Female Labor Supply and International Trade

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Abstract

We study the effect of spatial variation in female labor supply on international trade flows. We identify the set of gender-specific skills and argue that low female labor supply reduces the endowment of female-oriented skills and undermines comparative advantage in industries which use female labor intensively. We confirm this hypothesis using two different settings. First, we show that countries with low female labor supply, measured by female labor force participation, have comparative disadvantage in female-labor-intensive industries. To establish causality, we instrument female labor supply with cross-country differences in cultural values regarding the role of women in society. Second, we confirm the main hypothesis on trade data from Chinese regions. Using spatial variation in sex ratios resulting from the One Child Policy (OCP), we rely on the stringency of OCP as an exogenous female labor supply shifter. Other things equal, regions with higher female population share specialize in industries which use female labor intensively. We interpret our results as highlighting the importance of labor force gender composition for industry's productivity. Our results imply that the effect of gender imbalances in labor supply on labor market outcomes, observed in many parts of the world, can be mitigated through international trade by utilizing relatively abundant type of labor in export-oriented industries.

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1 Introduction

The Heckscher-Ohlin theory identifies factor endowments as an important determinant of comparative advantage. A central message is that an increase in supply of a factor will change the mix of country's exports and will have profound implications for the formation of equilibrium factors prices, product prices, and production structure. As such, identifying the determinants of comparative advantage is crucial for understanding of how markets function and for devising effective policies. In this paper we study the supply of female labor as a source of comparative advantage. The existing literature documents important differences between male and female workers in terms of their comparative advantage in tasks that require different skills, such as social and physical skills (Cortes et al., 2021). This distinction allows us to view male and female labor as two separate factors of production, and propose that differences in female labor supply across countries and time can shape comparative advantage. We confirm this prediction empirically and show that spatial variation in the relative female labor supply, both between and within countries, determines the pattern of specialization and foreign trade flows.

Female labor supply matters for international trade so long as female labor endowments vary across countries and demand for female labor varies across industries. We take two distinct approaches to measure differences in demand for female labor between industries. First, building upon previous literature, we identify two sets of skills in which men and women have different comparative advantage – social skills, in which women are relatively better than men, and physical skills, in which men have an advantage. We call these two skills *gender-specific*, and document important differences in variation of the demand for these two skills across industries. Using U.S. Census data on occupational employment by industry and the O*NET data on the importance of social and physical skills by occupation, we show that industries differ in their use of occupations that require frequent social interactions or use of muscle force. Our second approach does not require any assumptions about gender-specific skills. Instead, it measures industry's intensity in female labor simply as the share of female workers in total employment in US manufacturing industries, which reveals heterogeneity in demand for female labor regardless of its underlying causes.

In the presence of differences in gender-specific skill intensities across industries and differences in female labor supply across countries, we expect countries with scarce female labor supply to have a comparative advantage in industries that use physical skills intensively and disadvantage in industries which use social skills intensively. We formalize this insight of the Heckscher-Ohlin model in Section 3 using the theoretical framework by Chor (2010). The Heckscher-Ohlin mechanism operates through the effect of female labor supply on the endowment of gender-specific skills. If workers have a certain amount of gender-specific skills, then countries with low female labor supply would have relatively large endowment and low premium for physical skills, which provides physical-skill-intensive industries with a comparative advantage in the global market. The model establishes a gravity-type relationship between country's gender composition of the labor force and its exports, and informs our approach to the data.

We test the effect of female labor supply on comparative advantage using two different sources of spatial variation in female labor supply. We start with country-level analysis, and, using country-level bilateral trade data, find strong support for the empirical predictions of the model. Specifically, we show that countries with low female labor supply, as measured by the female labor force participation (FLFP) in manufacturing industry, have comparative disadvantage in industries that use female labor intensively. Of course, FLFP is an equilibrium outcome of supply and demand factors for female labor. Our approach to identifying the effect of female labor supply on trade is based on the insight of Alesina et al. (2013), who use differences in cultural norms across countries to predict female labor supply. They found that countries with traditional plough agriculture have gender norms that lead to greater gender inequality today, and result in less female participation in labor force. Using traditional plough agriculture prevalence as the instrument for the FLFP, the results provide convincing support for the hypothesis that female labor supply is an important determinant of a country's comparative advantage.

Our second empirical test of the theoretical model is based on Chinese regional trade data. The advantage of this data is a unique institutional setting which allows identifying exogenous sources of spatial variation in the female labor supply. In 1979 China introduced a one-child policy (OCP) – a population control policy which aimed to curb population growth and advance economic development. While the OCP successfully lowered the population growth rate, it also had unintended consequences for gender composition. Since the OCP's commencement, the male to female ratio in Chinese population started to grow, and by 2000 the sex ratio at birth reached 120 males per 100 females, far away from the natural balance point of 105, which prevailed in the country prior to the policy. Previous research suggests that the main driving force behind distorted sex ratios is the traditional preference for sons in Chinese culture, so that the dual pressure to have a son and to comply with the OCP induces sex-selection behavior among parents. We confirm that the exogenous variation in the relative female labor supply across Chinese cities, caused by spatial variation in OCP stringency and preference for sons, is a source of regional comparative advantage.

Using exports data by 283 Chinese cities in 74 manufacturing industries to 205 destination countries, we estimate the static version of the model for the year 2006, as well as the dynamic model in differences. Our empirical findings suggest that a changes in the gender composition of cities in China has a significant and robust effect on the pattern of Chinese exports. Cities with low share of female workers in total population, caused by strict OCP enforcement, lose comparative advantage in industries that require skills in which female workers are relatively better than male. In the baseline specification, we find that an increase in the share of female residents in total population of a city by one percentage point and a one standard deviation increase in skill intensity of an industry is associated with an increase in exports by 3.1% for social skills and a decrease by 9.2% for physical skills, which is very close to the magnitudes of estimates from the cross-country data. In the dynamic model, we look at the change in the gender composition across cities between 1979, the year when the OCP was officially introduced, and 2006. The dynamic specification allows us to control for time-invariant city-industry sources of comparative advantage, and the results we obtain are very similar to those in the static model.

Our main concern with identifying a causal effect of gender differences in labor supply across cities in China on trade is associated with internal migration of workers. Local labor market conditions may shape the pattern of comparative advantage, while also attracting immigrants of a particular gender from other regions. In the absence of reliable data on internal migration flows, we use spatial variation in the OCP stringency as an exogenous shifter for the relative female labor supply. The two instruments that we use are the provincial fine rates on excess fertility and the number of local amendments to the country-wide policy, both being strong predictors of the gender imbalances among newborns at the city level. The intuition underlying this identification strategy is that the decisions on fertility fines and general implementation of the OCP were decentralized to local authorities and were set in accordance with local fertility targets rather than economic conditions in the region. Therefore, the two instruments are plausibly exogenous to both the internal migration flows and the level of economic development of a city. The effect of gender imbalances in labor supply on trade becomes even stronger when we instrument the female share of the labor force with the OCP stringency variables.

Our study of the effect of the relative female labor supply on comparative advantage connects with three strands of related literature. First, it contributes to the large and growing literature examining the sources of comparative advantage. In addition to traditional factors of comparative advantage, such as cross-country differences in capital and skilled labor (Romalis, 2004), a number of non-traditional sources of comparative advantage were identified in recent literature, such as cross-country differences in institutions (Levchenko, 2007; Nunn, 2007; Manova, 2008; Bombardini et al., 2012), demographic composition (Cai and Stoyanov, 2016; Gu and Stoyanov, 2019), and fiscal policies (Sharma, 2017). We complement this line of research by showing that differences in gender composition of labor endowment across countries, emerging as a results of differences in gender norms within or across countries, is also a source of comparative advantage.

Second, our paper contributes to the vast literature on gender market outcomes.[1] Our findings reveal the importance of gender composition of the labor force for exports in industries that differ in their use of social and physical skills. Underlying this result is the evidence coming from sociology and labor economics literatures that women have a comparative advantage in tasks that require social skills and disadvantage in tasks that require physical skills. Our results support this evidence by showing that excess supply of male labor in a local labor market raises productivity of firms that use physical skills intensively and boost their competitiveness in the global market, increasing demand for physical skills and balancing the skill premium. Thus, our findings fit into an important literature analyzing implications of differences in relative productivity of men and women in different tasks for labor market outcomes.

The paper is also related to the vast literature on the socio-economic implications of China's OCP. The main focus of this literature is on the effect of population aging associated with the OCP (İmrohoroğlu and Zhao, 2018; Ge et al., 2018; Mehlum et al., 2016). Existing research emphasizes the effect of the OCP on health, education, and macroeconomic outcomes. For example, Zhang (2017) and Li and Zhang (2017) find improvements in educational attainment due to the OCP as parents tend to invest more into education of their single child. As fertility rate decreases and life expectancy increases, acceleration of population aging stimulates households to raise their saving rate, by 50% on average between 1980 and 2010 (İmrohoroğlu and Zhao, 2018). Disparities in sex ratios, associated with the OCP, have been linked to higher crime rates (Edlund et al., 2013) and higher male labor force participation rate (Zhang, 2017). The effect of the OCP on comparative advantage that we identify in this paper suggests that an increase in the relative male labor supply can, to some extent, be alleviated by an increase in demand for male labor through expansion in the production and exports of goods that use male labor intensively. Moreover, the effect of gender disparities on Chinese trade will get even stronger as new cohorts, more affected by the OCP, start entering the labor market.

The paper is organized as follows. Section 2 surveys the literature on gender-dependent skills. Section 3 describes theoretical mechanisms that link spatial gender imbalances to comparative advantage. Section 4 presents the empirical model and identification strategy, and Sections 5 discusses the data. Section 6 shows the empirical results, and Section 8 concludes.

[1] The only other study that we are aware of that explores the link between female labor supply and trade is by Li (2021). She shows that countries specializing in female-labor-intensive industries observe increase in female employment opportunities. We show that the relationship goes in the other direction as well: countries with greater supply of female labor experience increase in exports of female-labor-intensive products.

2 Gender difference in social skills and physical abilities

The idea that men and women have comparative advantage in different tasks is not new to economics.[2] Although men and woman do not differ in general intelligence, specific cognitive tasks reveal sex differences. In this section we provide a brief overview of the literature on two skills for which there is a broad consensus on the presence of gender differences – social skills and physical abilities.

2.1 Social skills

Social and interpersonal skills are becoming increasingly important in labor markets, and the greater adoption of automation and artificial intelligence would only raise the value of social skills that machines do not posses, such as empathy, communication, negotiations, and ability to manage others. In a recent paper Deming (2017) argues that the demand of social skills – broadly defined as the ability to work with others – increases in the US labor market, as reflected in the growing share of occupations requiring social skills and higher wages in those occupations. The author argues that both the importance and the reward for social skills is increasing because they reduce the marginal cost of cooperation and increase the economy of scale.[3]

A growing body of work in physiology literature documents the presence of female's advantage in social skills. For instance, Baron-Cohen et al. (2005) analyze the difference in brain structure between women and men and claim that at the population level females are stronger empathizers and males are stronger systemizers. Woolley et al. (2010) show that after controlling for the average intelligence of group members, the group productivity increases with the social sensitivity of the group members, which is positively correlated to the share of female members in the group. After analyzing the data from the Early Child Longitudinal Study, DiPrete and Jennings (2012) claim that from the beginning of school, girls have an advantage in acquisition of social skills, which grows over time through elementary schooling and improves their academic achievements. Studying IQ test scores and self- and peer- reported questionnaires about social skills, Szymanowicz and Furnham (2013) conclude that both men and woman tend to rate female partners as being better at social skills than male ones. Van der Graaff et al. (2014) investigated adolescents' development of 283 boys and 214 girls aged 13 to 18 in six consecutive years and found that girls show significantly higher level of empathetic concern than boys, which is an important social skill, and that the difference remained stable throughout adolescence. A large number of other studies in psychology demonstrates that women have higher scores than men in warmth, agreeableness, empathy and openness to feeling, which are all important attributes of social skills (Pohl et al., 2005; Rudman and Glick, 2012; Argyle, 2013; Merrell and Gimpel, 2014; Drydakis, 2017; Slater and Bremner, 2017).

Studies in behavioral and neuroscience literature confirm that women are better than men in understanding feelings and thoughts of other people, which enable them to better interact in the social world. These studies also find that women tend to have better performance than their male counterparts on verbal processing, emotion recognition and social interaction abilities

[2]For example, Galor et al. (1996) analyze the role of complementary between capital and female-specific skills as the channel though which capital accumulation affects gender wage gap. Acemoglu et al. (2004), Niederle and Vesterlund (2010), Kuhn and Shen (2012), Card et al. (2015), and Blau and Kahn (2017) are among many other studies that analyze the role of gender-specific attributes in economics.

[3]A large number of other studies document the importance of social skills for economic outcomes. For example, Mobius and Rosenblat (2006) confirm the importance of social skills by decomposing the beautify premium in an experimental labor market, and claim that the social skills are crucial in smoothing interactions among people. Weinberger (2014) studies the complimentary of cognitive and social skills and shows that the adult outcomes are closely correlated with the social skills obtained in the adolescent period.

(Beauchamp and Anderson, 2010; Berenbaum et al., 2011; Eagly and Wood, 2013; Li and Wong, 2016; Davis, 2018). In particular, Chapman et al. (2006) argue that the gender differences in social skills may in part reflect the developmental differences in brain structure and function. Mueser et al. (2010) analyze a community-dwelling sample of people older than 50 with severe mental illness and claim that aging was associated with worse social skills, whereas female gender was related to better social skills. Focusing on stress, which is a ubiquitous challenge in society where people consistently interact with others under the influence of stress, Tomova et al. (2014) show strong evidence that women flexibly disambiguate self and others under stress, enabling more accurate social responses, while men respond with increased egocentricity and less adaptive regulation. It explains gender difference in social skills such as empathy and pro-sociality.

