GLOBALINTO

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Gender Balance and Productivity

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Author(s) and company:	Carter Bloch (AU), Carita Eklund (AU), Kristof van Criekingen (AU)
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About GLOBALINTO

Close to ten years after the start of the financial crisis, productivity growth rates are still very low in European Union (EU) and OECD countries (Van Ark and Jäger 2017). Low growth stems partly from the financial crisis, but also appears to be part of a longer-term slowdown in productivity growth since the 1970's. This has prompted strong attention to possible reasons for the slowdown and potential policy responses also in relation to intangible capital.

While a number of possible explanations have been put forward, we lack convincing evidence of the main reasons behind the slowdown. Both research and policy are hampered by a lack of data and evidence. The GLOBALINTO project seeks to fill this gap.

The focus of GLOBALINTO, both in measurement and analysis, is on the role of intangibles; how they can be measured in a sustainable manner, their accumulation and diffusion, and their use in generating innovation and productivity growth. These processes are central in understanding the underlying factors behind the role of globalization, demographic change, the public sector and growth in SMEs.

GLOBALINTO will:

- Review existing literature, methodologies and data for measuring intangible assets.
- Conduct conceptual work on intangible assets and their relation to innovation and productivity, mapping key factors such as globalization and the role of value chains, how the demand side effects innovation and productivity, IT and digitization, and the role of public sector intangibles.
- Develop new measures of intangibles and advanced methods to link data and construct them.
- Utilize this new data to analyze the various potential explanations of the productivity puzzle, at both micro and macro levels.
- Conduct analyses of existing economic policies and their role in promoting intangibles investment, innovation and productivity growth

The project runs from February 2019 to January 2022.

Abstract

Discussions on gender balance benefits are increasing, which is important for the society's continuing route towards equality. While research and practice has shown that gender diverse groups outperform single gender groups by with diverse perspectives and a good work environment, the relationship between gender balance and firm performance overall remains understudied. We broaden the discussion from gender in management to the role of gender balance in knowledge intensive occupations which central for the creation of new knowledge and innovations. With unique panel data, we look at the Danish businesses from services and manufacturing from 2000 to 2016 and investigate firms' productivity gains from gender balance. We approximate gender balance with share of women in knowledge producing positions. Focus on these personnel is chosen as they make the strategic decisions and produce knowledge capital. We find that firm productivity is increasing in the share of women in knowledge intensive positions. This provides an economic argument for gender equality policies.

1. Introduction

Attention towards gender balance is increasing, while less than 5 percent of the CEOs were female in 2014. The benefits of women in leading positions include different attitudes and different values. Yet, gender bias is persistent among both genders and research talks increasingly about "second-generation" forms of gender bias, where the bias is known to exist but not recognized in practice (Ibarra, Ely, & Kolb, 2013). The gender imbalance in high management positions has led legislators to include a demand for a minimum share of women in the boards of publicly traded companies. (Christiansen, Lin, Pereira, Topalova, & Turk-Ariss, 2016)

Previous research documents a number of different benefits of gender balance for productivity. One is different characteristics between men and women. An example is a difference in risk aversion. Palvia, Vähämaa, and Vähämaa (2020) document a lower risk taking of banks with female CEO's and boards' chairpersons and, as a result, a lower likelihood of failure during the financial crises. Another example of benefits from management's gender balance is from Kravitz (2003), who explains that firms with few women in senior management ranks tend to embrace stereotypical gender roles[1]. This embracement leads to less women wanting to work for them, as combining the work with family obligations is more challenging while working there. As a result, we could think that the firm is overlooking half of the talent pool. Further, female leaders are needed as role models for younger female colleagues (Christiansen et al., 2016).

[1] Kravitz (2003) cites Frink et al. (2003) who document that the market performance increases until 50% of employees are women and starts to decrease thereafter.

One route to support productivity is innovation. New products can gain new customers to the firm or process innovations can support firm performance through efficiency. Gender balance among all employees has been documented to support innovativeness. Østergaard, Timmermans, and Kristinsson (2011, p. 507) investigate how diversity affects firm innovation and report that the effect side of gender balance is the second highest after diversity in education. Moreover, Ritter-Hayashi, Vermeulen, and Knoben (2019) extend the conversation of the relation between innovation and gender to include gender equality. They find a positive relation between innovativeness and gender balance in developing countries even without gender equality.

From a productivity perspective, research has mainly focused on the share of female managers. Christiansen et al. (2016, p. 9) find a positive correlation between several measures of firm performance and the share of female leaders. Tsou and Yang (2019) look at firm productivity in China and find that highly educated women improve firm performance. Similarly, Smith, Smith, and Verner (2006) find that women in top management matter for firm performance but the results depend on the qualifications of the female top managers. Hence, the results of Tsou and Yang (2019) and Smith et al. (2006) can be interpreted to mean that gender balance is important when combined with competences.

