014)	(0.016)	(0.024)	(0.021)	(0.021)
exporter	0.016*	0.023**	-0.011***	-0.008***	-0.005	-0.002	0.009	0.033***	0.100***
	(0.009)	(0.011)	(0.003)	(0.003)	(0.004)	(0.005)	(0.006)	(0.009)	(0.019)
importer	-0.021	-0.033***	0.019***	0.024***	0.027***	0.026***	0.015**	0.013*	0.018*
	(0.014)	(0.012)	(0.006)	(0.007)	(0.008)	(0.008)	(0.007)	(0.007)	(0.010)
total	0.125*	0.113**	-0.133***	-0.093*	-0.016	0.097	0.219**	0.365***	0.502***
	(0.071)	(0.056)	(0.046)	(0.057)	(0.075)	(0.094)	(0.092)	(0.080)	(0.084)
Structural effects									
age	0.942**	0.048	-0.516	-0.734**	-1.020**	-0.746	-0.735	-0.591	0.467
	(0.399)	(0.353)	(0.333)	(0.352)	(0.412)	(0.469)	(0.513)	(0.550)	(0.577)
employees	-0.234	-0.249	0.203	0.060	0.011	-0.000	-0.099	-0.637*	-0.324
	(0.253)	(0.212)	(0.176)	(0.192)	(0.221)	(0.251)	(0.284)	(0.327)	(0.441)
cap intensity	-0.044	-0.279	0.352*	0.479**	0.316	0.697**	1.594***	0.922**	1.077**
	(0.218)	(0.187)	(0.180)	(0.207)	(0.231)	(0.278)	(0.364)	(0.380)	(0.513)
exporter	-0.011	-0.027*	0.005	0.003	0.006	0.005	0.011	0.023	0.007
	(0.013)	(0.015)	(0.004)	(0.005)	(0.006)	(0.007)	(0.010)	(0.017)	(0.022)
importer	0.027	0.115	-0.121	-0.044	0.006	0.060	-0.015	-0.004	0.209
	(0.115)	(0.091)	(0.083)	(0.090)	(0.108)	(0.111)	(0.123)	(0.130)	(0.171)
total	-0.026	-0.020	0.198***	0.255***	0.177**	0.159*	0.130	0.107	0.052
	(0.091)	(0.065)	(0.060)	(0.063)	(0.072)	(0.083)	(0.091)	(0.093)	(0.110)
N	7,546	7,546	7,546	7,546	7,546	7,546	7,546	7,546	7,546

Notes: *** p<0.01, ** p<0.05, * p<0.1. Results are based on the Firpo et al. (2007) quantile decomposition method described in the main text (section 4.1). Industry, region and year dummies are included in the estimations but their coefficients are not reported for reasons of space.

TABLE A7—AVERAGE CHARACTERISTICS OF FIRMS AT THE BOTTOM/TOP OF THE PRODUCTIVITY DISTRIBUTION

	Bottom 10%			**Top 10%**		
	Female-owned	**Male-owned**	**Fem/Male**	**Female-owned**	**Male-owned**	**Fem/Male**
Number of employees	19.2	28.5	0.68	102.0	318.4	0.32
Female/male workers	1.1	0.5	2.23	0.4	0.5	0.70
Female/male skilled workers	0.7	0.4	1.61	0.6	0.4	1.39
Female/male unskilled workers	1.2	0.6	2.01	0.3	0.8	0.40
Wage per worker (birr)	2937.9	4249.8	0.69	10367.8	9955.9	1.04
Acces to credit (y/n)	0.2	0.2	0.91	0.5	0.5	0.90
Fixed assets to employees (birr)	29505.7	29601.6	1.00	96320.8	111581.4	0.86
Exporter (y/n)	0.0	0.0	..	0.1	0.3	0.30
Importer (y/n)	0.5	0.6	0.79	0.6	0.6	0.97
Sales (birr)	509578.3	886987.2	0.57	18900000	48600000	0.39
Value added (birr)	442123.5	658005.3	0.67	20300000	48400000	0.42
Largest 3 industries (% on total firms)	57.1%	69.4%	0.82	67.8%	49.0%	1.38
Based in Addis	36.5%	59.7%	0.61	28.8%	38.0%	0.76
Observations	77	696	0.11	59	714	0.08