Several recent studies analyze the economic implications of differences in social skills across genders. Cortes et al. (2021) argue that one of the factors contributing the gender wage gap reduction in the US is the growing demand for social skills: with increasing importance of social skills in many occupations, female advantage in those skills results in a greater skill premium for female workers. Deming (2017) also documents increasing demand for social skills in the US and develop a model of team production where employee with heterogeneous productivities can perform a variety of tasks required to produce final output. Workers with better social skills can specialize and trade tasks with other workers more efficiently, thus obtaining better reward by reducing coordination costs and allowing workers to exploit their comparative advantage. Several other studies show that female employees have better social skills than male, which give women an edge in competition for top positions (Sjöberg et al., 2001; Schaillée et al., 2015; Jerbashian, 2016; Drydakis, 2017; Krieger-Boden and Sorgner, 2018). In particular, Kim and Starks (2016) study the increasing proportion of women directors on the boards of S&P 1500 firms and conclude that women directors can bring advisory skills into the board, which enhances the board's advisory effectiveness and results in a positive impact on the firm value. Cortes et al. (2021) argues that on average women are good at building and maintaining a relationship with other members of the society, but naturally men are stronger in body strength.

2.2 Physical abilities

Physical strength is one of those attributes where the sex difference is stark. It is widely know that men, on average, are physically stronger than woman, and the difference is well documented for various age groups, cultures and geographic locations (Björkqvist, 1994; Archer, 2004; Eckes and Trautner, 2012). To a large extent, the difference is due to the relative amount of muscle weight in bodies. A study by Janssen et al. (2000) found that man have on average 12kg more of skeletal muscle mass than woman, and have 30-40% more body strength. In labor economics, the differences in physical abilities between genders was found to explain a substantial part of the gender wage gap (Welch, 2000; De Ruijter et al., 2003; England et al., 2002; Juhn et al., 2014). In the context of international trade, Juhn et al. (2013) find that trade liberalization in Mexico, associated with membership in the North American Free Trade Agreement, lowered the gender wage gap due to the presence of differences in physical abilities across genders. In particular, the authors claim that trade liberalization induced the most productive firms to adopt new IT-intensive technologies. This technological change lowers the demand for physical skills and narrows the gender wage gap. The same literature suggests that physical abilities are more substitutable with capital than cognitive skills, and a large skill premium for physical ability may stimulate firms to switch to technologies that rely more on using machines than physical labor.

3 Theoretical framework

In the presence of gender-specific skills, the gender composition of a local labor market would affect the relative supply of those skills and determine the pattern comparative advantage through the Heckscher-Ohlin channel. Specifically, if the relative female labor supply in a given country is higher than the world average, the premium on the female-specific skills will be low and the country would have a comparative advantage in industries which heavily rely on female-oriented skills.

To formally obtain this result, we follow the extension of the Eaton and Kortum (2002) model by Chor (2010), which uses a flexible theoretical framework with multiple industries, factors of production, importing and exporting countries. The representative consumer in an importing country has a nested utility function with the Cobb-Douglas preferences over goods and a constant elasticity of substitution (CES) sub-utility function over differentiated varieties of a good. Assuming that international markets for each variety are perfectly competitive and the production technologies are constant return to scale, the world price of each variety is proportional to its marginal cost of production, iceberg trade cost, and the inverse of productivity. Furthermore, assuming that the Ricardian productivity of each industry and country is drawn from the Gumbel distribution, for any pair of countries c_1 and c_2, their relative exports of good/industry i to country p is given by

$$\frac{X_{c_1pi}}{X_{c_2pi}} = \frac{\left(\varphi^i_{c_1}/mc^i_{c_1}d^i_{c_1p}\right)^\theta}{\left(\varphi^i_{c_2}/mc^i_{c_2}d^i_{c_2p}\right)^\theta}, \tag{1}$$

where X_{cpi} is the value of exports of industry i from country c to country p, d^i_{cp} is the iceberg trade cost of shipping one unit of i from c to p, and θ is the inverse of the productivity shock variance. We assume that the Ricardian productivity φ^i_c can be decomposed into additive country- and industry-specific components μ_c and μ_i, which in the empirical specification will be absorbed by fixed effects:

$$\ln \varphi^i_c = \mu_c + \mu_i \tag{2}$$

The term mc^i_c in equation (1) is the unit production costs of country c in industry i, which captures the Heckscher-Ohlin comparative advantage. Following Chor (2010), we parameterize the unit cost function as follows:

$$mc^i_c = \prod_{k\in K} (\omega_{ck})^{s_{ki}} \prod_{f\in F} (\omega_{cf})^{s_{fi}} \tag{3}$$

The unit cost function (3) is a Cobb-Douglas aggregator of input factor prices, where ω_{cj} is the price of factor j in country c, K is the set of gender-specific factors of production, and F is the set of conventional factors of production, such as physical capital and skilled labor. s_{ji} is the share of factor j in total production costs in industry i. The Heckscher-Ohlin comparative advantage operates through the endowment of production factors since differences in the supply of gender-dependent skills across countries affect the costs of producing and exporting the good to other markets. If the stock of social skills is decreasing with the female share in labor force, the supply of social skills in the country will decrease, thus raising the local skill premium for social skills. As a result, the marginal costs of production will increase, and more so in industries with larger expenditure share on social skills, thus deteriorating the country's comparative advantage in industries with high intensity in social skills.

If the Heckscher-Ohlin channel plays a role, the relative factor prices are inversely related to the relative factor endowments, and, as in Romalis (2004), the natural logarithm of the unit cost function becomes

$$\ln mc_c^i = -\sum_{k\in K} \phi_k^* s_{ki} \ln\left(FC_c^k\right) - \sum_{f\in F} \phi_f s_{fi} \ln\left(FC_c^f\right), \tag{4}$$

where FC_c^l is the endowment of factor $l \in K, F$ in country c, measured relative to some reference factor, and $\phi_k^* > 0$, $\phi_f > 0$. Substituting equations (2) and (4) into (1), we obtain

$$\begin{aligned} \frac{1}{\theta}\ln\left(\frac{X_{c_1pi}}{X_{c_2pi}}\right) &= \sum_{k\in K}\phi_k^* s_{ki}\ln\left(\frac{FC_{c_1}^k}{FC_{c_2}^k}\right) + \\ &\sum_{f\in F}\phi_f s_{fi}\ln\left(\frac{FC_{c_1}^f}{FC_{c_2}^f}\right) + (\mu_{c_1} - \mu_{c_2}) - \left(d_{c_1p}^i - d_{c_2p}^i\right) \end{aligned} \tag{5}$$

The interaction terms between sectors' factor cost shares and country's factor supplies are the key for our analysis, and the coefficients ϕ_k^* show the extent to which gender-specific skill are a source of comparative advantage. Equation (5) also allows to analyze the dynamic effect of changes in the gender composition of countries over time on comparative advantage. It is easy to see that if the female labor supply in countries c_1 and c_2 changes at different rates, their relative exports will also change: countries with a more rapidly decreasing female labor supply should observe a reduction in female-specific skill endowments and a boost in their premia. This, in turn, will shift the country's export structure away from industries which use female labor intensively through the Rybczynski effect.

The above discussion implies that if gender norms in one country discourage women from work, then the country will have a deficit of female labor, resulting in comparative disadvantage in industries which use female-specific skills. Similarly, if one city in China implements the OCP more stringently than another city, the former must have a stronger comparative advantage in industries which are intensive in physical skills and disadvantage in industries which are intensive in social skills. Furthermore, a more rapid decline in the female labor supply in one country/city relative to another should result in less exports in industries which use social skills intensively and more exports in industries which use physical skills intensively.

4 Empirical strategy

4.1 Static model

Equation (5) in the previous section demonstrates the relationship between female labor supply and the comparative advantage of a country. In moving from theory to data, we face two challenges. First, estimation of the Heckscher-Ohlin effect in equation (5) requires information on the share of each gender-dependent skill in total costs of each industry, s_{ki}. Since information on gender-dependent skill premia is unavailable, we construct an alternative measure of industry's intensity in gender-specific skills, I_i^k, which we describe in detail in Section 5.2. Second, we need information on country-level stocks of gender-specific skills FC_c^k. This information is also unavailable to us, but we know that the skill stock is related to the female labor supply. We assume that this relationship is linear, so that the country-level stock of gender-specific skills is a linear function of the relative female labor supply, FS_c:

$$\ln FC_c^k = \sigma_0^k + \sigma_1^k FS_c \tag{6}$$

where σ_0^k is the average level of the natural logarithm of the local stock of the gender-specific skill k, and σ_1^k is the semi-elasticity of FC_c^k with respect to FS_c. Because the local stock of social skills is increasing with the female labor supply, we expect $\sigma_1^k > 0$ if k is a female-specific skill. At the same time, the local stock of physical skills is decreasing with the local female labor supply, and we expect $\sigma_1^k < 0$ for physical abilities. Therefore, the theoretical model (5) can be estimated with the following empirical model:

$$\ln X_{cpi} = \sum_{k \in K} \beta_k I_i^k \times FS_c + \sum_{f \in F} \phi_f I_i^f \times FC_c^f + \gamma_{cp} + \gamma_{pi} + \varepsilon_{cpi} \tag{7}$$

where $\beta_k = \phi_k^* \sigma_1^k$ are the main coefficients of interest. Based on our previous discussions for equation (6) and (5), σ_1^k is positive for social skills and negative for physical abilities, while ϕ_k^* is always positive. Therefore, $\beta_k > 0$ for female-specific skills and $\beta_k < 0$ for male-specific ones.

In equation (7), the estimates of β_k coefficients allow us to test the static theoretical prediction developed in Section 3. Since the intensity in gender-specific skills, I_i^k, varies across industries i, and the relative female labor supply FS_c differs across countries c, we can derive β_k from a static empirical model (7) as follows

$$\beta_k = \frac{\partial^2 \ln X_{cpi}}{\partial I_i^k \partial FS_c} \tag{8}$$

If the difference in skill intensities across industries is positive ($\partial I_i^k > 0$), then a higher female labor supply ($\partial FS_c > 0$) must result in a higher exports from country c if k is a female-specific skill ($\beta_k > 0$).

In equation (7), we also control for two standard Heckscher-Ohlin input factors, namely, physical capital and human capital. As long as countries export more in industries which intensively use their abundant factors, we expect $\phi_f > 0$ for these two factors of production. The exporter-importer fixed effect γ_{cp} in equation (7) capture iceberg trade cost between trading pairs, and the importer-industry fixed effect γ_{pi} capture product prices and other demand shifters in importing countries, including those which may be driven by cross-country differences in gender structure.

The final point to note is that the theoretical model by Chor (2010) can accommodate the effect of female labor supply on differences in Ricardian productivities across countries. If male workers are less productive in tasks that require a gender-specific skill k but still perform those tasks due to some labor market friction, the Ricardian productivity term (2) will also depend on the interaction of industry's intensity in skill k, I_i^k, and the country's relative female supply, FS_c:

$$\ln \varphi_c^i = \mu_c + \mu_i + \sum_{k \in K} \rho_k^* I_i^k \times \ln FS_c$$

As long as industries inherit the gender distribution of a local labor market, a decrease in the female labor supply would imply a Ricardian productivity disadvantage in industries which use social skills intensively ($\rho_k^* > 0$) and a productivity advantage in industries which use physical skills intensively ($\rho_k^* < 0$). In such case, the Ricardian comparative advantage term $\sum_{k \in K} \rho_k^* I_i^k \times (\ln FS_{c_1} - \ln FS_{c_2})$ would enter the equation (5), and the main coefficients of interest in (7) become $\beta_k = \phi_k^* \sigma_1^k + \rho_k^*$. We would still expect β_k to be positive for female-specific and negative for male-specific skills, but the coefficient would capture both the the Ricardian and the Heckscher-Ohlin channels through which female labor supply affects trade.

4.2 Dynamic model

In order to test the dynamic prediction of the theoretical model regarding the effect of a change in gender composition across countries over time, we time-difference equation (7) and estimate the following empirical model:

$$\triangle lnX_{cpi} = \sum_{k\in K} \beta_k I_i^k \times \triangle FS_c + \sum_{f\in F} \phi_f I_i^f \times FC_c^f + \nu_{cp} + \nu_{pi} + \varepsilon_{cpi} \tag{9}$$

where Δ indicates the time-difference operator, ν_{cp} and ν_{pi} are the exporter-importer and importer-industry fixed effects that capture time trends in bilateral trade costs and demand shifters in importing countries. Allowing gender composition of population to change over time, we fist assume that the industries' factor intensities are constant in order to focus on the female labor supply as a single dynamic factor leading to changes in the comparative advantage. Then, we show that this assumption is not critical for the estimates of β_k, and demonstrate that changes in gender composition at the country level do not pick up the effect of changes in factor intensities on comparative advantage. The positive (negative) coefficients on the variables of interest, β_k, show that countries with relatively larger changes in the female labor supply gain (lose) comparative advantage in industries that heavily rely on female-specific skills.

The main advantage of adding time dimension into the data structure is that it allows controlling for the omitted time-invariant factors in the static model. In particular, many country-industry characteristics, which have been shown in previous studies to determine comparative advantage, are persistent over time. Among those factors are the cross-country institutional differences, the level of financial development, the quality of the judicial systems and education systems. Due to data limitations and different industry classifications used in this and the previous studies, we cannot control for all of these factors in the static cross-sectional model (7), but we can difference them out in a dynamic model (9) and alleviate a potential omitted variable bias problem.

4.3 Endogeneity problems

Although in both the country-level and city-level settings we use the same empirical model to estimate the effect of female labor supply on trade, different ways of measuring the female labor supply imply completely different identification challenges. In this section we discuss identification threats to each of the two frameworks along with the proposed instrumental variable solutions.