Following previous research, we hypothesis that gender balance supports productivity and that the relationship might have an inverted U shape (Frink et al., 2003; Nielsen et al., 2017). However, the share of women in management is not the whole story. We broaden the focus from managers to knowledge producing employees following the intangible capital literature (as used in Piekkola, 2014). This enables us to cover gender balance benefits in ICT, product development and all management levels in addition to the CEO positions and account for the importance of competences.

We contribute to the literature about the question of gender balance and productivity by investigating a unique panel data on Danish firms from 2000 to 2016 and widening the focus from management to overall knowledge creation. The share of women in knowledge producing positions varies a lot between the firms in our data. The median share of women in knowledge producing positions is zero but the average is approximately 20 %. The results from panel data estimation show that many companies are losing in productivity, as their share of women is smaller than the optimal calculated from the estimation, which is 10 to 20 % higher than the median.

2. Literature review

A group can be diverse in languages, nationalities, education backgrounds or in gender, to name a few dimensions. This research focuses on gender balance[2]. This is a timely topic as one can argue that gender equality is far from achieved in business. Only 14 % members in executive boards in EU are women (Marinova, Plantenga, & Remery, 2016, p. 1777) and less than 5 % of CEO's in 2014 (Christiansen et al., 2016). The number has remained low despite that several research studies have reported benefits from gender balance.

Men and women have naturally different characteristics that can support each other. An example is Palvia et al. (2020), who report that banks with women as CEO or board of directors positions took fewer risks and had 5 % higher levels of equity capital than banks led by men only, which realized as fewer failures during the financial crises. Gender balance benefits also the recruitment and keeping the recruited employees. Female leaders tend to support non-stereotypical gender roles (Kravitz, 2003), which, for example, helps to combine work and family obligations. Benefits of female leaders also include role models and family friendliness (Christiansen et al., 2016, pp. 13-14). If a company loses women in the recruitment, it is, in practice, losing the half of the talent pool.

Like other types of diversity, also gender diversity, has some obstacles or hindering factors. One of them is a different communication style and another one is biased assessment of the time that a female colleague has been speaking (Cutler & Scott, 1990). It is common for both genders to report that women speak for a longer time than they actually have in practice (Cutler & Scott, 1990). An example of hindering factors with longitudinal data is Frink et al. (2003), who finds support for an inverted U-shape between gender and organizational performance.

> *"Employee diversity is often considered to be positive since it might create a broader search space and make the firm more open towards new ideas and more creative. Ideally, diversity should increase a firm's knowledge base and increase the interaction between different types of competences and knowledge. As the cultural, educational and ethnic background among employees becomes more diverse so does the knowledge base of the firm."* (Østergaard et al., 2011, p. 500)

Teams can be expected to be more innovative when the members represent different knowledge backgrounds and potential user groups (Cummings, 2004). Previous research has documented that diversity has innovation enhancing features and gender balance seems to be of no exception (Ritter-Hayashi et al., 2019; Østergaard et al., 2011). A bit contradictory, Glass and Cook (2018) find that female CEOs mainly affect diversity policies but has no effect on firm's innovation policies. Østergaard et al. (2011) utilizes Danish register data (linked employer-employee data, LEED or IDA) and innovation survey data. The authors argue that

[2] Gender balance describes our data better as we only have female or male variable. To be precise, one could say that we are looking at a simplified version of gender diversity.

innovation requires interaction, where also other employees than the top management team matter.

There is an ample amount of research on team diversity and innovativeness. Wang, Cheng, Chen, and Leung (2019, p. 703) remind managers that surface level diversity, such as race, are less important for team innovativeness than, for example, cultural values and worldview that they call "deep-level" of diversity. They also note that remote work may not allow the team to access the benefits of deep diversity. Also, Taylor and Greve (2006) investigate how diversity relates to incremental and radical innovations by looking at the comic industry and use variance of performance of a proxy for radicalness or aiming for radical innovations. Their findings give support for diverse teams as performance varies the most for teams with diverse members (Taylor & Greve, 2006, p. 735).

2.1. Gender and Productivity

Gender diversity can attract a larger pool of potential employees to search from when hiring, increase commitment in diverse employees (for example by mentoring, family friendly policies and role models benefits) and even support innovativeness. Thus, one could expect to see productivity benefits from gender diversity. Already, several publications have focused on gender at the board of directors.