***Source*:** Authors' elaborations on CSA manufacturing census data.

FIGURE A1 HERE

FIGURE A2 HERE

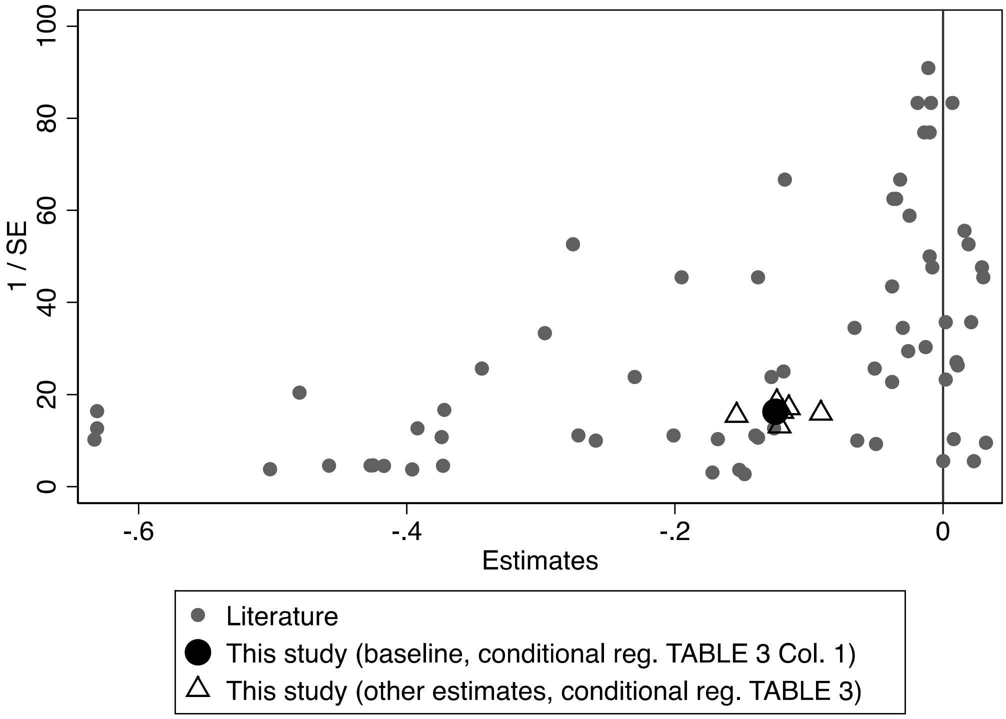
FIGURE A3 HERE

FIGURE A4 HERE

FIGURE A5 HERE

FIGURE A6 HERE

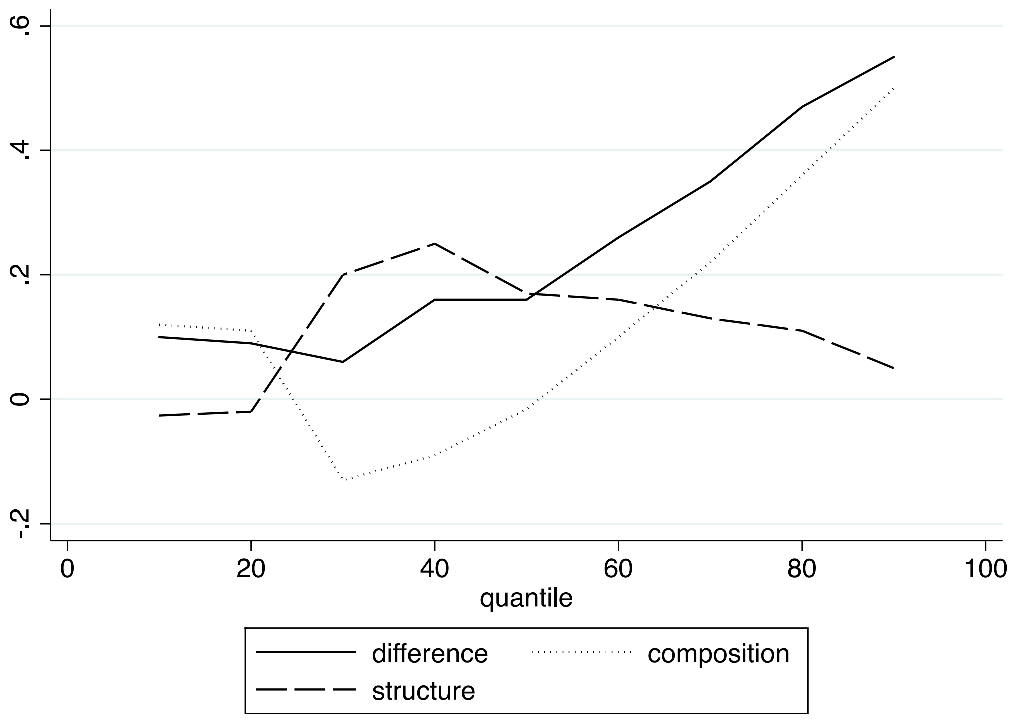
FIGURE 1. FUNNEL PLOT OF COEFFICIENT ESTIMATES AND PRECISION FOR THIS AND RELEVANT OTHER STUDIES