4.3.1 Endogeneity of female labor force participation

The main concern with the FLFP variable comes from the fact that its realized level is formed under the influence of both the supply and the demand factors. Low FLFP may be a result in low employment opportunities in export-oriented industries if the country specializes in products that are intensive in male-specific skills.

In order to isolate the cross-country variation in the FLFP that stems from variation in the female labor supply, we employ an instrumental variable approach. As an IV for the FLFP we use a measure of the prevalence of traditional plough agriculture in a country from Alesina et al. (2013). In their study, the authors find that societies that traditionally used plough agriculture have lower female participation in the workplace, and they attribute these differences to gender norms developed within societies over centuries. Since plough agriculture is intensive in physical labor, in which men have an advantage, it encouraged division of labor along gender lines in which men work outside the home in the field and women specialize in activities inside the home. Over time, such division of labor generated social norms that require women to work from within a house, reducing female labor supply. The authors find that these norms are still prevalent in modern societies and show that traditional plough agriculture is a strong predictor of lower FLFP in a country and women' participation in other economic and political activities. Furthermore, these relationships are not sensitive to conditioning on income per capita of a country, suggesting that not only the plough use is pre-determined relative to present-day trade flows, but also that its effect on the relative female labor supply is independent of the country's economic development.

4.3.2 Endogeneity of female population share

The main identification challenge in estimating equation (7) with the data on female population share of Chinese cities is the internal migration in China. A large population of internal migrants may play an important role in determining gender composition of the local labor markets. If there are any socio-economic factors co-determining city-level exports and the gender composition of migrants, these factors would confound the effect of the female labor supply on the comparative advantage and lead to biased estimates of β_k coefficients. Therefore, internal migration is a crucial channel that links potential confounding factors to city-level female population share.

One such confounding factor is the economic system in China prior to 1979. Before 1979, China was a closed centrally planned economy. Many economic decisions, such as location for a new plant, were often driven by political considerations rather than market factors. As a result, economic activity in many industries was not spread evenly across cities but was often concentrated in geographic clusters. Since industries differ in their intensities in gender-dependent skills, establishment of a certain industrial cluster in a city may have a differential effect on the local demand for male and female workers. For instance, establishment of a large steel plant may attract disproportionately more male migrant workers who are better endowed with physical abilities, thus, lowering the city's female population share. At the same time, steel plant operation will increase steel exports by that city for many years to come. Therefore, pre-1979 economic conditions that stimulate internal migration may have a long-lasting effect on both the female labor share and the exports of a city, and incur a potential endogeneity problem.[4]

Another possible confounding factor is the improvement of inter-city public transit system, which reduces the cost of traveling within China. As a result, it stimulates internal migration between regions and makes it easier for young people to work far away from their hometowns and travel back home only occasionally to reunite with families. As such, transportation system is a factor facilitating internal migration and determining the city-level gender structure. At the same time, improving infrastructure reduces transportation cost and boosts exports, especially in industries with high share of transportation costs in the value added.

In both examples from above, the threat to identification of the effect of female labor supply on trade is coming from the presence of third factors, which affects both the structure of exports and the gender composition of a city though internal migration. To address these endogeneity concerns, we employ two instrumental variables for FS_c, both related to the stringency of OCP in China. These instruments identify changes in the female population share stemming from the

[4] Of course, endogenous choice of geographic location by firms after 1979, when economy started its transition to a market economy, can also be a confounding factor if industries continue to clustered in certain areas and attract immigrant workers of a particular gender. However, this source of endogeneity will partially be alleviated by the fact that firms from gender-skill-intensive industries would have incentives to locate in cities with imbalanced sex ratios.

OCP, thus isolating the effect of the OCP on cross-city difference in gender composition from the effect of internal migration. We then instrument the interaction terms $I_i^k \times FS_c$ with $I_i^k \times \widehat{FS}_c$, where $\widehat{FS}_c$ is one of the instruments for the female population share.

The stringency and enforcement of the OCP had a substantial geographic variation in China. The central government set different fertility targets for different provinces, and the decisions on benefits and penalties for violations had been decentralized to the local authorities. The OCP was strictly enforced in urban regions, while in rural areas mothers of daughters were allowed to have a second child. The policy also had more lax limits on the number of children for ethnic minorities.[5] Since urban areas are concentrated in the coastal provinces and ethnic minorities tend to reside in the border provinces, the gender imbalances, implied by the OCP, vary substantially across provinces, as Figure 2 shows. Some studies argue that the strength of preference for sons also varies across provinces in China. For example, Poston Jr et al. (1997) find that spatial variation in preference for sons is related to the sex ratio at birth, while Das Gupta et al. (2003) relate regional variation in sex ratios to cultural differences and the role of woman in a family.

Figure 4 illustrates variation in the female share before and after introduction of the OCP. In the figure, we plot the histograms of the female population share across cities for age groups 0-21, born after the introduction of the policy (left panel), and 22-65, born prior to the policy (right panel), along with the fitted normal distribution densities. By comparing the female share distributions of the two population groups, we see that the OCP affected not only the mean of the female share, which was the main target of the policy, but also the variance. The cross-city coefficient of variation of the female share in post-1979 cohorts is almost twice as large as in the pre-1979 cohorts.[6] As the previous studies demonstrate, this increased variation is systematically related to spatial variation in son preference and the stringency of the OCP.

Our first instrument for the female population share is the OCP violation fine rate. As previously discussed, the main factor behind growing sex ratio at birth in China is the combination of the fertility control policy and the preference for sons. In regions with tighter fertility control measures parents are more likely to invest in sex selection, and the sex ratio at birth is likely to be higher. This logic suggests that the spatial variation in the OCP strictness can predict variation in the female labor share. One of the most important measures of policy strictness is the OCP violation fine rate. Families that exceeded their fertility limits were required to pay a fine, which was set by provincial authorities and formulated in multiples of household annual income. Ebenstein (2010) reports substantial variation in fine rates across provinces, ranging from 10% to 160% of the household's annual income. Furthermore, he documents strong positive relationship between provincial fine rates and the male fraction of births.[7]

The intuition underlying the validity of this instrument is the high degree of decentralization of the OCP implementation. While the population control was applicable throughout China, local authorities were left to formulate their own regulations and develop enforcement mechanisms.

[5] The OCP allowed for other more subtle exceptions from the strict limit of one child, which could also introduce geographic variation in OCP implementation. For example, "a second child is permitted under special conditions such as the first child is disabled, a spouse return from overseas, the first child is a girl and the couple has real difficulties, or one spouse is a deep-sea fisherman or works in underground mining for more than five years" (Liao, 2013; Ge et al., 2018; Zhang, 2017). The definition of "real difficulties" was open to interpretation by officials at the city level.

[6] The standard deviation of the cross-city female share distribution increased from 0.018 for people born during 1935-1978 to 0.028 for those born during 1979-2000.

[7] Along with financial punishment for policy violation, there were non-financial enforcement mechanisms, such as dismissal from employment and disqualification from social benefits. However, fines were the major component of the enforcement policy, and the average fine rates have been shown to relate well to other enforcement mechanisms.

With such system of OCP administration, the violation fine rates were set not by the central government in accordance with a certain economic criteria, but by the provincial authorities in accordance with local conditions. As a result, the variation in fines across provinces mostly comes from the variation in pre-OCP fertility rates and targets rather than economic conditions that may determine future trade composition of a province. Furthermore, the fine rates were set many years before the affected cohorts entered the labor market, and are thus unlikely to be related to future migration flows.

The main shortcoming of the above instrument is that the fine rates on excess fertility were set by provincial authorities and thus do not vary across cities within a province.[8] However, the implementation of the OCP was carried out by prefectural officials, who often set their own fertility target and instituted localized enforcement policies. For example, local authorities may include additional regulations on internal immigrants, monthly bonuses for families that obey the OCP, or some technical details regarding the enforcement of the OCP at the city level. While local variability in the policy is known to be important, it is hard to quantify and often unobservable.

In order to explore heterogeneity in the OCP intensity across cities, we complement the provincial fine rates with the second instrument that captures variation in the policy within provinces. That second instrumental variable is the number of city-level amendments to the country-wide OCP, announced in the local government printed media.

In general, high frequency of policy amendments is related to stronger incentives to comply with the OCP at the local level, and the relationship between this instrument and the female population share can be either positive or negative. On one hand, local amendments improve compliance rate, which is negatively related to the sex ratio at birth. On the other hand, local amendments to the OCP may signal that the policy fertility targets were not met in previous years due to weak enforcement or for some other reasons, thus making the sex ratio at birth closer to natural. Regardless of whether the relationship between the local policy amendments and the female share is positive or negative, this would be a valid instrument as long as it is uncorrelated with internal migration in future periods. While differences in policy enforcement across cities may affect the decision of a family to reside in one city over another and alter sex ratios at birth, it is difficult to think of any reasons for why enforcement may have differential effect on the internal migration of male and female workers in subsequent periods. Because in this study we use 2000 Census data and the effects of government regulation may manifest themselves prior to their official announcement due to disclosure, we count the number of local government amendments of the OCP before October 2000.

5 Data

In order to estimate the effect of female labor supply on comparative advantage using equation (7), we construct a data set by bringing together four data sources: i) a measure of relative female labor supply by country/city, ii) the measures of industry-level intensities in gender-dependent skills, iii) industry-level exports by country/city, and iv) industry-level intensities in capital and skilled labor, as well as country/city-level measures of endowments in these factors of production. The resulting cross-country data set is comprised of 138 exporting counties, 83 manufacturing

[8] Each province applied different fine rate on different categories of families. Ebenstein (2010) use this fact and construct city-level fines from the variation in demographic composition across cities within the same province. However, the demographic composition, especially the share of ethnic minorities, is strongly correlated with the level of economic development, which may render the prefecture-level fines endogenous.

industries and 186 export destinations at 5-year intervals from 1995 to 2005. The sample for China includes 283 cities, 74 industries and 205 destination countries for the year 2006. In what follows, we describe in detail the construction of the main variables for the static and the dynamic models.

5.1 Relative female labor supply

Since the relative female labor supply is unobservable, we use measures reflective of the local female labor supply, and then rely on instrumental variables to purge these measures from other influences. As a measure of relative female labor supply at the country level we use FLFP in manufacturing sector for prime-age women (25-64 years old), taken from the World Banks's *World Development Indicators*. This measure is constructed as the rate of female participation in the workplace multiplied by the share of manufacturing sector in total employment. Of course, the FLFP is an equilibrium outcome of supply and demand conditions. For this reason, in the empirical analysis we isolate the supply-driven portion of the FLFP by instrumenting it with institutional characteristics that are plausibly independent of the demand-side conditions, as we explain in detail in Section 5.5. Figure 1 illustrates variation in the FLFP across countries.

To construct the FS_c variable for Chinese cities, we use the female population share among local residents from the 2000 China Population Census (CPC). The CPC records information on 1,180,111 individuals from 345,167 households at 4-digit CSLID prefecture/city level, selected randomly by the National Bureau of Statistics of China (NBSC). Because we use Chinese exports data for the year 2006 while the CPC data is for the year 2000, we construct FS_c variable as a share of female residents in the total number of residents of city c for the 12-21 age cohort. We focus on this age group for two reasons. First, 12-year-olds in 2000 Census will enter the legal working age of 18 in 2006 and may enter the labor market. Second, people aged 21 in 2000 is the first cohort affected by the OCP, introduced in 1979. Constructed this way, FS_c variable is a good approximation for the female share in the 18-27 age group in 2006. For the sample of 283 cities that we use in the baseline regressions, FS_c has a mean of 0.50 and a standard deviation of 0.04. Table 1 lists distribution characteristics of the FS_c variable, while Figures 2 and 3 show differences in FS_c across provinces and cities, respectively. Appendix A1 provides more details on the sources of variation underlying spatial differences in the OCP and sex ratio imbalances across regions in China.

There are two issues with the above measure of female population share of a city that may affect the quality of the variable. First, as discussed in Section 4, there is a lot of internal migration in China. Some immigrants move permanently to a new place of residence which would be reflected in the Census data, but a large number of others stay registered in one city and work in another. Liang and Ma (2004) estimate the floating population, which are migrant workers residing in cities where they have no local registration, at 145 million, or more than 10 percentage of the Chinese total population. We rely on our instruments to deal with the issue of internal migration.

The second problem with the quality of FS_c variable is related to the problem of unregistered children who will be missing from the Census data. The OCP requires parents who have out-of-plan birth to pay a hefty fine, and some parents may want to delay registration in order to avoid the penalty. Moreover, such parents are less likely to delay registration of sons because lack of registration can make it difficult to enroll a child into high school, and strong son preference suggests that parents are more willing to invest in education of sons. Indeed, many studies argue that unreported girls is an important factor of the observed sex ratio imbalance in China.[9] Unfortunately, the measurement error problem, induced by disproportionately unreported female births, not only distorts the FS_c variable, but also correlates with our instrumental variables. To address this problem, we rely on the fact that most unreported children get registered as teens in order to get immunization and attend high school. In Section 6.2.3 we show that our IV results are robust to using the female population share constructed for residents aged 16-20 in 2000 Census, which is the first cohort affected by the OCP and the least likely to suffer from the measurement error resulting from unreported births.

5.2 Industry-level intensities in gender-specific skills

In constructing I_i variable we take two different approaches. The first approach is to obtain a direct measure of industry's intensity in female labor as a share of female workers in total sectorial employment. As long as there are gender differences in skill requirements of different jobs, women will select into industries that require female-specific skills, and it will be reflected in the female share of industry's labor force. For country-level analysis, we construct female employment share from the US data at 4-digit North American Industry Classification System (NAICS), using 2000 Annual Survey of Manufactures. One may be concerned that the female employment share of an industry can be an endogenous response to the deficit of female workers in the local labor market. Constructing female employment share from the US data avoids this problem.