Results on gender diversity in boards have somewhat mixed results. Ali, Ng, and Kulik (2014) find that gender balance has a positive and linear relation to the productivity of the employees and an inverted U-relationship between age diversity and return on assets. Marinova et al. (2016) investigated gender in boards in Danish and Dutch companies and almost 37% of firms had at least one female board member. Yet, Marinova et al. (2016, p. 1786) find no relation between having more women on the boards and firms' performance and call for more research with non-listed companies and with panel data approach.

Partly in line with Marinova et al. (2016), Triana, Miller, and Trzebiatowski (2014, p. 625) find that "*diversity can lead to less strategic change*". Yet, the relation between strategic change and powerful female managers is moderated by the business conditions. The relationship between strategic change and gender is negative when firm performance is low and positive when firm is performing well. The results can be interpreted in light of different risk aversion, like Palvia et al. (2020): women tend to be more risk averse than men and, perhaps because of this, more likely to resist strategic change when under negative demand conditions. However, Palvia et al. (2020) report that banks with more women outperformed the others due to less prior risk taking.

Board gender balance is an important factor but far away from the executive tasks. Luanglath, Ali, and Mohannak (2019) investigate the relationship of gender diversity in top management teams (TMT) to employee productivity. They find a positive relation and that the relationship is even stronger for firms that have a low level of gender diversity in boards. Luanglath et al.

(2019, p. 80) interpret that a company can still benefit from gender diversity though hiring women as managers, even if it had been unsuccessful in attracting women in its board before.

To cover also the strategy implementing management level, Dwyer, Richard, and Chadwick (2003) investigate gender on management level, and not only on TMT-level. Their estimation sample consisted of 177 questionnaire responses (total sample was 535). The findings imply that gender diversity gains depend on the chosen strategy and culture of the firm, such as growth orientation.

Previous research either focus on CEO's or all employees (Smith et al., 2006). Focus on CEOs is too narrow – and all employees too broad. When focusing on all employees, where all tasks are viewed as equal, is a too simplified approach although all employees matter. Hence, we look at knowledge producing employees, whose work could benefit the companies in years to come. In the definition of knowledge producing employees, we follow the literature on intangible capital.

2.2. Knowledge producing employees

Intangible capital is a tool to calculate and evaluate the knowledge investments that the firm is making (Piekkola, 2014). The main route in the estimation is own employees of the firm (Görzig, Piekkola, & Riley, 2010). The method assumes that employees in certain positions, such as ICT (information communication technology), create knowledge capital of a fraction of their time. This is called investment share of labor and is, for example, 50 % for ICT (Görzig et al., 2010). To calculate the full share of intangible investment, this investment share of labor is complemented with the usage of intermediate inputs and capital. For ICT, this could for example be a license on SAP or TEAMS software (intermediate input). Görzig et al. (2010, p. 19) approximate that the share of intermediate inputs fluctuates depending on country between 31 % and 54 %. When the Intangible Capital method is used to calculate the capital stock, we assume that the knowledge depreciates over time, in a similar manner as physical capital does.

The used intangible producing occupations origins to the work of Ilmakunnas and Piekkola (2014). Employees are divided into organizational, R&D and ICT workers (Ilmakunnas & Piekkola, 2014, p. 454). They classify an employee to organizational worker if his/her occupation is management, marketing (worker or superior), administration (in management both worker and superior level qualify, in services only superior), finance superior, personnel management or project management. R&D workers classification is more straightforward with R&D or R&D service workers. Ilmakunnas and Piekkola (2014) classify computer and computer processing services into ICT workers.

3. Methods and Data

To approach comprehensively the question of gender diversity, we use Danish register data (linked employer-employee data, LEED, or IDA) that covers all firms and persons registered in Denmark and focus on years 2000-2016. We calculate intangible capital as discussed in the literature review following stream of literature started by Görzig et al. (2010), Corrado, Hulten, and Sichel (2009), Corrado, Haskel, Jona-Lasinio, and Iommi (2014) and Roth and Thum (2013). To analyze the gender diversity, we look at the share of women in intangible capital producing positions (SWIPP). These positions are especially interesting as in these the employee is more likely to have a say and to generate knowledge capital, such as intangible capital.

We use two main estimation strategies with focus on explaining production[3] and productivity. First, we estimate a production function with intangible capital and the share of women in intangible producing positions using ordinary least squares, fixed effects and random effects. Here, following Ali et al. (2014), we lag independent variables by one year in order to reduce possible multicollinearity issues. Second, we use Olley and Pakes (1996) and Levinsohn and Petrin (2003) methods to estimate the production function, where intangible capital is treated in line with the physical capital. The production function estimation explains firms' value-added with the firms' capital, employees (without employees who are involved in intangible capital production), intangible capital measures and the share of women in intangible capital producing positions[4]. The benefit of Olley and Pakes (1996) and Levinsohn and Petrin (2003) methods is accounting for firm exits.

