



# Men, women, and machines: How trade impacts gender inequality



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## ABSTRACT

This paper studies the effect of trade liberalization on an under-explored aspect of wage inequality – gender inequality. We consider a model where firms differ in their productivity and workers are differentiated by skill as well as gender. A reduction in tariffs induces more productive firms to modernize their technology and enter the export market. New technologies involve computerized production processes and lower the need for physically demanding skills. As a result, the relative wage and employment of women improves in blue-collar tasks, but not in white-collar tasks. We test our model using a panel of establishment level data from Mexico exploiting tariff reductions associated with the North American Free Trade Agreement (NAFTA). Consistent with our theory we find that tariff reductions caused new firms to enter the export market, update their technology and replace male blue-collar workers with female blue-collar workers.

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## 1. Introduction

In this paper, we consider an under-explored aspect of trade liberalization – its impact on gender inequality in the labor market. It is well-known that labor market inequality can reinforce gender inequality in other areas, including education, health, or the treatment of women in the household (see Duflo (2012) for a survey). Given that many developing countries have already adopted or are now in the process of adopting trade liberalization policies, an important question is whether this will move them closer to, or further from, the goal of gender equality, one of the eight stated goals in the U.N. Millennium Development Goals Report (UN, 2009). Aside from equity concerns, the effect of liberalization policies on gender outcomes may also be of interest from a long-run growth perspective since there is now growing evidence that empowering women promotes education and better children's outcomes (Thomas, 1990; Duflo, 2003; Qian, 2008).

Our theory builds on the basic framework of the new trade models of Melitz (2003), Bustos (2011a), Bustos (2011b) and their predecessors. Heterogeneous firms choose between old and new technologies that require different amounts of white and blue-collar tasks. White and blue collar tasks can be performed by male or female workers. Reminiscent

of Autor et al. (2003) in which computers replace the need for routine physical tasks, the new technology in our model replaces the need for physically demanding skills, “brawn.”<sup>3</sup> Thus, relative to the old technology, women are more productive in blue-collar jobs in the new technology. By lowering the cost of entering foreign markets, trade liberalization causes some firms to start exporting and adopt the modern technology. This improves women's labor market outcomes in the blue-collar tasks, while leaving them unchanged in the white-collar tasks.

We test our model using establishment level data from Mexico, exploiting tariff reductions associated with the North American Free Trade Agreement (NAFTA). Consistent with the previous literature and the predictions of our model, we find that tariff reductions increased exports through the entry of new firms into the export sector. We find evidence that these newly exporting firms updated their machinery and equipment, not only relative to non-exporting firms but also relative to existing exporters. Moreover, investment was especially pronounced in the new, computerized equipment category imported from developed countries. As predicted by our model, we find that tariff reductions improved female labor outcomes through this channel. Trade liberalization increased the ratio of female blue-collar workers to male blue-collar workers as well as the relative wage of female blue-collar workers. By contrast, we find little evidence of increasing female shares in white-collar occupations, where the relative importance of physically

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<sup>3</sup> Empirical evidence in Weinberg (2000) and Rendall (2010) on the process of technological change in the US also supports this assumption.

demanding skills is unlikely to have changed. We provide several robustness checks to make sure that these results are not due to the endogeneity of tariffs. We provide evidence that other mechanisms, including import market competition or the different attitudes towards women among foreign firms are unlikely to explain our findings.

In terms of skill distribution within firms (measured as the ratio of white-collar to blue-collar workers), we find mixed results. We find little evidence of skill-upgrading in newly exporting firms in terms of employment but we do find larger increase in white-collar wages, both in absolute terms and relative to blue-collar wages. These results are consistent with the idea that labor inputs are differentiated along multiple dimensions: gender-specific skills as well as the more traditional occupation-specific skills.

In studying the effect of trade liberalization on gender inequality, our paper brings together two distinct literatures: a trade literature on the effects of trade liberalization in developing countries, and a labor literature on skill-biased technological change. The first, more recent literature has studied the effect of trade liberalization on heterogeneous firms, finding evidence for technology and quality upgrading as well as wage effects. [Bustos \(2011b\)](#) builds a model where firms that differ in productivity choose technology as well as export status. Using a panel of Argentinean manufacturing firms in the context of a regional free trade agreement, MERCOSUR, she finds that trade liberalization led to increases in spending on technology and hiring of more skilled workers. [Verhoogen \(2008\)](#) uses a similar set-up but uses exchange rate shocks, rather than tariff reductions, as source of variation. Using a panel data set of Mexican manufacturing plants, he finds that the 1994–1995 peso devaluation increased exports and wages particularly at those plants with higher initial productivity. [Csillag and Koren \(2011\)](#) study a period of trade liberalization in Hungary, and show that employees working with machinery imported from developed countries earn a wage premium. They argue that such machinery represents technology upgrading, which is consistent with the interpretation of our findings.<sup>4</sup>

The second literature is a labor literature on skill-biased technological change that has described the implications of technology upgrading for gender inequality. This literature has primarily focused on the evolution of wage inequality between men and women in the US (e.g., [Autor et al. \(2003\)](#), [Blau and Kahn \(1997\)](#), [Rendall \(2010\)](#), [Weinberg \(2000\)](#)). We take from this literature the idea that technological change, in particular the introduction of computerized production processes, has lowered the need for physically demanding skills and has therefore favored women in certain occupations (see also [Galor and Weil \(1996\)](#)).