For the analysis of Chinese exports, we construct sectorial female employment share from the 2004 Chinese Industrial Enterprises Database (CIED), maintained by the NBSC, which contains information on the location and industrial affiliation of all Chinese firms with annual sales over 5 million Chinese Yuan, or approximately $600,000 US dollars at 2006 exchange rate. The database records employment at each firm by gender, and we aggregate this information up to industry level. The two measures constructed from the US and the Chinese data are highly correlated, with the rank correlation of 0.8, and produce similar results, which we report in the robustness section. Because we work with 4-digit NAICS industrial classification, we need to convert CIED data into 4-digit NAICS. In CIED, firms are classified by the 4-digit Industrial Classification for National Economic Activities (ICNEA), which we map into the 4-digit NAICS in two steps. First, we convert 4-digit ICNEA into the 3-rd revision of the 4-digit International Standard Industrial Classification (ISIC) by applying concordance tables from China's National Bureau of Statistics. Second, we use the concordance tables from U.S. Census Bureau to convert 4-digit ISIC into 4-digit NAICS.

Our second approach to constructing I_i is to identify a particular gender-specific skill and quantify industry's intensity in that skill. In constructing industry intensities in gender-specific skills, we rely on occupation-level data from the Occupational Information Network (O*NET). The database provides measures of importance of social and physical skills for over 900 occupations in the US. To obtain industry-level measures of skill intensities, we match O*NET occupation-specific importance scores to occupational composition of US 4-digit NAICS industries, and construct the employment-weighted scores of skill importance using the following

[9]For example, Cai and Lavely (2003) compare 1980 and 2000 Censuses and conclude that 12.8 million fewer girls were born over this period than would normally be expected, and that 8.5 million were truly missing due to sex selection, while the remaining 4.3 million were not reported at birth. Later studies by Goodkind (2004) and Shi and Kennedy (2016) find a larger share of unreported girls, between 20 and 30 million, and a smaller share of late registrations.

formula:

$$I_i^k = \sum_j Occup\_share_{ij} \times Skill_j^k \tag{10}$$

where $Skill_j^k$ is the level of importance of the gender-specific skill k for occupation j, $Occup\_share_{ij}$ is the share of occupation j in industry i, and I_i^k is the intensity of gender-specific skill k for industry i. Equation (10) shows that the variation in each gender-dependent skill intensity across industries comes from the variation in the level of skill importance across occupations, as well as from the variation in the occupational structure between industries.

We measure $Skill_j^k$ in equation (10) using O*NET information on the importance of social and physical skills for different occupations. In the O*NET database, both social and physical skills are complex categories that include multiple related measures. The category of social skills contains the following six basic skills: Coordination, Instructing, Negotiation, Persuasion, Service Orientation, and Social Perceptiveness. Specifically, Instructing, Negotiation and Persuasion reflect the importance of communication skills, Service Orientation and Social Perceptiveness capture the importance of understanding, and Coordination and Negotiation measure the importance of interpersonal relations. The category "Physical abilities" include nine basic skills: Dynamic Flexibility, Dynamic Strength, Explosive Strength, Extent Flexibility, Gross Body Coordination, Gross Body Equilibrium, Stamina, Static Strength and Trunk Strength. Due to high correlation between skills within each category, we combine all skills within each group into one aggregate measure using the principle component analysis (PCA).

The occupational employment shares for 4-digit NAICS industries come from the US Bureau of Labor Statistics. After matching occupational employment shares to the O*NET importance measures of social and physical skills at the 7-digit Standard Occupational Classification (SOC), we use the shares of occupational employment as weights in equation (10), and calculate the intensity of social and physical skills in 4-digit NAICS industries as a weighted average of social and physical skills importance across occupations within an industry.

Since occupational composition at the industry level is not available for China, we use this variable for the analysis of both the country-level and city-level exports. One may naturally be concerned that the US employment shares may not accurately reflect the demand for different occupations in China, in which case I_i^k with US employment shares will be a noisy measure of the importance of the gender-specific skill k. We assume that the relative ranking of industries in their use of gender-dependent skills in China is similar to that in the US, which is indeed the case for the female employment share. However, we cannot test this assumption in the absence of information on the SOC occupational structure of Chinese industries. The advantage of using US occupational shares is that these shares are independent of changes in the Chinese labor markets. Using Chinese employment shares in equation (10) may result in endogeneity of I_i^k because occupational employment shares may reflect industries' response to changes in the relative supply of female labor by substituting away from the use of gender-dependent skills that become scarce. If industries differ in the ease with which they can substitute away from using gender-dependent skills, I_i^k variable, constructed with the Chinese employment shares, would be endogenous in equation (7).

In Table 2, we list ten industries with the highest and the lowest intensities in female labor, social skills and physical abilities, while Table 3 reports ten occupations with the highest and the lowest intensities in gender-specific skills. For occupations which do not require much interaction with other workers, such as material moving workers, vehicle and machine operators, or assemblers, the importance of social skills is low. As a result, in industries where most workers enter in these occupations, the intensity in social skills is also low.[10] In contrast, industries that produce electronic equipment and machinery tend to be intensive in social skills because of a relatively large share of workers in these industries being in occupations that require social interactions, such as managers, sales/marketing specialist and engineers. Operations managers, business operation specialists, engineering technicians and engineers are among occupations with the highest intensity in social skills. These positions have relatively high employment share in industries such as navigational, measuring, electro-medical and control instruments manufacturing, communications equipment manufacturing and semiconductor manufacturing. More than 40% of workers in these industries enter as engineers and operation managers, making these industries among the most intensive in social skills. Table A1 in the Appendix provides detailed information on occupational employment composition for all 74 manufacturing industries used in our analysis. And in the Appendix Table A2 we show that our main results are not driven by outliers in the constructed I_i^k variables.

5.3 Exports data

Estimation of equation (7) requires exports data by industry and destination country. The country-level exports data we obtained from the UN-TRAINS database at 6-digit Harmonized System classification, which we map into 4-digit NAICS industries using concordance from Pierce and Schott (2009).

As for Chinese exports, we first need to define a local labor market within a country because the main objective of this paper is to relate demographic characteristic of workers in local labor markets to the comparative advantage of firms operating in these markets. Our definition is based on the 4-digit China Standard Location Identification System (CSLID), which divides China into 344 geographic units and includes all prefecture-level cities and four municipalities. For simplicity, we call these geographic units "cities". Defined this way, each city is a sizable geographic area with most workers being employed in a city of their residence. Furthermore, the *hukou* policy of workers' registration is conducted at the prefecture level, making it easier for workers to move and seek new employment within a city than across. This makes cities a logical choice of a geographic unit for local labor markets in our analysis.[11]

The information on city-industry-level exports is obtained from the Chinese Customs Database (CCD), administered by the China's General Administration of Customs. The CCD records firm-level export flows by destination country at 8-digit Harmonized System (HS) industry code, which we convert into 4-digit NAICS using the Pierce and Schott (2009)'s concordance. In the end, we construct the data set of Chinese exports by 4-digit CSLID city, 4-digit NAICS industry, and destination country for the year 2006, the most recent year for which the trade data are available.[12]

[10]For example, in Apparel and Leather Tanning and Finishing industries more than half of the labor force work as operators of sewing and cutting machines. Both occupations are among ten occupations with the lowest levels of social skill importance.

[11]For example, a study by Xu et al. (2006) finds that Chinese cities located as close as 50 kilometers to each other have segmented labor markets, reflected in differences in the gender wage gap, returns to education, and occupational premia.

[12]The first cohort of workers who were affected by the OCP entered Chinese labor market either in 1997 (if they completed high school) or in 1995 (if they completed only middle school). Hence, we want to work with as recent trade data as possible, so that a larger share of the labor force would be affected by the OCP.

5.4 Endowments and intensities in skilled labor and physical capital

For cross-country analysis, the measures of intensity in skilled labor and physical capital at the industry level are taken from Cai and Stoyanov (2016).The skill intensity measure is constructed as the share of non-production workers in total sectoral employment, and capital intensity as the log of the ratio of capital stock over total employment, both derived from 1998 US Census of Manufacturers. Data on physical capital endowment, measured as log of capital stock per worker, is retrieved from the Penn World Table for the year 2000. Human capital stock is obtained from Barro and Lee (2013) and is measured with the share of population with secondary and tertiary education, also for the year 2000.

For the analysis of Chinese exports data, the industry-level measures of intensity and the city-level measures of endowment in skilled labor and physical capital are all derived from the 2004 CIED. The main reason of choosing the CIED for the year 2004 is that only in this year the CIED collects firm-level information on physical assets and employee educational attainment. For every firm in the data, we define capital stock as the value of firm-level fixed assets, which is then aggregated up to industries and cities. The industry-level capital intensity is constructed as the natural logarithm of the ratio of capital stock to total sales of an industry, while the city-level capital endowment is the natural logarithm of the ratio of capital stock to total sales in a city. Similarly, the industry-level intensity in skilled labor and the city-level endowment of skilled labor are obtained as the natural logarithms of the share of skilled labor force in total employment of an industry and a city, respectively.[13] In total, the information on skilled labor and physical capital controls is available for 340 cities and 74 industries in 2004.

5.5 Instrumental variables

Our instrument for the female labor force participation at the country level is the traditional use of plough agriculture, taken from Alesina et al. (2013). The authors collect information on pre-industrial plough use for over 1,000 ethnic groups, and then use geographic distribution of these groups within a country to construct an index of plough prevalence. This measure provides the estimate of the fraction of the population of a country that traditionally engaged in plough agriculture.

In order to address the endogeneity problem of the female population share of cities in Chinese data, arising from its correlation with the flow of workers across cities, we employ two instrumental variables for FS_c. Information on the OCP violation fines, our first instrument, is taken from Ebenstein (2010). The fine on excess fertility is defined as a share of a household's annual income. Typically, the fines were collected as annual deduction over multiple years, and the rates that we use are the corresponding present value of a one-time penalty.

The second instrumental variable is the number of city-level amendments to the country-wide OCP. This instrument is a count variable, calculated as the number of announcement by local authorities, both province- and city-level, regarding modifications to the OCP and implemented between 1979 and 2000. All local government announcements are retrieved from the online database of local government legislation "Lawinforchina Weekly",[14] built in 1985 and maintained by the Peking University, using "China one-child policy" as a search key word. After breaking down provincial announcements into city-level announcements, we obtain 1,302 local government announcements regarding the OCP from 1979 to 2000 across 340 cities.

[13] Skilled workers are those with at least a college degree. Information on skill composition of labor force is obtained from CIED.

[14] The website is www.pkulaw.com/law/lar

Table 1 provides summary statistics for our baseline sample. Although the above instruments are pre-determined relative to future trade flows, one may still be concerned that the instruments are not completely exogenous if correlated with other economic characteristic that matter for trade. The conflation of the OCP stringency with the level of economic development is the greatest concern. For example, the OCP stringency, such as fertility targets, or OCP enforcement mechanisms, such as fine rates, may be different for high- and low-income regions. To gain a better understanding of how much variation exist in the female population share and our two instruments apart from income level, in column (1) of Table 4 we report the correlation coefficients between the GDP per capita of a city on one hand and the instrumental variables and the FS_c variable on the other. We find that sex ratios tend to be more distorted in less developed cities as the correlation between GDP per capita and FS_c is positive. The two instruments are also positively correlated with GDP per capita of a city but that correlation is weaker and statistically significant only at 10% confidence level. Since OCP implementation was carried out by local authorities, we do not find strong evidence that implementation varied across cities in a way that is related to their economic development. At the same time, both instruments have strong and statistically significant association with the female population share.

6 Empirical results

This section presents evidence on the importance of female labor supply for trade using cross-sectional data, first discussing the results from cross-country analysis, and then focusing on the findings related to Chinese cities. The next section presents results from the dynamic model estimation.

6.1 Country-level evidence

In this section we use variation in the relative female labor supply across countries in the year 2000 to test the hypothesis that gender composition of labor force is a factor of comparative advantage. Table 5 presents the IV estimation results for equation (7). For ease of comparison, we report standardized beta-coefficients in all tables. Since the dependent variable is defined at more disaggregated level than the main explanatory variables, the standard errors are clustered by country-industry to correct for correlation between export destinations for the same industry and country.

The first column includes only the two standard Heckscher-Ohlin factors of comparative advantage – the abundance of a country in physical capital interacted with the industry's capital intensity, and the abundance of a country in skilled labor interacted with the industry's intensity in skilled labor. The coefficients on both interactions are estimated to be positive and statistically significant at one percent level, confirming that countries with relatively large endowments in capital and skilled labor have comparative advantage in industries which use these two factors intensively.

Columns (2)-(4) add the two key variables, namely, the interactions of the industry-level intensities in gender-dependent skills and the country-level FLFP. Consistently with Alesina et al. (2013), traditional plough use in agriculture is a good predictor of the FLFP and the instruments are strong in the first stage. We find that the interaction of social skill intensity and FLFP has a positive and statistically significant relationship with exports in column (2), which is consistent with the hypothesis that gender composition is a determining factor of a country's comparative advantage when demand for social skills varies across industries. The coefficient on the interaction of physical skill intensity and FLFP is negative, as expected, and also significant, meaning that countries with high share of female workers export less in industries with a strong reliance on physical abilities of the labor force. The magnitudes of both coefficients decline when the two interaction terms are included together in column (4), reflecting negative correlation between intensities in social and physical skills, but both coefficients remains statistically significant at 5% confidence level. This result suggests that the division of labor across countries, facilitated by international trade, to some extent mitigates the differences in national labor markets, caused by disparities in female labor supply. Countries with relatively high female labor supply tend to employ more female workers by specializing and exporting products that require skills more commonly found in female workers, such as social skills.