Equation 1 presents a simple production function estimation, from the first estimation strategy, where $lnva_{i,t}$ stands for the logarithm of value-added of firm i at year t. It is explained by a constant term and lagged and logarithmic capital stock (K), number of employees excluding those who participate in intangible production (empnoic) and intangible capital (consisting of RD, OC and ICT). The share of women in intangible producing employees (SWIPP) is included also in a squared form due to the hypothesis of inverted U relationship or decreasing returns.

$$(1)\quad lnva_{i,t} = \beta_0 + \beta_1 lnK_{i,t-1} + \beta_2 lnempnoic_{i,t-1} + \beta_3 lnIC_{i,t-1} + \beta_4 SWIPP_{i,t-1} + \beta_5 SWIPP^2{}_{i,t-1} + controls + \varepsilon_{i,t}$$

In the second estimation strategy, production function is estimated with Olley and Pakes (1996) or Levinsohn and Petrin (2003) method as presented at the equation 2. The equation produces an estimate for total factor productivity (TFP). Equation 3 explains this TFP with the share of women in intangible producing positions (SWIPP).

$$(2)\quad lnva_{i,t} = \beta_0 + \beta_1 lnK_{i,t-1} + \beta_2 lnIC_{i,t-1} + \beta_3 lnempnoic_{i,t-1} + controls + \varepsilon_{i,t}$$

$$(3)\quad TFP_{i,t} = \beta_0 + \beta_1 SWIPP_{i,t-1} + \beta_2\, SWIPP^2{}_{i,t-1} + controls + \varepsilon_{i,t}$$

[3] The firm level production is approximated by the firm's value added.

[4] As a robustness check, we have estimated production function without intangibles and included them in second stage.

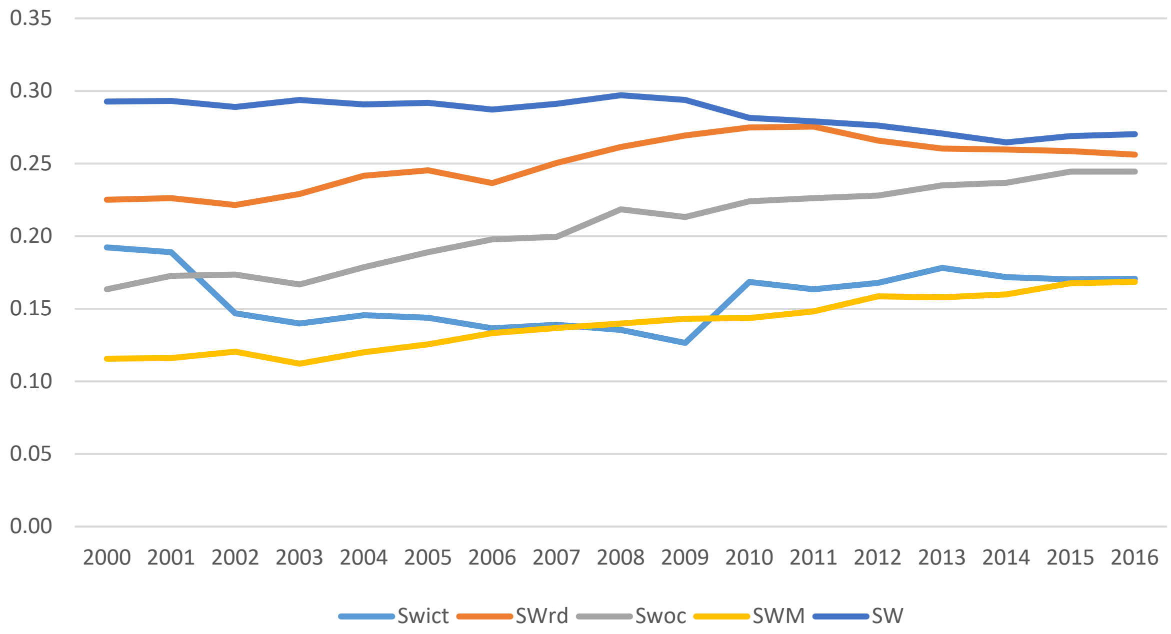
Table 1 presents the data. We limit the observations to firms that have at least 10 employees and to firms that have knowledge producing employees. We can notice that the share of women in top management (SWTM) is very low, 2 %. The share of women in management (SWM) is higher, 14 %, but still far from half. When looking at the share of women in knowledge (intangible capital) producing positions (SWIPP), we see that there are considerably many women in technological capital producing positions (26%) and in organizational capital, i.e., management and marketing, positions (20%). Overall average of women in knowledge (intangible capital) producing positions (SWIPP) is 22%. Meanwhile, the share of female employees (SW) is 29%.

Table 1. Descriptive statistics.