Notes: A 'funnel plot' is commonly employed in the meta-analysis literature, to see how estimates compare across studies (see, e.g., Egger et al. 1997). It serves as a visual aid to detect (publication) bias or systematic heterogeneity across different studies. Here the horizontal axis represents the coefficient of 'female ownership', capturing the estimated productivity gap between male- and female-owned firms. The vertical axis represents the inverse of the standard error of the corresponding coefficient, a measure of the precision of the estimate. The graph compares our baseline estimate of the female ownership coefficient from the conditional regression in Table 3, column 1 (and other Table 3 estimates of the coefficient) with estimates in similar studies. The graph shows that most studies report negative coefficients, implying that female-owned firms are, on average, less productive than male-owned firms. The other studies included in this graph are Jones (2012), Aterido and Hallward-Driemeier (2011), Bardasi et al. (2011), Rijkers et al. (2010), and Sabarwal and Terrell (2008) (cf. section 1).

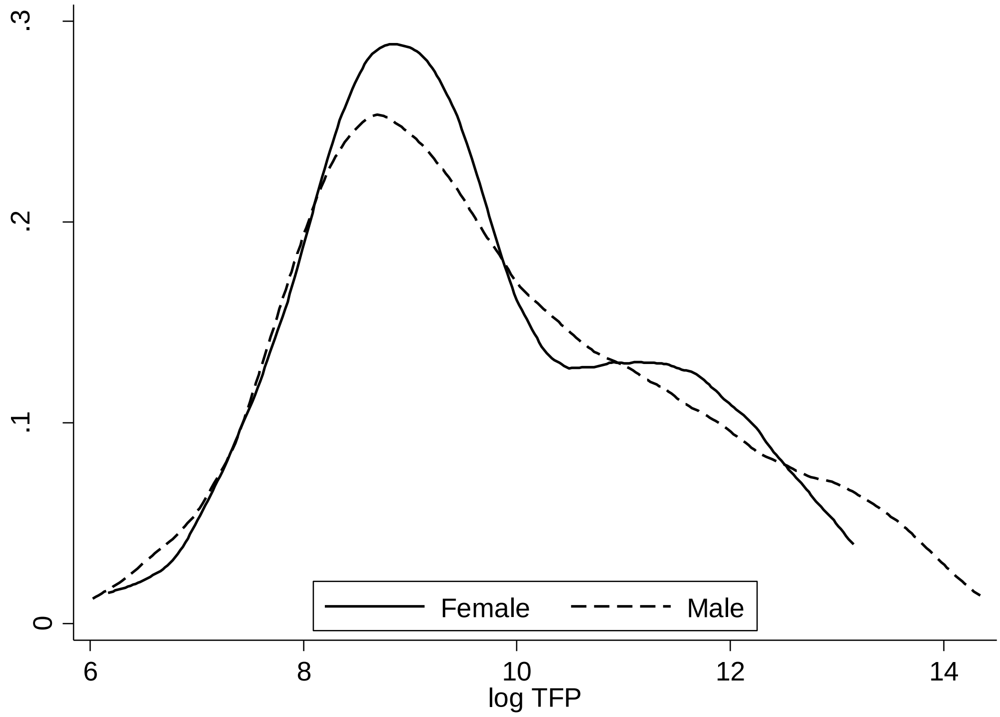
Figure [Click here to access/download;Figure;FIGURE 2.docx]