To interpret the magnitudes of these coefficients, recall that in constructing the explanatory variables, both the FLFP and the skill intensities are standardized across countries and industries, respectively, before being interacted in equation (7). Suppose a certain industry has a one standard deviation greater intensity in social skills than the rest of the economy. Focusing on the estimation results for the most complete specification in column (4), where the coefficient on the social skill interaction is equal to 0.075, a one standard deviation increase in the FLFP of a country will increase country's export in that industry by

$$exp\left\{\beta_{social\ skills} \times std\left(lnX_{cdi}\right)\right\} = exp\left\{0.075 \times 3.37\right\} = 1.288$$

or by 28.8%, given that the standard deviation of the log of exports is equal to 3.37 (see Table 1). Since $std\left(FLFP_c\right)$ is equal to 3.4 percentage points, a one percentage point increase in the female labor force participation will increase exports by $exp\left\{0.075 \times 3.37 \div 3.4\right\} = 1.077$, or by 7.7%. Similarly, if an industry has a one standard deviation greater intensity in physical skills than the rest of the economy, a one standard deviation (a one percentage point) increase in country's FLFP will lower country-industry exports by 41.0% (14.5%).

The results in Columns (2)-(4) focused on two skills, social and physical, at which men and women are likely to have different productivities. In column (5), we estimate a specification with skill intensity variable I_i^k with the share of female sectoral employment in the US, which does not require taking a stance on gender differences in a particular skill. As long as there are gender differences in skill requirements of different jobs, be it social/physical or any other skill, women will select into industries that require female-specific skills, and it will be reflected in the female share of industry's labor force.

Column (5) in Table 5 again confirms that differences in gender composition across countries affect their relative exports. The positive coefficient on the interaction term implies that an increase in the female labor supply of a country will result in more exports by industries which use female labor intensively. A one percentage point increase in country's FLFP, combined with a one percentage point increase in industry's female employment share, is associated with a 0.95 percentage point increase in exports.

6.2 Evidence from Chinese cities

6.2.1 OLS results

We now turn to the results of our baseline model (7), estimated on Chinese city-level data. Table 6 presents the OLS estimates, structured similarly to country-level findings from Table 5. Across all specifications in Table 6, the coefficients on capital and skilled labor are estimated to be positive and significant, indicating that capital- and skilled labor-abundant cities in China have comparative advantage in industries that use capital and skilled labor intensively.

The first column includes only the two standard Heckscher-Ohlin factors of comparative advantage – the abundance of a city in physical capital interacted with the industry's capital intensity and the abundance of a city in skilled labor interacted with the industry's intensity in skilled labor. The coefficients on both interactions are estimated to be positive and statistically significant at five percent level, confirming that cities with relatively large endowments in physical capital and skilled labor force have comparative advantage in industries which use these two factors intensively.

Columns (2)-(4) include interactions of the female population share of a city with industries' intensities in gender-specific skills. Similarly to the findings from country-level analysis, we observe that the coefficient on social skill interaction is always positive and significant at least at 5% confidence level, and the coefficient on physical skill interaction is negative and also significant. These results indicate that cities where the share of women in total labor supply is low are less likely to export in industries that use social skills intensively and more in industries that are intensive in physical skills. Not only both coefficients of interest are statistically significant and have expected signs, but they are also economically meaningful. If an industry has one standard deviation greater intensity in social skills than the rest of the economy, then a one percentage point increase in the female population share will increase relative exports of that industry by 1.4%. Similarly, if that industry has one standard deviation greater intensity in physical skills, its relative exports will decline by 2.7%. These magnitudes are substantially smaller than 7.7% and 14.7%, implied by the estimates from the cross-country analysis in column (4) of Table 5.

Column (5) of Table 6 provides further evidence on the responsiveness of foreign trade to variation in female labor supply. When industry intensity is measured with the share of female employment, the coefficient β is estimated to be positive and significant at 1% confidence level. This result again emphasizes the theoretical prediction that low female labor supply in a city undermines its comparative advantage in industries that employ a disproportionately large share of female workers. Specifically, a one percentage point increase in the female population share of a city, along with a one percentage point increase in the female employment share of an industry, is associated with a 0.34 percentage points reduction in exports.

6.2.2 IV results

As we discussed earlier, the female population share variable is likely to be endogenous in the presence of internal migration of workers. In this section we explore the instrumental variable strategy, described in Section 4.3.

The IV results are presented in Table 7, with columns (1) and (2) showing the OLS results for comparison. We first instrument the female population share with the provincial OCP violation fine rate in column (3). The instrument is relevant, with the first-stage F-stat exceeding 10 for both variables. It is also valid, in that the fine rates are independent of the subsequent migration flows and are only weakly correlated with the level of economic development of a city. The second stage estimates in column (3) show that not only do the OLS results, hold up, but they are actually stronger when we instrument the female population share. Both coefficients on the social and physical skill interactions preserve expected signs and statistical significance, but they also increase (in absolute values) relative to OLS, roughly quadrupling to 0.074 for social skills and to -0.175 for physical skills. This suggests that the endogeneity concerns due to internal migration are not inflating our results but, if anything, biasing the OLS results toward zero. Column (4) reports the results with the city-level amendments to the OCP as an instrument for

FS_c. The coefficient estimates support conclusions from column (3) that the distribution of both the social and the physical skills across cities matter for foreign trade.

In column (5) we use the two instruments together. The second stage results are consistent with the results in columns (3)-(4). Specifically, both coefficients of interest have expected signs and significant at five percent confidence level. The Hansen-J overidentification test does not reject the hypothesis of exogeneity of instruments, although it is not too far from rejecting the null. To some extent, this result is not particularly surprising, given that our two instruments exploit variation across different administrative geographic areas.The second stage estimates have expected signs and are statistically significant. As an interesting aside, notice that the magnitudes of both coefficient estimates are very similar to those obtained from cross-country data.

Lastly, results with the female employment share as a measure on intensity in female labor, presented in column (6), not only hold up, but are actually strengthened when we instrument for the female population share. It is also remarkable that the estimate of 0.067 is very close to the the coefficient value 0.057 estimated on cross-country data.

Comparing the IV results in columns (3)-(6) to the OLS results allows us to make another important conclusion. We find that the IV estimates of interaction terms involving gender-specific skills are always larger (in absolute value) than the OLS coefficients. If the OLS coefficients were overstated due to positive correlation between female population share and the level of economic development of a city, we would expect to see smaller coefficient estimates in IV specifications because both of our instruments have weaker correlation with the GDP per capita at the city-level than FS_c (see Table 4). Since we find the opposite, the positive correlation between our instrument and the level of economic development of a city is unlikely to be a concern for identification.

Overall, the IV results in Table 7 provide strong support to the predictions of the theory. The IV approach demonstrates that the gender composition of a city has a causal effect on trade. Focusing on the most complete specification in columns (5), the IV estimates imply an economically significant impact of female labor supply on exports. Specifically, a one percentage point increase in female population share of a city and a one standard deviation increase in social skill intensity of an industry will lead to a 3.1% increase in exports. Conversely, a one percentage point increase in city's female labor share combined with a one standard deviation increase in physical skill intensity of an industry will lead to an 9.2% reduction in exports. As such, we find compelling evidence for the hypothesis that the variation in female labor supply has a causal impact on foreign trade.

6.2.3 Extensions

Results with exports aggregated across destinations In column (1) of Table 8 we estimate a reduced-form version of the gravity model (7) with exports aggregated across destination countries.[15] Since the key explanatory variables only vary by city and industry, we regress city c's exports in industry i, $\ln X_{ci}$, against the interaction terms capturing comparative advantage forces, while controlling for city and industry fixed effects. The standard errors are clustered by city. Column (1) shows that the estimates with data aggregated across destinations are less precise than the baseline IV results. Both coefficient estimates are of the expected signs and their magnitudes are very similar to those in column (5) of Table 7, but only the interaction on

[15] All regressions in Table 8 are modifications of the baseline IV specification from Column (5) of Table 7. In Table A2 in the appendix we also demonstrate the robustness of our results to exluding observations with extreme values of the explanatory variables.

physical skills is statistically significant at 10% level. However, one should keep in mind that such specification may generate biased estimates, stemming from the relationship between the Ricardian productivity and the market conditions in destination countries. As Costinot et al. (2011) put it, the comparative advantage models do predict aggregate industry trade flows, but proper tests of these models should be based on exporter-importer-industry data with importer-industry fixed effects in order to control for the factors of comparative advantage in importing countries.

Unregistered births in Census data As we discuss in Section 5.1, the official Census data may undercount the number of girls. Parents may not want to report a second birth in order to avoid OCP violation penalties, and the incentives to hide female births are stronger in a country with a preference for sons. Alternatively, some families may delay registration of a girl until they have a son. Although late registrations are prevalent and may distort official data on sex ratios, most studies suggest that the vast majority of missing girls are truly missing. For example, comparing Census data from different years, Cai and Lavely (2003) find that one-third of all girls missing in one Census wave are registered in the next one by the age of majority, while two-thirds are truly missing. They also find that unreported births are overwhelmingly registered by the age of fifteen. To verify that our results are not influenced by late registrations, we re-estimate the main IV regression using demographic data for residents aged 16-21 in 2000 Census. These are the first five cohorts affected by the OCP and the least likely to suffer from measurement error resulting from unreported births. The estimate on the social skill interaction from this specification, reported in column (2) of Table 8, is very similar to the baseline estimate, while the effect of physical skill, if anything, is even stronger.

Controlling for other skills In our analysis we focus on two sets of skills, social and physical, for which we have substantial evidence on productivity differences by gender. We thus expect that the variation in gender composition across cities will have the strongest effect on relative exports of industries with the largest differences in social and physical skill intensities. In this section we explore the possibility that the sex ratio differences may affect trade through other skills. For that, we construct measures of industry intensities in cognitive, routine, and manual skills in the same way as we constructed intensities in social and physical skills using expression (10).[16] If one believes that none of these skills are male or female-oriented, then trade flows should be less responsive to variation in any of the new intensity measures in the presence of heterogeneity in sex ratios across cities, and the exercise can be viewed as a placebo test. Columns (3)-(6) of Table 8 show the estimates from this test, and the results are broadly consistent with our expectations. None of the new skills are individually or jointly significant. Including all three additional measures of skill into the baseline specification in column (6) does not change the sign and significance of coefficient on social skill interaction, although it increases in magnitude. The point estimate on physical skills, however, becomes substantially smaller and statistically insignificant. The most likely reasons is a high degree of correlation between the measures of intensity in physical and manual skills, which makes it difficult to separately identify the effects of these two skills. At the same time, the coefficients on cognitive and routine skill interactions are never statistically significant, confirming that these two skills are not associated with relative

[16] The PCA measure of cognitive skills is constructed from the O*Net measures of importance of "Management of Financial Resources," "Management of Personnel Resources," "Inductive Reasoning," "Information Ordering," "Oral Comprehension," and "Originality." Manual skill intensity is based on "Manual Dexterity," "Rate Control," "Reaction Time," "Response Orientation," and "Wrist-Finger Speed." Routine intensity is constructed from "Importance of repeating same tasks," "Work schedule", and "Level of competition."

productivity differences by gender.

Controlling for differences in economic development Table 4 reveals that our instruments are correlated with income per capita of a city. Since the industrial structure changes with the level of economic development, it may raise a concern about exogeneity of instruments. To mitigate this concern, we show that our results are robust to conditioning on the city's level of economic development. Specifically, we include in (7) the interactions of industry intensity in social and physical skills with the log of city's GDP per capita. Because the OCP fine rates may also be related to other characteristics of a city, such as factor endowments, we also control for the interactions of social and physical skill intensities with city's endowment in physical and human capital. Similarly, the underlying industry characteristic of interest, the intensity in gender-dependent skills, could be correlated with other industry characteristics, such as intensity in capital and skilled labor. To show that the variation in female labor supply across cities affects exports through gender-dependent skills, we include in model (7) the interactions of female population share of a city with industries' intensity in capital and skilled labor.

We report the result of specification with the above control variables in column (7) of Table 8. There, we only report the estimates on the interactions of GDP per capita with skill intensities in the table, and do not report the estimates on the remaining six interaction coefficients for brevity. We observe that the interactions of GDP per capita with social and physical skill intensities are not statistically significant, while the two main coefficients of interest preserve expected signs and significance. Therefore, there is no evidence that the variation in OCP implementation across cities picks up cross-city heterogeneity in economic development or other omitted interaction variables.

Additional instruments for female labor share In this section we employ three additional instruments for female population share that rely on different identifying assumptions. Given that these instruments exploit different sources of data variation, we view this as a stringency test.

Locally-born female population share. Another instrumental variable that we use for FS_c is the locally-born female population share, defined as the share of women who were born in the city among the total locally-born population. The 2000 CPS, from which we retrieve demographics data, records whether an individual was born in the city of current residence or not. This allows separating locally-born city residents from immigrants. However, the Census does not provide information on the city of birth, which prevents us from constructing complete cross-city migration flows. Therefore, the locally-born female population share can isolate the effect of immigration into a city from the FS_c variable, but it cannot control for the migration of workers out of the city. Hence, this instrumental variable offers only a partial solution to a possible endogeneity of FS_c variable.

Minority share. One of the factors related to the stringency of OCP enforcement is the share of ethnic minority groups in a city. Minority groups were exempted from the OCP until 1989, which is the time period of our study (Skalla, 2004). This implies that in cities with large share of ethnic minorities a substantial fraction of population is not covered by a one-child limit, resulting in less sex selection and closer to normal gender ratios. This motivates our second additional instrument, which is the share of non-Hun locally born residents in total population of a city. One may be concerned that the ethnic composition of a city may be related to the level of economic development and to a pattern of comparative advantage, a concern that need to be kept in mind in interpreting our estimation results with this instrument. The minority share of a city is constructed as a share of non-Han residents in the 12-21 years old age group, using data from 2000 CPC.