Variable	Mean	Sd	Obs	Description
va	12.785,25	83.773,42	69877	value added
K	21.243,27	217.660,60	69877	capital
inv	6.566,87	4.6691,82	69877	Change in inventory
intermediate	253,56	5.649,63	69877	intermediate inputs
empnoic	106,48	472,87	69877	number of employees excluding those involved in intangible production
emp	116,03	511,73	69877	number of employees
ocasset	1.251,93	7.130,59	69877	Organizational capital assets
rdasset	9.066,69	110.959,40	69877	Technical capital assets
ictasset	1.162,85	14.565,91	69877	Information communication technology capital assets
intasset	9.251,37	118.805,60	69877	Intangible capital assets
SWIPP	0,22	0,29	69877	Share of women in knowlegde (intangible capital) producing positions
SWIPPI	0,34	1,05	69877	SWIPPI*intasset
SWictP	0,15	0,27	18557	Share of women in ICT producing positions
SWrdP	0,26	0,34	43677	Share of women in RD producing positions
SWocP	0,20	0,30	55522	Share of women in OC producing positions
SWTM	0,02	0,12	69877	Share of women in top management
SWM	0,14	0,23	61098	share of women in management
SH	0,29	0,22	69877	share of women

Figure 1 presents how the share of women has evolved over time. The share of women (SW) looks to have decreased over time. The share of women was 29% in 2000 and is 27% in 2016. A similar trend is visible in the share of women in ICT (SWict). Meanwhile, the share of female managers has increased from 12% to 17 %. Share of women in technical knowledge positions (SHrd) has fluctuated but increased from 23 % to 26%. Also, the share of women in organizational knowledge producing positions has increased, from 16 % to 24 %. This means that there are eight percentage points more women in management and marketing. Overall, the share of women, in these firms, has decreased a bit but the share of women in management, marketing and technological knowledge production has increased.

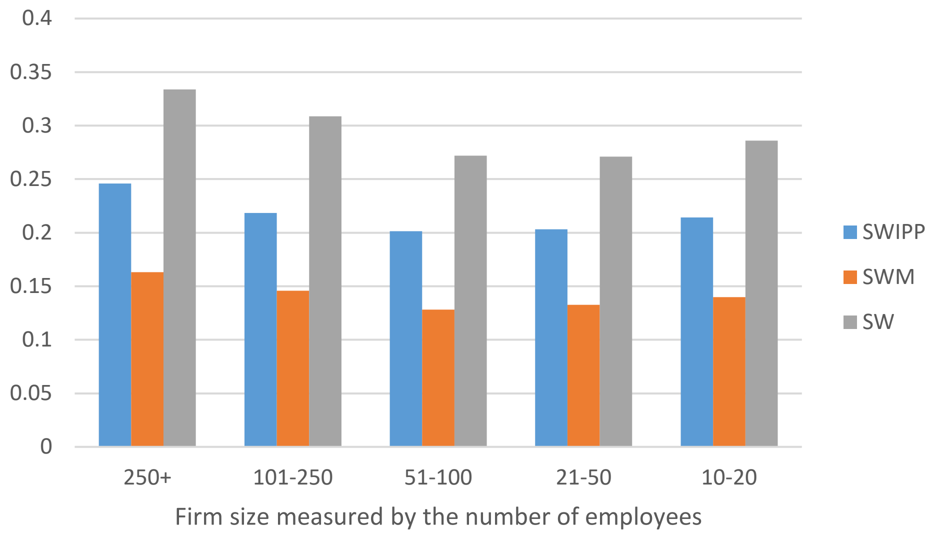
Figure 1. The development of the shares of women over time.



As the average share of women in figure 1 seems low, figure 2 breaks the sample down by the share of the observed company. Largest firms are in the first group, 250+, meaning that they have at least 251 employees. We have approximately 5500 observations in this group that has the highest share of women (SW) with 33.3%. It also has the highest average value of women in management (16.3%) and intangible capital producing positions, SWIPP, (24.6%). Second largest group, 101-250, includes observations with the number of employees between 101 and 250. This group consists of 8500 observations. The middle group, 51-100, consists of 11200 observations and has the lowest average share of women in management (SWM) with 12.8%. The fourth group, 21-50, is the largest in coverage with 24400 observations. The fifth group, 10-20, consists of the smallest firms in our sample, e.g., firms with at least 10 employees but 20 the most. There are 11000 observations in this group.

Figure 2 illustrates that the large firms are more important employers for women than middle-sized firms are. The difference of the share of women (SW) between group 250+ and group 101-250 is 3 %. The difference in the share of women in management (SWM) of these groups is 1.7 %.

Figure 2. The average shares of women over firm sizes.