FIGURE 2. RESULTS DECOMPOSITION ANALYSIS



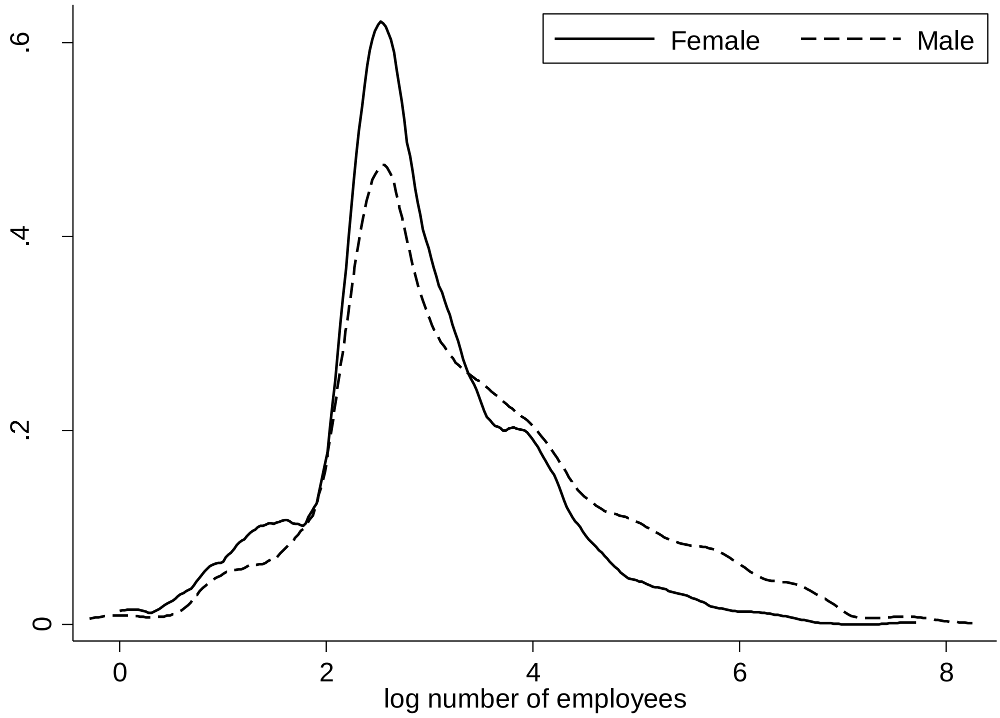
Notes: This graph shows male-female differences in firm productivity (in log TFP) at each decile of the productivity distribution, and their decomposition into (observed) composition and (unobserved) structural effects according to the approach of Firpo et al. (2007, 2009).

FIGURE 3. FEMALE- VS. MALE-OWNED FIRM PRODUCTIVITY DISTRIBUTIONS, FULL SAMPLE



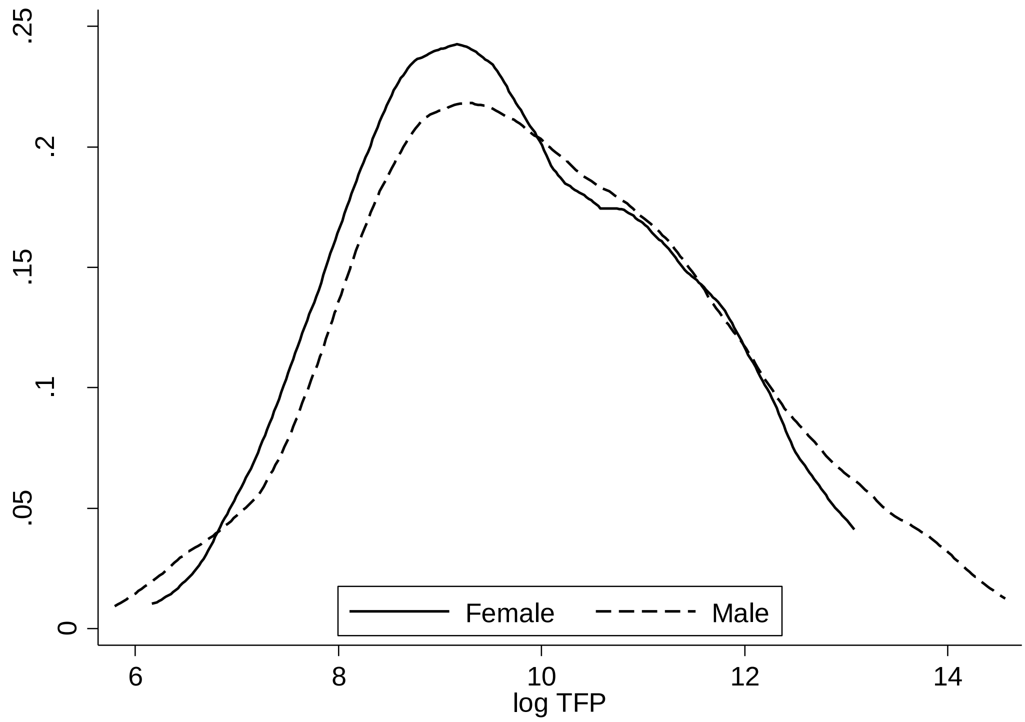
Notes: Densities of log TFP distributions are estimated using an Epanechnikov kernel function and a bandwidth that minimises the mean integrated squared error under Gaussian assumptions. Top and bottom 1% of log TFP distributions are trimmed (separately for male and female distributions).