OCP violation rate. Our third additional instrument for the female labor share is the rate of the OCP violations at the city level. We define an OCP violating household as the household with at least two children and the youngest one born after 1979, the year when the OCP was officially introduced. In the presence of a strong son preference and high penalties for OCP violations, some families may be willing to violate the OCP and accept the penalty as long as the newborn is a boy, in which case they would be more likely to invest more in gender planning and selection.[17] It follows that a higher OCP violation rate indicates a stronger son preference, resulting in a higher gender determination and selection rates at pregnancy. Therefore, high rates of the OCP violations should have negative relationship to the local female population share.[18] While the OCP violations at birth are independent of subsequent internal migration, it may be affected by local economic conditions, such as income levels and the ability or inability to pay the penalties, and can thus matter for the factors determining comparative advantage. The advantage of this instrument is that it is the only one available to us that captures son preference in the area. However, that instrument may capture not only the variation in preference for sons across cities but also other factors not fully exogenous to the determinants of comparative advantage. This implies that our results using this instrument need to be interpreted with caution.

The results with additional instrumental variables are presented in Table 9. The first-stage results for all instruments are strong, with F-stat well over ten for both endogenous variables. When the female population share is instrumented with the locally-born female share in column (2), both coefficients on skill interactions preserve expected signs and statistical significance. However, this instrumental variable addresses the problem of internal migration only partially by controlling for the inflow of workers into a city but not the outflow.

Column (3) uses the share of ethnic minorities in a city to instrument for the local female share. The coefficient on the physical skill interaction is negative, significant, and substantially larger than the OLS estimate. In contrast, the coefficient estimate on the social skill interaction, while still positive and larger in magnitude than the OLS estimate, is statistically insignificant. The third additional instrumental variable that we use is the city-level share of the households that violate OCP by having a second child after the policy was officially introduced in 1979. The results with this instrument are presented in column (4). As with the baseline IV results, not only both coefficients preserve expected signs and remain significant, but the estimates are also larger in absolute value than the OLS estimates.

In column (5) we use all five instruments together, along with an interaction of the OCP fine and the minority share as an additional instrument. The intuition being this interaction as an additional instrument is that ethnic minorities were often exempted from a strict one-child limit. As such, the same OCP violation fine should have more impact on fertility and sex ratios in cities where the share of ethnic minorities is small. At the first stage, each instrument, except for the fine rate, has a significant impact on the interaction term it was supposed to predict, and the F-stat is greater than ten for both interactions. The second stage results with all instruments

[17] Consistently with this expectation, we find in our data that the share of girls among children born after 1979 is 0.48 for the first child in the family, and it decreases to 0.44 for the second. Using survey data, Junhong (2001) also find evidence of stronger sex selection at birth among second children: 39% of women had ultrasound during the first pregnancy and 55% for the second. The author also found that ten percent of determined female fetuses were aborted.

[18] It is important to note that, technically, not all second children are born in violation of the policy. In some regions families were allowed a second child if the first one is a girl. However, the logic behind the instrument still applies: families would have stronger incentives for gender planning with the second child. With that in mind, we call all cases when a second child is born after 1979 as "OCP violation".

together are reassuringly consistent with the results in Table 6. Specifically, both coefficients of interest have expected signs and significant at five percent confidence level.

We should note that the Hansen-J overidentification test rejects the hypothesis of exogeneity of instruments, and the difference-in-Hansen test reveals that it is the share of OCP violating households instrument that is likely to be invalid. To some extent, this result is not particularly surprising, given that this instrument produces estimates that are notably different from other instruments. It could be that the family's decision to violate the policy captures not only the OCP penalties and family's preference for sons, but also other potentially endogenous factors, such as income level.

Although none of our additional instruments is perfect, the results are consistent with our previous findings. Taken together, these IV approaches provide further evidence that gender composition of the labor force has causal effect on foreign trade.

7 Dynamic model estimation results

In this section, we estimate the baseline model on panel data. For country-level analysis, we collect data on the FLFP, trade flows and factor endowments from 1990 to 2005 at five year intervals. Changes in the city-level female population shares in China were constructed over the time period between 1979, the year the OCP was introduced, and 2006, the final year of our sample. The Chinese customs trade data is available to us only for the 2000-2006 period and the change in exports is constructed over this six-year period. It should be noted that the first five cohorts, affected by the OCP, were already in the labor market in 2000, and our dependent variable may not fully reflect the response of trade flows to labor market shock. As such, one might expect our results to be attenuated.

7.0.1 Country-level estimates

In trying to estimate the dynamic model (9) on cross-country data, we face a challenge that the plough prevalence instrument cannot predict the *change* in the female labor force participation, at least not in short panels such as ours. For that reason, for cross-country analysis we only report results of the pooled regression estimates, presented in columns (1) and (2) of Table 10. The dynamic model (9) we estimate only on the Chinese city-level data in the next subsection. Both columns (1) and (2) of Table 10 include exporter-importer-year and importer-industry-year fixed effects. Therefore, our empirical specification identifies the role of female labor supply on trade entirely from the variation within exporter-importer cells across industries. Comparing these results with Table 5, we find that the coefficient estimates are remarkably similar to the cross-sectional results for the year 2000. This result suggests that our estimates are not confined to a particular year but hold during the time period that spans 25 years.

7.0.2 Results with time-invariant factor intensities

In this section, we focus on estimating the dynamic model (9), described in Section 4.2, and relate changes in gender composition of cities in China over time to changes in exports. Because the change in sex ratios during 1979-2006 time period were driven by introduction of new policies that we can quantify, our OCP stringency instruments are strong predictors of the changes in female labor supply, and perform well in the first stage. This time-difference specification allows us to address additional omitted variable bias concerns. In particular, it differences out all time-invariant importer-industry characteristics, such as persistent determinants of importers' comparative advantage, as well as many exporters' characteristics, including institutional factors.

Following the structure outlined in Section 4.2, we start by assuming that factor intensities are constant over time, so that exports respond only to changes in the gender composition. Columns (3)-(4) of Table 10 report the IV estimates for China using the two instruments from Table 7. We find that changes in the female population share of a city during the first ten years of the OCP had a significant effect on exports through both social and physical skills channels. The coefficient on the social skill interaction is statistically significant and equals to 0.07, which is similar to the estimate of 0.056 based on the cross-sectional data (column 5 of Table 7). Similarly, the coefficient on physical skill interaction is also significant but smaller in absolute value, −0.069. Only the coefficient estimate of the female labor intensity interaction becomes insignificant, while remaining positive. Overall, the results in Table 10 confirm that changes in the gender structure within a city over time have significant implications for comparative advantage.

7.0.3 Results with time-varying factor intensities

Analysis in the previous subsection rests on the assumption that industries' skill intensities are stable over time, so that changes in trade flows react only to changes in the female population share of a city. Here, we check if trade responds to changes in factor intensities as well. Since skill intensities are constructed from skill importance measures, weighted by occupational shares, we allow for both the occupational importance of gender-related skills and the occupation composition of an industry to change over time. In Appendix A2 we provide a theoretical decomposition of the changes in the explanatory variables, $\Delta\left(I_i^k \times FS_c\right)$, into (i) changes in the gender composition of a city, (ii) changes in the importance of social and physical skills within occupations, and (iii) changes in the occupational composition of industries. This allows us to refine the previous analysis of comparative advantage dynamics by studying the impact of structural changes within industries, as well as the demographic changes within cities.

Equation (13) in the Appendix represents the empirical model with the $\Delta\left(I_i^k \times FS_c\right)$ interaction decomposed into three effects described above. In order to construct the first term in equation (13), the change in the occupational composition at the industry level, we collected historical data on sectorial occupation structure from the US Bureau of Labor Statistics. Changes in sectorial occupation structure are constructed for the time period between 1980 and 2006. Data for the second term, the change in the importance of gender-dependent skills by occupation, is obtained from the O*NET. The earliest year for which the O*NET data is available is 1998, and we choose it as the base year for constructing the time difference. Because the general trends in occupational requirements may not be measured accurately in short differences, we also try using the difference between 1998 and 2018 as a robustness exercise.

The IV estimation results for equation (13) are presented in Table 11. Column (1) shows the results when the difference in skill importance measures are constructed over 1998-2006 time period, while results in column (2) are for the 1998-2018 period. As in the previous section, even controlling for changes in skill intensities, city-level changes in the female population share leads to changes in the pattern of exports in a way predicted by the theory. For example, in column (1) only changes in $\Delta\left(I_i^k \times FS_c\right)$ interaction that are caused by changes in gender composition of a city have a significant effect on exports. Perhaps surprisingly, neither changes in occupational composition of industries nor changes in skill importance of occupations have any heterogeneous effect on trade in cities with different gender structure. The data shows no evidence that an increase in social skill intensity or a decrease in physical skill intensity of an industry leads to more exports by cities with higher female population share.

8 Conclusions

This paper demonstrates that the composition of trade across industries responds to exogenously-driven changes in female labor supply. If industries differ in their use of female labor, we would expect a shortage of female labor supply to put female-labor-intensive industries into comparative disadvantage. We confirm this insight using cross-country and Chinese city-level trade data. To establish a causal effect of female labor supply on country's exports, we rely on historical cultural norms towards female employment as an exogenous factor of female labor supply. Our identification strategy for city-level data relies on the spatial variation in female labor share in population across Chinese cities that results from variations in population control measures, imposed by the central government, combined with the traditional preference for sons. Several measures of city-level OCP stringency serve as reasonably exogenous IVs for female population share. Our results indicate that if in 1980-s a city enforced OCP more strictly than the rest of the country, by 2006 its female population share will be lower. As a result, the city will tend to export less in industries that are intensive in female-oriented skills, such as social skills, and more in industries dominated by male-specific skills, such as physical abilities. We show that these results economically sizable and are robust to using different instrumental variable strategies.

Our results speak to several topics on literatures in international trade and labor economics. While many economic implications, associated with a reduction in labor supply and population aging, have been well studied, we show that changes in the gender composition of the labor force also have important implications for trade and labor markets. We demonstrate that an increase in female labor supply alters country's export and production mix towards female-labor intensive products. According to the Heckscher-Ohlin model of trade, that works to increase the relative demand for female labor and decrease the gender wage gap. We also show that the combination of restrictions on fertility, whether economic or administrative, and social preference for sons, observed not only in China but in many developing countries around the world, shapes the pattern of comparative advantage. This suggests that a decline in a relative female labor supply can, to some extent, be balanced by an increase in the relative demand for male-oriented skills, utilized in exporting sectors that take advantage of falling premia for those skills. Thus, the effect of imbalances in sex ratios on labor markets can be offset, at least partially, through trade in products that embed gender-specific skills.

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Figure 1: The geographic distribution of female labor force paticipation and animal plow agriculture.

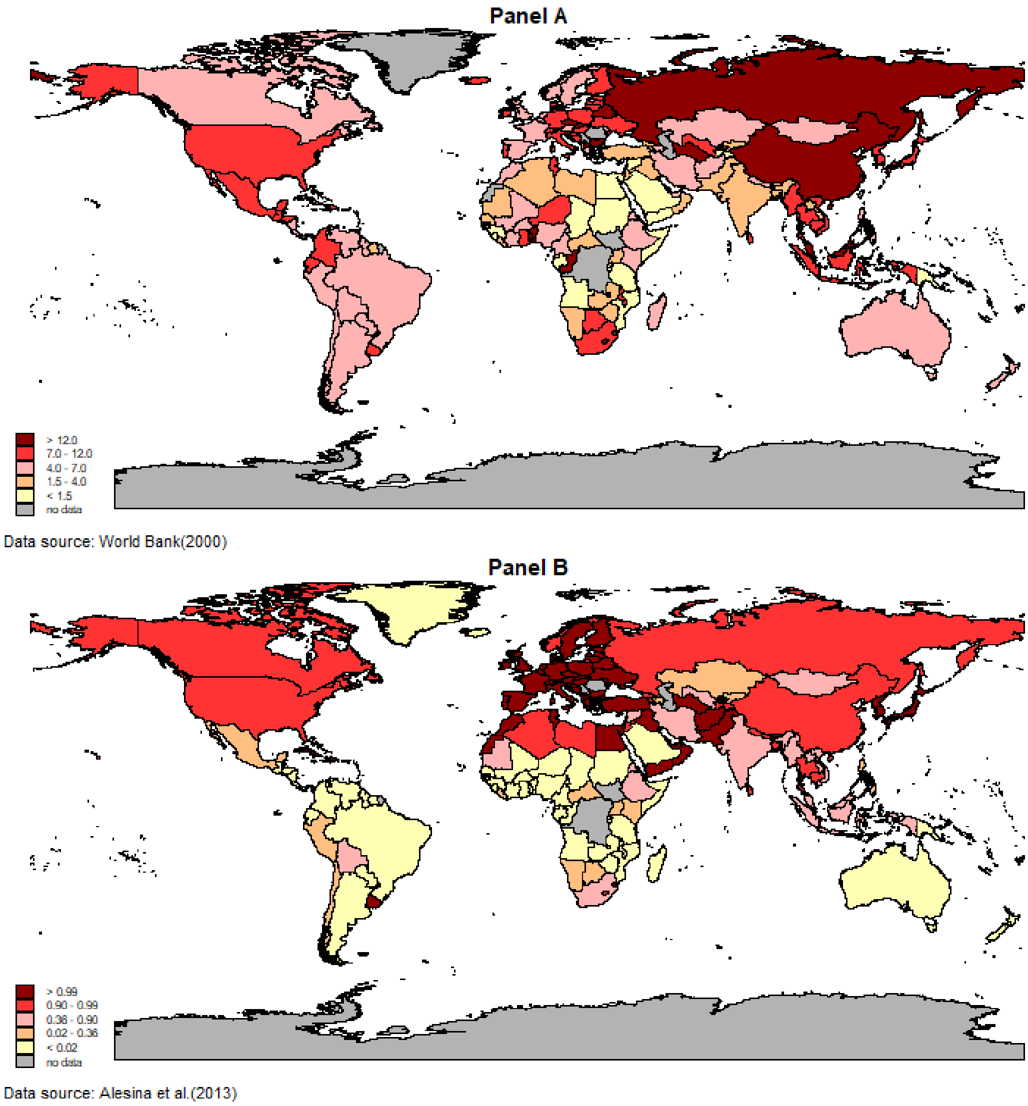

Figure 2: The geographic distribution of locally born Chinese female population share in 2000 across provinces (age group 0-21).