The low percentage of women awakens a question, is there an optimum gender share in knowledge producing positions, production and productivity wise, and if there is, is it less than one fourth? If the share of women in knowledge producing positions (SWIPP) has an inverted U-relationship to production or productivity, we can calculate that the optimum share, based on our data, would be the highest point of that inverted U curve. For this to be the case SWIPP needs to have a positive coefficient and $SWIPP^2$ needs a negative coefficient.

4. Results

This chapter reports the estimation results from production and productivity functions estimated as presented on the previous section. Table 2 presents simple production function estimates where the share of women in knowledge producing positions is included.

4.1. Production function estimates

Table 2 presents simple production function estimates where the share of women in knowledge producing positions is included. OLS 1 & 2 use ordinary least squares, RE 1 & 2 and FE 1 & 2 random and fixed effects. Dependent variable is logarithm of value added. Regressions 1 include only the share of women in knowledge producing positions (SWIPP) while regressions 2 include also its interaction term with intangible capital (SWIPPI). While SWIPP and its squared term are statistically highly significant, SWIPPI is not.

Table 2. Production function estimates with intangibles and the share of women in knowledge producing positions

	OLS 1	OLS 2	RE 1	RE 2	FE 1	FE 2
	ln va	ln va	ln va	ln va	ln va	ln va
l. lnK	0.0572***	0.0573***	0.0572***	0.0573***	0.0405***	0.0405***
	(0.00156)	(0.00156)	(0.00156)	(0.00156)	(0.00169)	(0.00169)
l. lnL	0.682***	0.683***	0.682***	0.683***	0.578***	0.578***
	(0.00364)	(0.00364)	(0.00364)	(0.00364)	(0.00423)	(0.00423)
l. ln IC	0.0168***	0.0180***	0.0168***	0.0180***	0.00421***	0.00427**
	(0.000870)	(0.00124)	(0.000870)	(0.00124)	(0.000943)	(0.00130)
SWIPP	0.324***	0.331***	0.324***	0.331***	0.205***	0.203***
	(0.0187)	(0.0194)	(0.0187)	(0.0194)	(0.0191)	(0.0198)
SWIPP2	-0.392***	-0.399***	-0.392***	-0.399***	-0.263***	-0.260***
	(0.0201)	(0.0207)	(0.0201)	(0.0207)	(0.0205)	(0.0211)
SWIPPI		-0.00889		-0.00889		0.00410
		(0.00691)		(0.00691)		(0.00697)
SWIPPI2		0.00103		0.00103		-0.00121
		(0.000989)		(0.000989)		(0.00100)

Year dummies	yes	yes	yes	yes	yes	yes
N	87856	87856	87856	87856	87856	87856

* p < 0.05, ** p < 0.01, *** p < 0.001

For productivity estimations in sections 4.2., table 3 presents production function estimates with Olley and Pakes (1996), OP, and Levinsohn and Petrin (2003), LP, methods. Regressions OP 1 and LP 1 present simple production function with only physical capital (K) and labor (L). Regressions OP 2 and LP 2 include also our measure of knowledge capital, intangible capital (IC). In each of the regressions, the coefficient for labor is high: approximately 0.9 in OP&LP 1 and approximately 0.8 in OP&LP 2. The coefficient for capital is 0.08 in OP regressions and 0.07 in the LP regressions. Yet, both of the regressions report similar coefficient estimates for intangible capital, namely 0.01.

Table 3 includes also as a robustness check LP estimation, LP 3, where intangible capital is divided into its three parts (ICT, RD and OC). This change would decrease the coefficient of labor by 0.11 and increase the coefficient of capital by 0.008 compared to LP 2.

Table 3. Production functions for TFP estimation.

	OP 1	**OP 2**	**LP 1**	**LP 2**	**LP 3**
ln L	0.867***	0.824***	0.891***	0.842***	0.757***
	(0.011)	(0.009)	(0.008)	(0.010)	(0.010)
ln K	0.083***	0.083***	0.065***	0.071***	0.079***
	(0.004)	(0.003)	(0.002)	(0.001)	(0.012)
ln IC		0.014***		0.014***	
		(0.0004)		(0.0034)	
ln ICT					0.035***
					(0.008)
ln RD					0.012
					(0.009)
ln OC					0.042***
					(0.010)
N	100235	100235	86998	86998	86998

All variables are in a logarithmic form, dependent variable is value added. OP and LP stand for the method used. Regressions OP 1 and LP 1 do not include intangible capital stock, unlike OP 2 and LP 2. As a robustness, LP 3 includes intangibles in three parts.