FIGURE A1. FEMALE- VS. MALE-OWNED FIRM SIZE DISTRIBUTIONS



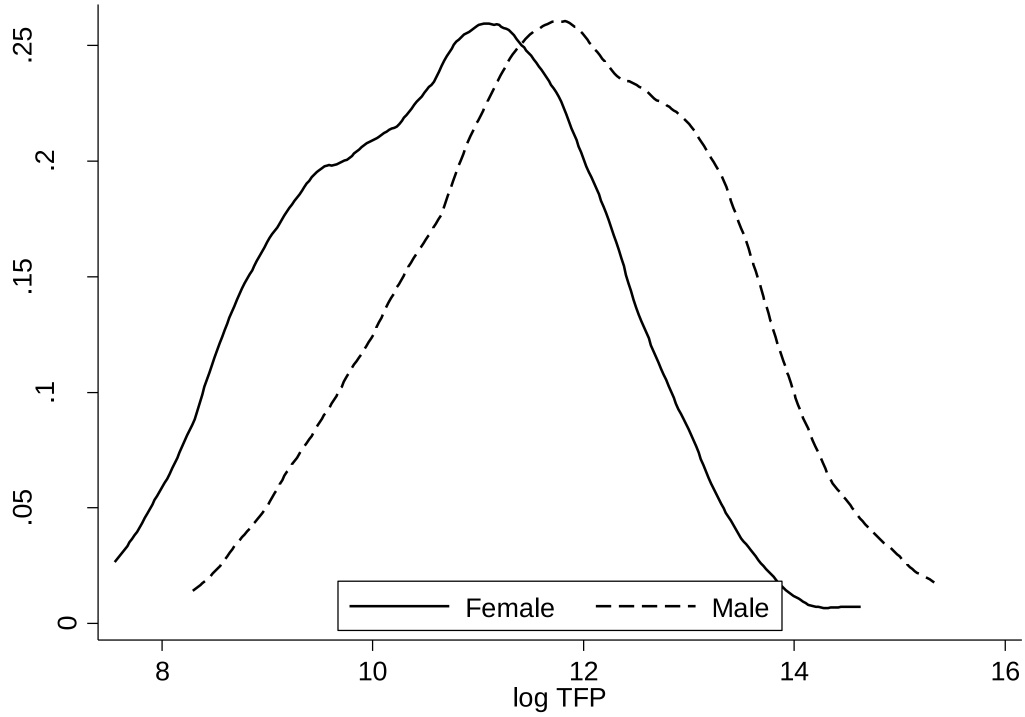
Note: Densities of log number of employees distributions are estimated using an Epanechnikov kernel function and a bandwidth that minimises the mean integrated squared error under Gaussian assumptions.