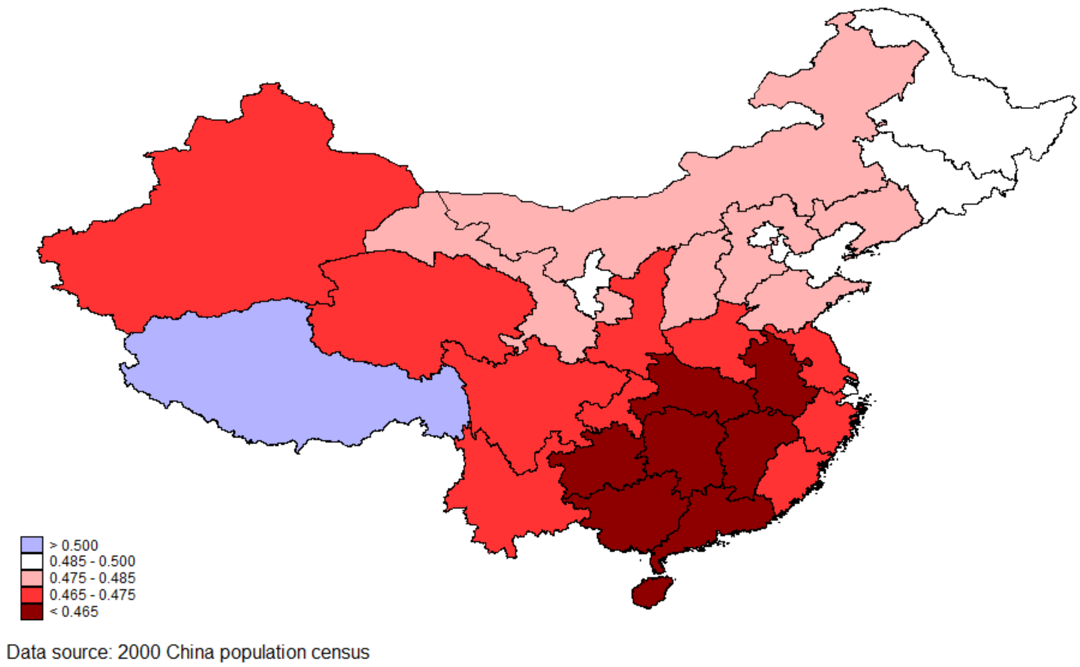

Figure 3: The geographic distribution of Chinese female population share in 2000 across cities (age group 12-21).

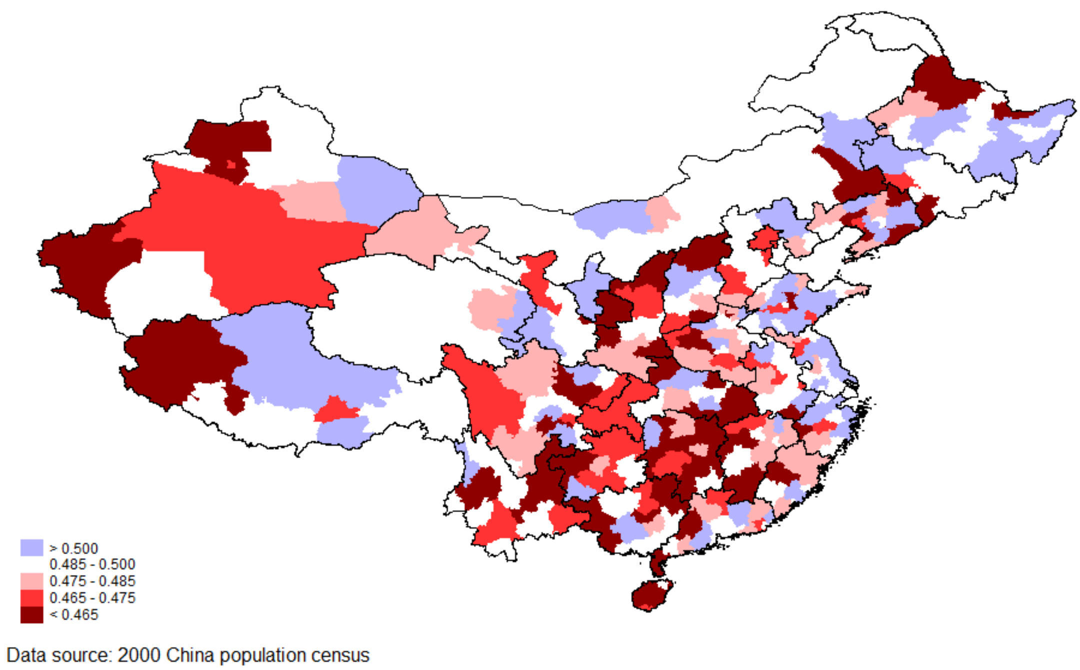

Figure 4: The distribution of the locally born female population share in China across cities for age groups 0-21 and 22-65.

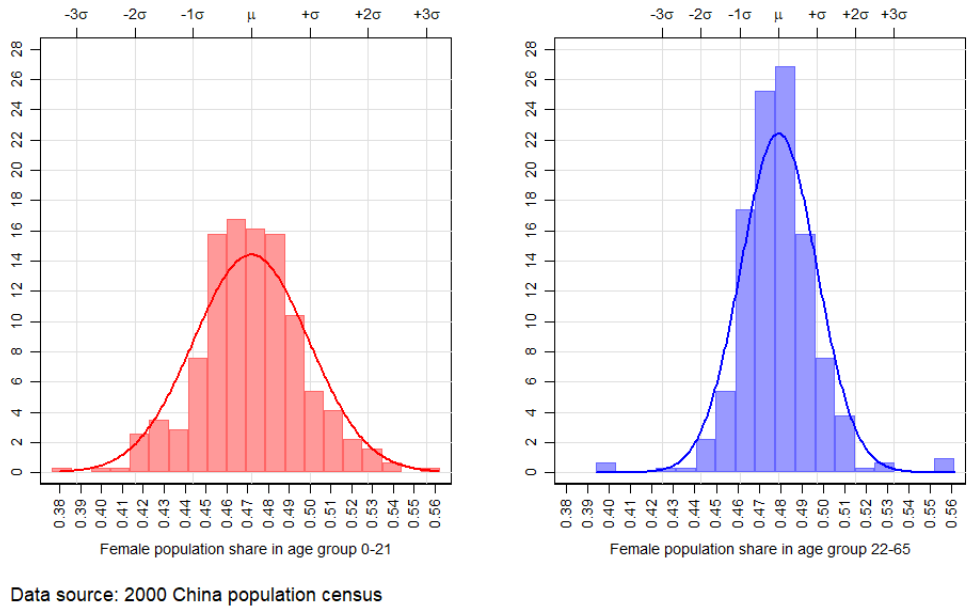

Table 1: Summary statistics.

	mean	std	10^{th}	25^{th}	50^{th}	75^{th}	90^{th}
Panel A: Country-level data							
Female labor supply							
Female labor force participation rate	7.52	3.40	3.54	5.59	7.10	9.13	12.07
Industry-level intensities in gender-specific skills							
Female industry employment share	0.34	0.13	0.19	0.24	0.32	0.43	0.50
Intensity in social skills	84.20	8.11	76.53	79.85	83.70	89.67	94.42
Intensity in physical skills	67.54	15.27	51.65	57.76	68.75	78.90	85.20
Exports							
Log of exports	4.55	3.37	0.21	2.18	4.50	6.91	8.97
Physical capital							
Log of industry capital intensity	2.58	0.79	1.86	2.13	2.54	3.01	3.66
Log of capital endowment	11.08	1.17	9.26	10.42	11.39	11.97	12.17
Skilled labor							
Industry skilled labor intensity	0.30	0.13	0.17	0.21	0.28	0.37	0.47
Skilled labor endowment	2.72	0.62	1.87	2.19	2.79	3.19	3.53
Instrumental variable							
Plough prevalence	0.77	0.39	0	0.82	0.99	1	1
Panel B: Chinese prefecture-level data							
Female labor supply							
Female population share	0.50	0.04	0.46	0.48	0.50	0.52	0.54
Industry-level intensities in gender-specific skills							
Female industry employment share	0.30	0.07	0.21	0.23	0.29	0.34	0.40
Intensity in social skills	84.35	7.61	76.83	79.89	83.78	89.16	93.13
Intensity in physical skills	67.64	13.33	53.48	58.96	68.50	78.78	82.32
Exports							
Log of exports	10.94	2.75	7.48	9.23	10.96	12.76	14.41
Physical capital							
Log of industry capital intensity	4.00	0.66	3.28	3.68	4.02	4.38	4.92
Log of capital endowment	4.39	0.52	3.73	4.04	4.40	4.75	5.12
Skilled labor							
Industry skilled labor intensity	0.13	0.06	0.05	0.08	0.12	0.16	0.20
Skilled labor endowment	0.12	0.06	0.07	0.08	0.10	0.14	0.22
Instrumental variables							
The OCP violation fine	1.76	0.47	1.15	1.49	1.87	2.17	2.71
Number of OCP amendments	5.06	3.91	2	2	4	7	8

Table 2: Manufacturing industries with the highest and the lowest intensities in female labor, social skills and physical abilities.

10 industries with the highest intensity			10 industries with the lowest intensity		
Rank	NAICS4	Industry description	Rank	NAICS4	Industry description
		Female Employment Share			
1	3152	Cut and Sew Apparel Manufacturing	1	3362	Motor Vehicle Body and Trailer Manufacturing
2	3151	Apparel Knitting Mills	2	3273	Cement and Concrete Product Manufacturing
3	3131	Fiber, Yarn, and Thread Mills	3	3312	Steel Product Manufacturing from Purchased Steel
4	3169	Other Leather and Allied Product Manufacturing	4	3315	Foundries
5	3149	Other Textile Product Mills	5	3323	Architectural and Structural Metals Manufacturing
6	3162	Footwear Manufacturing	6	3334	Ventilation, Heating, Air-Conditioning, and Commercial Refrigeration Equipment
7	3132	Fabric Mills	7	3361	Motor Vehicle Manufacturing
8	3344	Semiconductor and Other Electronic Component Manufacturing	8	3324	Boiler, Tank, and Shipping Container Manufacturing
9	3341	Computer and Peripheral Equipment Manufacturing	9	3241	Petroleum and Coal Products Manufacturing
10	3333	Commercial and Service Industry Machinery Manufacturing	10	3274	Lime and Gypsum Product Manufacturing
		Social Skills			
1	3254	Pharmaceutical and Medicine Manufacturing	1	3162	Footwear Manufacturing
2	3345	Navigational, Measuring, Electromedical, and Control Instruments Manufacturing	2	3161	Leather and Hide Tanning and Finishing
3	3342	Communications Equipment Manufacturing	3	3169	Other Leather and Allied Product Manufacturing
4	3344	Semiconductor and Other Electronic Component Manufacturing	4	3151	Apparel Knitting Mills
5	3364	Aerospace Product and Parts Manufacturing	5	3117	Seafood Product Preparation and Packaging
6	3241	Petroleum and Coal Products Manufacturing	6	3116	Animal Slaughtering and Processing
7	3251	Basic Chemical Manufacturing	7	3132	Fabric Mills
8	3341	Computer and Peripheral Equipment Manufacturing	8	3274	Lime and Gypsum Product Manufacturing
9	3332	Industrial Machinery Manufacturing	9	3152	Cut and Sew Apparel Manufacturing
10	3231	Printing and Related Support Activities	10	3212	Veneer, Plywood, and Engineered Wood Product Manufacturing
		Physical Abilities			
1	3131	Fiber, Yarn, and Thread Mills	1	3341	Computer and Peripheral Equipment Manufacturing
2	3273	Cement and Concrete Product Manufacturing	2	3342	Communications Equipment Manufacturing
3	3371	Household and Institutional Furniture and Kitchen Cabinet Manufacturing	3	3346	Manufacturing and Reproducing Magnetic and Optical Media
4	3262	Rubber Product Manufacturing	4	3345	Navigational, Measuring, Electromedical, and Control Instruments Manufacturing
5	3212	Veneer, Plywood, and Engineered Wood Product Manufacturing	5	3344	Semiconductor and Other Electronic Component Manufacturing
6	3315	Foundries	6	3364	Aerospace Product and Parts Manufacturing
7	3219	Other Wood Product Manufacturing	7	3333	Commercial and Service Industry Machinery Manufacturing
8	3116	Animal Slaughtering and Processing	8	3391	Medical Equipment and Supplies Manufacturing
9	3328	Coating, Engraving, Heat Treating, and Allied Activities	9	3169	Other Leather and Allied Product Manufacturing
10	3221	Pulp, Paper, and Paperboard Mills	10	3332	Industrial Machinery Manufacturing

Table 3: Selected occupations with the highest and the lowest importance in social skills and physical abilities.