4.2. Productivity estimates

Using the productivity estimates from table 3, this section reports the relationship between the share of women in knowledge producing positions (measured by intangible capital producing positions) and productivity. Table 4 includes regressions for TFP where the measures of TFP are from the OP (tfp 1-3) and the LP model (tfp 4-6). The method used in the TFP regressions below is simple ordinary least squares. For both of these measures, the first regression includes only share of women in knowledge producing positions, its square and interaction with intangible capital. The second regression includes also the squared version of the interaction (SWIPPI2). The third regression is a robustness check, where intangible capital (IC) was not placed on the production function but on the TFP estimation instead. The total factor productivity for the latter is taken from the regressions OP 1 and LP 1.

When intangible capital is included on the second stage, on the TFP estimation, and not on the production function estimation, we can see that the coefficients for the interaction term (SWIPPI) drop a bit, but are now significant. Yet, across regressions tfp 1-3 and tfp 4-6, coefficients for the share (SWIPP) and its squared form (SWIPP2) remain stable.

Table 4. TFP estimation

	tfp 1	**tfp 2**	**tfp 3**	**tfp 4**	**tfp 5**	**tfp6**
TFP estimate origins to regression:	*OP 2*	*OP 2*	*OP 1*	*LP 2*	*LP 2*	*LP1*
SWIPP	0.206***	0.217***	0.214***	0.217***	0.236***	0.225***
	(0.0172)	(0.0175)	(0.0178)	(0.0185)	(0.0188)	(0.0191)
SWIPP2	-0.245***	-0.259***	-0.257***	-0.237***	-0.262***	-0.254***
	(0.0185)	(0.0189)	(0.0192)	(0.0199)	(0.0204)	(0.0206)
SWIPPI	-0.00744***	-0.0302***	-0.0137*	-0.00929***	-0.0394***	-0.0182**
	(0.00218)	(0.00480)	(0.00655)	(0.00220)	(0.00487)	(0.00670)
SWIPPI2		0.00456***	0.00231*		0.00581***	0.00322***
		(0.000832)	(0.000956)		(0.000834)	(0.000959)
l. ln IC			0.00689***			0.00689***
			(0.00112)			(0.00115)
year dummies	yes	yes	yes	yes	yes	yes

_cons	0.0361***	0.0383***	0.0216***	0.0426***	0.0453***	0.0330***
	(0.00638)	(0.00639)	(0.00654)	(0.00692)	(0.00694)	(0.00708)
N	69877	68914	68914	61541	60601	60601

As in the production function, in the productivity estimation the share of women in knowledge producing positions (SWIPP) has an inverted U-relationship to the dependent variable. The coefficient of SWIPP is 0.2 in each of the tfp regressions and its squared form, SWIPP2, is on average -0.25. The value of SWIPPI is negative and is larger when the squared form of interaction term (SWIPPI2) is included and if intangible capital is included only at the tfp estimation. The opposite relation between SWIPPI and productivity compares to SWIPP and productivity can be a signal of industrial differences. In other words, the relationship might be flatter in intangible (or knowledge) intensive industries than other industries. Another possibility is relation to firm size. As figure 2 presented, medium sized firms in our sample had the smallest share of women in knowledge producing positions. Both small (10-20 employees) and large (more than 250 employees) firms' share of women in knowledge production is higher than medium firms' (51-100 employees) share.

The result that the coefficient for SWIPP is positive while its square (SWIPP2) is negative suggests a share of women for which tfp is highest (all else equal). If we do a simple back of envelop calculation for the optimal share of women in knowledge producing positions, in our sample, we would arrive to the share being 40 %, i.e. based on:

$$0.2x - 0.25x^2 + c = 0$$

If we calculate the same optimum share from production function estimation from section 4.1., the equation would slightly differ. Coefficients would be 0.3 (RE, OLS) or 0.2 (FE) and multiplier for squared x 0.4 (RE, OLS) or 0.3 (FE). In these cases, the optimal share would be 38% (RE, OLS) or 33% (FE).

5. Conclusions and Discussion

Knowledge and innovation competences are important drivers for growth in high price level countries, such as the Nordic countries and Denmark. Østergaard et al. (2011, p. 507) have documented a positive relationship between gender diversity and firm innovativeness in Denmark, which motivates research questions about the relationship between production or productivity and the gender balance. The findings of this research indicate that Danish companies could be more productive, if they employed a higher share of women in knowledge producing positions, such as management and product development.

Firms without female leaders miss half of the talent pool as less women want to work for them due to their stereotypical gender roles and lack of role models (Christiansen et al., 2016, pp. 13-14; Kravitz, 2003). There are several behavioral reasons why in practice women are not selected and self-select out. An example is a biased estimation of speaking time, when women speak, where both men and women find that she has spoken longer than she actually has (Cutler & Scott, 1990). Another is second generation gender bias, consisting of the lack of role models, career paths designed for males, a lack of access to networks and sponsors and blindness towards ideal leadership and gender (Ibarra et al., 2013).