FIGURE A2. FEMALE- VS. MALE-OWNED FIRM PRODUCTIVITY DISTRIBUTIONS, ADDIS ABABA ONLY



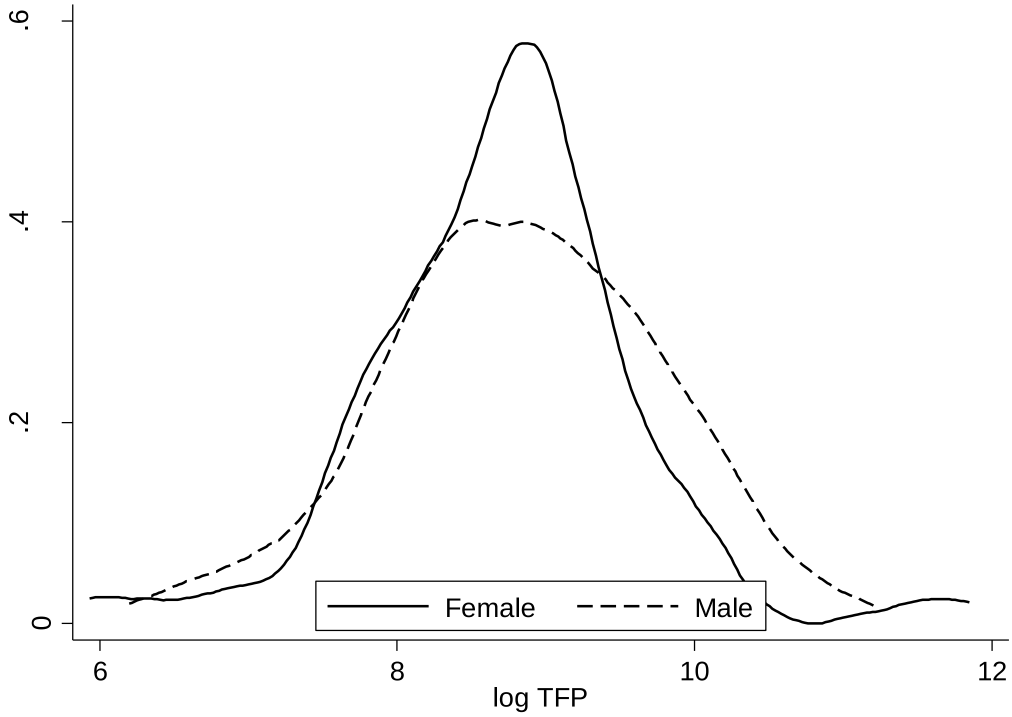
Notes: Densities of log TFP distributions are estimated using an Epanechnikov kernel function and a bandwidth that minimises the mean integrated squared error under Gaussian assumptions. Top and bottom 1% of log TFP distributions are trimmed (separately for male and female distributions).

FIGURE A3. FEMALE- VS. MALE-OWNED FIRM PRODUCTIVITY DISTRIBUTIONS, FOOD AND BEVERAGES (ISIC 15) INDUSTRY ONLY



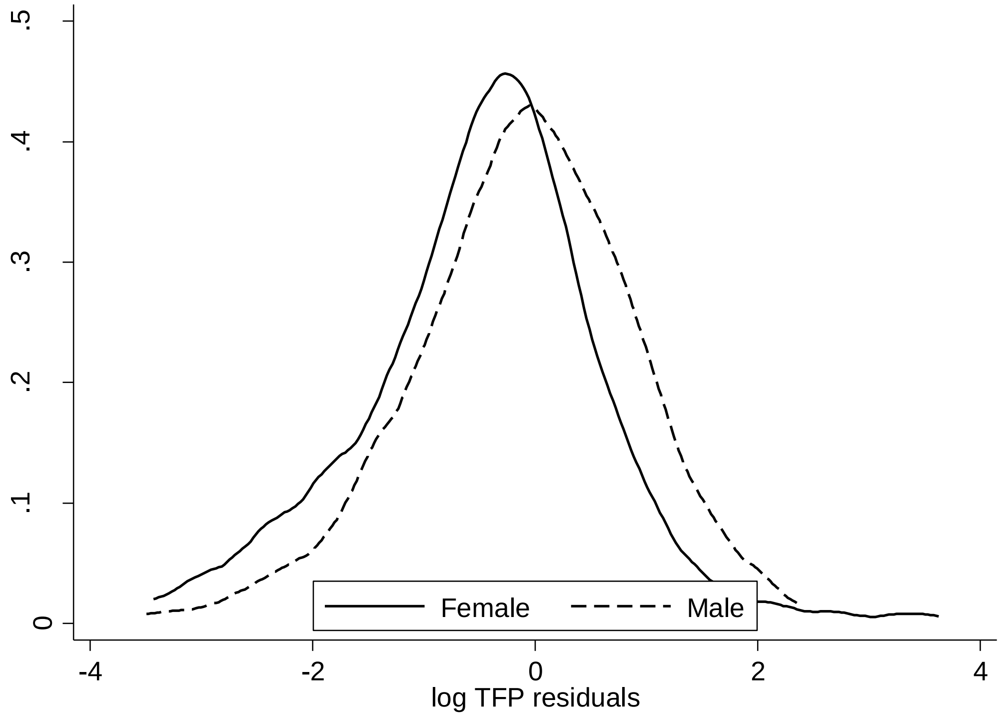
Notes: Densities of log TFP distributions are estimated using an Epanechnikov kernel function and a bandwidth that minimises the mean integrated squared error under Gaussian assumptions. Top and bottom 1% of log TFP distributions are trimmed (separately for male and female distributions).