While the link between trade liberalization and demand for skilled workers has been widely and rigorously examined with firm and industry level data,<sup>5</sup> there is relatively little work exploring labor market outcomes of men and women.<sup>6</sup> Most previous papers use household surveys to examine trends in the gender wage gap and are different

<sup>4</sup> Different approaches have been taken to model how firm-level heterogeneity translates into wage inequality among workers. Departing from the assumption of perfect labor markets, [Helpman et al. \(2010\)](#) and [Helpman et al. \(2011\)](#) introduce search frictions where more productive firms search more intensively for quality workers and pay higher wages. Similarly, [Amiti and Davis \(2012\)](#) develop a model of fair wages in which more productive firms share profits and pay higher wages to workers. Trade and the entry of these productive firms into the export sector increases their revenue relative to non-exporting firms, thereby increasing wage dispersion across firms. [Frias et al. \(2009\)](#) show that labor market imperfections are empirically important in explaining the higher wages paid by exporting firms.

<sup>5</sup> Some earlier studies in the Mexican context include [Behrman et al. \(2000\)](#), [Cragg and Epelbaum \(1996\)](#), [Feliciano \(2001\)](#), [Hanson and Harrison \(1999\)](#), [Revenga \(1997\)](#), [Robertson \(2004\)](#). See also [Attanasio et al. \(2004\)](#), [Pavcnik \(2003\)](#), [Topalova and Khandelwal \(2011\)](#) and [Goldberg and Pavcnik \(2007\)](#).

<sup>6</sup> [Saure and Zoabi \(2011\)](#) study the impact of NAFTA on the US labor market. They find that trade liberalization led to lower female labor force participation and increased the gender wage gap in the US. This forms an interesting contrast to our findings on the other side of the border, and suggests that the impact of trade liberalization on gender outcomes may depend on the level of economic development. [Oostendorp, \(2009\)](#) provides a cross-country study of globalization and gender outcomes.

from the approach taken here. In one of the earliest studies to employ firm-level data to study gender outcomes, [Ozler \(2000\)](#) finds that female employment share is positively related to export share of output among manufacturing plants in Turkey. The study is based on a single cross section and does not discuss the possible channels leading to this empirical finding. [Ederington et al. \(2010\)](#) use firm level data and find that Colombian tariff reforms increased relative employment of blue-collar women, an empirical finding they interpret as being due to reductions in discrimination. [Aguayo et al. \(forthcoming\)](#) use household and firm level data and find tariff changes accompanying NAFTA increased demand for female labor within and between industries. Relative to this previous paper, we offer a more in-depth analysis of the mechanisms underlying the within-industry increase in female employment and wage bill share.<sup>7</sup>

More broadly, our paper contributes to the literature on the determinants of gender roles during the process of economic development (see, e.g., [Alesina et al. \(2011\)](#) or the survey by [Duflo \(2012\)](#)). Our results suggest that the opening up of trade may have important consequences for the status of women in society.

This paper is organized as follows. [Section 2](#) summarizes the tariff reductions that accompanied signing of NAFTA in 1994, describes the basic trends in relative wages and employment of women in Mexico over the 1990s and motivates the link between trade and gender that we formally developed in the model of [Section 3](#). [Section 3](#) outlines the model which links trade liberalization and the demand for female labor. [Section 4](#) describes the data. [Section 5](#) presents the main empirical results. [Section 6](#) concludes.

## 2. Background

We study a particular trade liberalization episode during the 1990s, the case of Mexico. Mexico implemented unilateral tariff reductions in the 1980s to join the GATT in 1986. By 1987, the highest tariff was reduced to 20% and the tariff structure was simplified to include only 5 different rates: 0%, 5%, 10%, 15%, and 20%. Starting in 1990, Mexico's opening strategy switched to pursuing bilateral free trade agreements, with the most important being the North American Free Trade Agreement (NAFTA) with U.S. and Canada which took effect in 1994. On average, tariffs applied by US (export tariffs) in 1991 were 6.1% and fell between 1991 and 2000 by approximately 5 percentage points. The data is based on the CMAP industry classification and there is considerable variation in the size of the declines across industries. Meanwhile, during the same period, Mexican tariffs imposed on imports from NAFTA countries (import tariffs) decreased on average by 13 percentage points (from 16.1% in 1991 to 2.6% in 2000) across CMAP sectors.<sup>8</sup> Since more than 80% of the trade occurs with the U.S., we would expect a priori that the decline in tariffs would lead to large increases in trade flows. [Fig. 1](#) shows the trends in exports and imports as fractions of GDP. The figure shows that while the unilateral tariff reductions had some impact in the 1980s, trade flows accelerated in the 1990s, after the bilateral agreement with the major trading partner was reached. Interestingly, trade flows appear to have stagnated again in the 2000s most likely due to a recession in the U.S. and China's entry into the WTO.

### 2.1. Trends in women's relative wage and employment share

While the focus of this paper is to study the impact of trade on production within the firm, it is nevertheless useful to start with an overview of the aggregate change in female wages and employment over this period. [Aguayo et al. \(forthcoming\)](#) use household surveys to

<sup>7</sup> See [Juhn et al. \(2013\)](#) for a summary of some of our results.

<sup>8</sup> We thank Leonardo Iacovone for providing us with the tariff data. Tariff data was available originally at the 8-digit Harmonized System (HS) classification and was matched to the Mexican CMAP class classification as explained in [Iacovone and Javorcik \(2010\)](#). More information on the tariff data is provided in the on-line appendix Table C1.

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