Some evidence supports this bias, such as: less diverse management could do bolder decisions than diverse ones (Triana et al., 2014, p. 625). Yet, this partly contradicts with Østergaard et al. (2011, p. 507) who finds benefits to innovation from gender diversity. While Triana et al. (2014, p. 625) look at management decisions, Østergaard et al. (2011, p. 507) look at innovation. Also, Marinova et al. (2016, p. 1786) find no relation between having more women on the boards of listed companies and the firms' performance, suggesting that the gender does not matter.

This paper has widened the discussion on gender and firm performance in two ways. First, the data covers all firms with 10 or more employees that are located in Denmark, using a panel format. Second, we widen the focus from management positions to knowledge producing positions. We investigated production and productivity with the share of women in knowledge producing positions that include management, technical and ICT knowledge creating positions following a measurement strategy in innovation economics, intangible capital (Ilmakunnas & Piekkola, 2014; Piekkola, 2018).

We find that the optimal share of women in knowledge producing position should be 10-20 % higher than the current average. An important question for firms is why is the share of women in these positions lower than optimal? Gender studies report several behavioral reasons why men tend to be chosen over women – without a proper economic justification (Ibarra et al., 2013). One way to improve gender diversity is to present it first through regulation.

As Christiansen et al. (2016) present, gender balance in leadership provides different attitudes and values and the strong gender imbalance has led legislators to demand a minimum share of women in the boards of publicly traded companies. Our results speak in favor for this legislation: we see an inverted U relationship between the share of women in knowledge producing positions (that include both technical and management knowledge production) and productivity. Yet, the turning point in productivity can be almost twice the current share of women.

Furthermore, gender equality is a value that does not ethically need to be more productive than inequality. Yet, productivity would motivate companies to act. Our results provide some of that motivation because we find that Danish companies could be more productive, if they had more women in positions where they could innovate. This finding is in line with research of Palvia et al. (2020), who find benefits of female leaders in banking industry.

Based on our results, it looks like companies would benefit from hiring more women in knowledge producing positions. On average, companies have 22 % women in these positions. Yet, these results suggest that the optimal share would be between 33 and 40 %. A limitation in this approximation is that the data does not cover many cases with high share of women. Thus, the optimal share can be even higher than 40 %. Another limitation lies in our sample construction. We use Danish register data and, hence, cover all companies registered to Denmark. We know the education and work positions of each employee. Yet, small companies might not report work positions precisely and thus we have excluded them from the study. Hence, our results are for companies with at least ten employees. We call for more research to widen the understanding of gender diversity in the management and innovation in small companies.

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Appendix.

The utilization of intangible capital and the share of women fluctuates over industries. Table A1 presents the sectors' average values below. The average value added and number of employees (emp) are the highest in high tech. The highest average capital (K) is on knowledge intensive services (KIS). The highest share of women in intangible producing positions (SWIPP) is in management services but RD services, LKIS (low knowledge intensive sector) and KIS are not that far away. This higher share might origin to the share of women in management (SWM), where management services lead other sectors with an average share of women of 20%. LKIS is second, with a share close to 19%. Yet, in the share of women in intangible producing positions excluding management (SWIPPEM), low teach sectors have 39,8%, LKIS 38,5 % and management services 34,9%.

Table A1. Average sector values and the share of firms without intangibles.

	high tech	med high tech	med low tech	low tech	KIS	ICT services	RD services	management services	LKIS
VA	24685,04	8156,80	4305,80	6822,97	6538,94	5205,64	5711,28	4134,35	3781,90
K	237,48	55,15	102,21	65,00	260,56	16,40	28,45	53,81	61,87
emp	175,59	105,47	63,30	90,41	71,83	55,62	69,72	56,65	66,83
intangibles	64541,33	11348,95	4014,55	3215,72	10398,47	12079,22	17527,43	3245,73	1970,19
SWIPP	0,193	0,158	0,225	0,225	0,257	0,148	0,290	0,311	0,277
SWM	0,146	0,094	0,154	0,128	0,177	0,133	0,159	0,200	0,187
SWIPPEM	0,187	0,180	0,272	0,398	0,263	0,141	0,295	0,349	0,385
IC missing	0,18	0,24	0,48	0,49	0,34	0,30	0,19	0,46	0,55
ICT missing	0,61	0,80	0,84	0,86	0,64	0,32	0,82	0,80	0,88
RD missing	0,20	0,29	0,66	0,68	0,58	0,65	0,16	0,81	0,76
OC missing	0,44	0,44	0,62	0,53	0,60	0,68	0,71	0,49	0,62
N	3394	13835	174765	18626	40240	10420	8913	12351	85114

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