FIGURE A4. FEMALE- VS. MALE-OWNED FIRM PRODUCTIVITY DISTRIBUTIONS, MINERAL PRODUCTS (ISIC 26) INDUSTRY ONLY



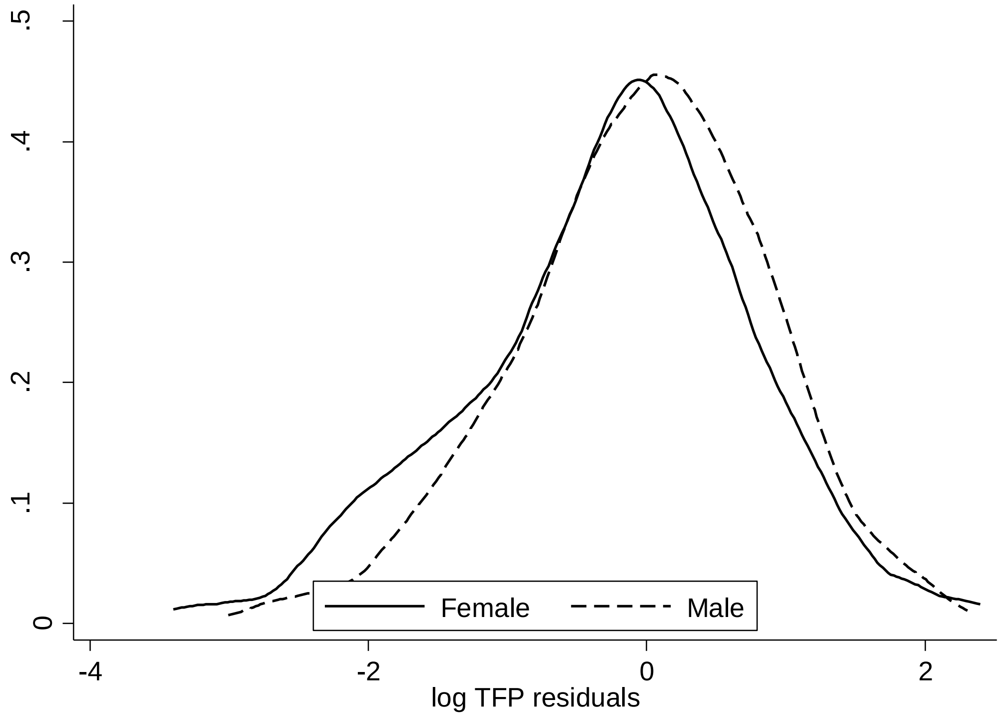
Notes: Densities of log TFP distributions are estimated using an Epanechnikov kernel function and a bandwidth that minimises the mean integrated squared error under Gaussian assumptions. Top and bottom 1% of log TFP distributions are trimmed (separately for male and female distributions).

FIGURE A5. FEMALE- VS. MALE-OWNED FIRM PRODUCTIVITY RESIDUAL DISTRIBUTIONS, CONTROLLING FOR SECTORS



Notes: Residuals are obtained from a regression of log TFP on 4-digit ISIC industry dummies. Densities are estimated using an Epanechnikov kernel function and a bandwidth that minimises the mean integrated squared error under Gaussian assumptions. Top and bottom 1% of log TFP residual distributions are trimmed (separately for male and female distributions).

FIGURE A6. FEMALE- VS. MALE-OWNED FIRM PRODUCTIVITY RESIDUAL DISTRIBUTIONS, CONTROLLING FOR SECTORS, FIRM SIZE AND CAPITAL INTENSITY



Notes: Residuals are obtained from a regression of log TFP on 4-digit ISIC industry dummies, log of number of employees, and log of ratio of capital to the number of employees. Densities are estimated using an Epanechnikov kernel function and a bandwidth that minimises the mean integrated squared error under Gaussian assumptions. Top and bottom 1% of log TFP residual distributions are trimmed (separately for male and female distributions).