10 occupations with the highest intensity of gender-dependent skills			10 occupations with the lowest intensity of gender-dependent skills		
Rank	SOC	Occupation description	Rank	SOC	Occupation description
		Social Skills			
1	112	Advertising, Marketing, Promotions, Public Relations, and Sales Managers	1	537	Material Moving Workers
2	111	Top Executives	2	517	Woodworkers
3	411	Supervisors of Sales Workers	3	514	Metal Workers and Plastic Workers
4	113	Operations Specialties Managers	4	516	Textile, Apparel, and Furnishings Workers
5	491	Supervisors of Installation, Maintenance, and Repair Workers	5	513	Food Processing Workers
6	414	Sales Representatives, Wholesale and Manufacturing	6	512	Assemblers and Fabricators
7	413	Sales Representatives, Services	7	372	Building Cleaning and Pest Control Workers
8	131	Business Operations Specialists	8	352	Cooks and Food Preparation Workers
9	511	Supervisors of Production Workers	9	533	Motor Vehicle Operators
10	191	Life Scientists	10	493	Vehicle and Mobile Equipment Mechanics, Installers, and Repairers
		Physical Abilities			
1	372	Building Cleaning and Pest Control Workers	1	112	Advertising, Marketing, Promotions, Public Relations, and Sales Managers
2	493	Vehicle and Mobile Equipment Mechanics, Installers, and Repairers	2	413	Sales Representatives, Services
3	517	Woodworkers	3	172	Engineers
4	537	Material Moving Workers	4	113	Operations Specialties Managers
5	514	Metal Workers and Plastic Workers	5	131	Business Operations Specialists
6	492	Electrical and Electronic Equipment Mechanics, Installers, and Repairers	6	192	Physical Scientists
7	352	Cooks and Food Preparation Workers	7	414	Sales Representatives, Wholesale and Manufacturing
8	516	Textile, Apparel, and Furnishings Workers	8	111	Top Executives
9	513	Food Processing Workers	9	191	Life Scientists
10	533	Motor Vehicle Operators	10	411	Supervisors of Sales Workers

Notes: This table includes occupations with at least 0.5% share of employment in the manufacturing sector.

Table 4: Correlation between female population share and instrumental variables.

	Log GDP per capita	*Female population share*	*The OCP violation fine*	*Number of OCP amendments*
Log GDP per capita	1	-	-	-
Female population share	0.180**	1	-	-
The OCP violation fine	0.132*	0.198***	1	-
Number of OCP amendments	0.125*	0.390***	0.472***	1

Notes: * significant at 10%, ** significant at 5% and *** significant at 1%.

Table 5: IV results with country-level data.

	(1)	(2)	(3)	(4)	(5)
Social Skill Intensity$_i$		0.126***		0.075**	
$\times$*Female Labor Force Participation*$_c$		(0.034)		(0.032)	
Physical Ability Intensity$_i$			-0.178***	-0.158***	
$\times$*Female Labor Force Participation*$_c$			(0.035)	(0.036)	
Female Employee Intensity$_i$					0.057**
$\times$*Female Labor Force Participation*$_c$					(0.027)
Capital Intensity$_i$	0.024***	0.027***	0.035***	0.034***	0.040***
$\times$*Capital*$_c$	(0.004)	(0.005)	(0.005)	(0.005)	(0.005)
Skilled Labor Intensity$_i$	0.072***	0.052***	0.045***	0.037***	0.069***
$\times$*Skilled Labor*$_c$	(0.004)	(0.007)	(0.008)	(0.010)	(0.005)
First Stage F-stat for Female Employee	-	-	-	-	48.8
First Stage F-stat for Social Skills	-	50.1	-	25.5	-
First Stage F-stat for Physical Skills	-	-	50.0	30.8	-
Observations	442,619	433,748	433,748	433,748	318,062

Notes: The dependent variable is the natural logarithm of exports from country c to destination country d in industry i in year 2000. In all specifications the female labor force participation rate of a country is instrumented with an index of the traditional use of plough in that country's agricultural sector. * significant at 10%, ** significant at 5% and *** significant at 1%. Standardized beta coefficients are reported. Robust standard errors in parentheses are clustered by exporter-industry.

Table 6: OLS results with Chinese city-level data.

	(1)	(2)	(3)	(4)	(5)
Social Skill Intensity$_i$		0.036***		0.018**	
$\times [12-21]$ *Female Share*$_c$		(0.010)		(0.007)	
Physical Ability Intensity$_i$			-0.051***	-0.044***	
$\times [12-21]$ *Female Share*$_c$			(0.009)	(0.009)	
CN Industry Female Intensity$_i$					0.037***
$\times [12-21]$ *Female Share*$_c$					(0.008)
Capital Intensity$_i$	0.063***	0.066***	0.054***	0.057***	0.056***
$\times$*Capital*$_c$	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
Skilled Labor Intensity$_i$	0.022***	0.028***	0.031***	0.033***	0.020***
$\times$*Skilled Labor*$_c$	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
R^2	0.434	0.435	0.437	0.437	0.435
Observations	246,038	246,038	246,038	246,038	246,038

Notes: The dependent variable is the natural logarithm of exports from Chinese city c to destination country d in industry i in year 2006. Standardized beta coefficients are reported. Robust standard errors in parentheses are clustered by city-industry. All specifications include city-destination and industry-destination fixed effects. * significant at 10%, ** significant at 5% and *** significant at 1%.

Table 7: IV Results with Chinese city-level data.

	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	IV	IV	IV	IV
Social Skill Intensity$_i$	0.018**		0.074**	0.056***	0.056***	
$\times [12-21]$ *Female Share*$_c$	(0.007)		(0.033)	(0.021)	(0.021)	
Physical Ability Intensity$_i$	-0.044***		-0.175***	-0.141***	-0.141***	
$\times [12-21]$ *Female Share*$_c$	(0.009)		(0.047)	(0.031)	(0.031)	
CN Industry Female Intensity$_i$		0.037***				0.067***
$\times [12-21]$ *Female Share*$_c$		(0.008)				(0.023)
Capital Intensity$_i$	0.057***	0.056***	0.040***	0.043***	0.043***	0.049***
$\times$*Capital*$_c$	(0.009)	(0.009)	(0.013)	(0.012)	(0.012)	(0.010)
Skilled Labor Intensity$_i$	0.033***	0.020***	0.063***	0.055***	0.055***	0.018***
$\times$*Skilled Labor*$_c$	(0.006)	(0.006)	(0.013)	(0.010)	(0.010)	(0.006)
Instruments for Female Share	-	-	The OCP Violation Fine Rate (VFR)	Number of OCP Amendments (NMA)	VFR & NMA	VFR & NMA
First Stage F-stat for CN Female Employee	-	-	-	-	-	27.2
First Stage F-stat for Social Skills	-	-	21.1	19.1	9.7	-
First Stage F-stat for Physical Skills	-	-	14.2	10.5	5.5	-
Hansen J Test P-Value	-	-	-	-	0.424	0.306
R^2	0.437	0.435	-	-	-	-
Observations	246,038	246,038	246,038	242,551	242,551	242,551

Notes: The dependent variable is the natural logarithm of exports from Chinese city c to destination country d in industry i in year 2006. Standardized beta coefficients are reported. Robust standard errors in parentheses are clustered by city-industry. All specifications include city-destination and industry-destination fixed effects. * significant at 10%, ** significant at 5% and *** significant at 1%.

Table 8: Extensions.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$Social\ Skill\ Intensity_i$	0.055		0.133	0.043**	0.058	0.177**	0.071***
$\times [12-21]\ Female\ Share_c$	(0.037)		(0.089)	(0.020)	(0.067)	(0.088)	(0.022)
$Physical\ Ability\ Intensity_i$	-0.180*		-0.129***	-0.069	-0.135***	-0.015	-0.050***
$\times [12-21]\ Female\ Share_c$	(0.101)		(0.036)	(0.075)	(0.047)	(0.077)	(0.018)
$Social\ Skill\ Intensity_i$		0.056*					
$\times [16-21]\ Female\ Share_c$		(0.031)					
$Physical\ Ability\ Intensity_i$		-0.220***					
$\times [16-21]\ Female\ Share_c$		(0.062)					
$CN\ Industry\ Female\ Intensity_i$							
$\times [12-21]\ Female\ Share_c$							
$Cognitive\ Skill\ Intensity_i$			-0.091			-0.151	
$\times [12-21]\ Female\ Share_c$			(0.090)			(0.105)	
$Manual\ Skill\ Intensity_i$				-0.073		-0.114	
$\times [12-21]\ Female\ Share_c$				(0.085)		(0.089)	
$Routine\ Skill\ Intensity_i$					-0.014	0.013	
$\times [12-21]\ Female\ Share_c$					(0.064)	(0.075)	
$Capital\ Intensity_i$	0.024	-0.020	0.013	0.016	0.015	0.013	0.016
$\times Capital_c$	(0.015)	(0.031)	(0.019)	(0.019)	(0.019)	(0.020)	(0.016)
$Skilled\ Labor\ Intensity_i$	0.092***	0.091***	0.075***	0.077***	0.076***	0.075***	0.051***
$\times Skilled\ Labor_c$	(0.014)	(0.013)	(0.009)	(0.009)	(0.009)	(0.009)	(0.011)
$Social\ Skill\ Intensity_i$							0.015
$\times GDP\ Per\ Capita_c$							(0.011)
$Physical\ Ability\ Intensity_i$							-0.009
$\times GDP\ Per\ Capita_c$							(0.013)
Destination Countries	No	Yes	Yes	Yes	Yes	Yes	Yes
First Stage F-stat for Social Skills	1.2	7.4	7.5	6.8	7.6	5.1	71.9
First Stage F-stat for Physical Skills	1.8	5.3	5.4	7.6	7.2	5.5	69.3
First Stage F-stat for US Female Employee	-	-	-	-	-	-	-
First Stage F-stat for Cognitive Skills	-	-	7.4	-	-	5.3	-
First Stage F-stat for Manual Skills	-	-	-	4.6	-	4.2	-
First Stage F-stat for Routine Skills	-	-	-	-	6.6	5.8	-
Hansen J Test P-Value	0.484	0.433	0.262	0.219	0.213	0.192	0.004
Observations	9,429	242,551	242,551	242,551	242,551	242,551	220,319

Notes: The dependent variable in columns (2)-(6) is the natural logarithm of exports from Chinese city c to destination country d in industry i in year 2006. In column (1) exports is aggregated across destinations to city-industry level. Standardized beta coefficients are reported. Robust standard errors in parentheses are clustered by city-industry. Column (1) includes city and industry fixed effects. Columns (2)-(6) include city-destination and industry-destination fixed effects. * significant at 10%, ** significant at 5% and *** significant at 1%. In all specifications, city-level female share is instrumented with the OCP violation fine and the number of city-level OCP amendments.

Table 9: Results with additional instrumental variables.

	(1) OLS	(2) IV	(3) IV	(4) IV	(5) IV
Social Skill Intensity$_i$	0.020***	0.038**	0.070	0.116***	0.054***
$\times [12-21]$ *Female Share*$_c$	(0.007)	(0.019)	(0.077)	(0.031)	(0.017)
Physical Ability Intensity$_i$	-0.040***	-0.055***	-0.160***	-0.091**	-0.107***
$\times [12-21]$ *Female Share*$_c$	(0.008)	(0.021)	(0.055)	(0.036)	(0.020)
Capital Intensity$_i$	0.052***	0.047***	0.009	0.035*	0.028*
$\times$*Capital*$_c$	(0.012)	(0.014)	(0.025)	(0.019)	(0.015)
Skilled Labor Intensity$_i$	0.063***	0.068***	0.084***	0.087***	0.075***
$\times$*Skilled Labor*$_c$	(0.007)	(0.007)	(0.015)	(0.009)	(0.008)
Instruments for Female Share	-	Locally-born Female Share (LFS)	Ethnic Minority Share (EMS)	Share of Household Violating OCP (SHV)	LFS, NMA VFR, EMS VFR× EMS, SHV
First Stage F-stat for Social Skills	-	28.1	18.3	46.0	21.7
First Stage F-stat for Physical Skills	-	19.9	34.5	32.3	18.8
Hansen J Test P-Value	-	-	-	-	0.000
R^2	0.437	-	-	-	-
Observations	246,038	245,926	246,030	246,038	242,439

Notes: The dependent variable is the natural logarithm of exports from Chinese city c to destination country d in industry i in year 2006. Standardized beta coefficients are reported. Robust standard errors in parentheses are clustered by city-industry. All specifications include city-destination and industry-destination fixed effects. * significant at 10%, ** significant at 5% and *** significant at 1%.

Table 10: Estimates of the dynamic model.

	(1) Country IV	(2) Country IV	(3) China IV	(4) China IV
Social Skill Intensity$_i$	0.088***			
$\times$*Female Labor Force Participation*$_{tc}$	(0.019)			
Physical Skill Intensity$_i$	-0.147***			
$\times$*Female Labor Force Participation*$_{tc}$	(0.021)			
Female Employee Intensity$_i$		0.044***		
$\times$*Female Labor Force Participation*$_{tc}$		(0.017)		
Social Skill Intensity$_i$			0.070**	
$\times \triangle$ *Female Share*$_c$			(0.033)	
Physical Ability Intensity$_i$			-0.069**	
$\times \triangle$ *Female Share*$_c$			(0.029)	
CN Industry Female Intensity$_i$				0.025
$\times \triangle$ *Female Share*$_c$				(0.043)
Capital Intensity$_i$	0.034**	0.039***	-0.009	-0.011
$\times$*Capital*$_c$	(0.003)	(0.003)	(0.011)	(0.014)
Skilled Labor Intensity$_i$	0.004***	0.071***	0.014**	0.029***
$\times$*Skilled Labor*$_c$	(0.006)	(0.003)	(0.006)	(0.008)
Instruments for Skills Endowment	Traditional Plough Usage	Traditional Plough Usage	VLF & NMA	VLF & NMA
First Stage F-stat for Social Skill	80.1	-	42.1	-
First Stage F-stat for Physical Ability	97.6	-	41.8	-
First Stage F-stat for Female Labor	-	48.8	-	96.7
Hansen J Test P-Value	-	-	0.211	0.197
R^2	-	-	-	
Sample Period	1990, 1995, 2000, 2005			
Fixed Effects	exporter-importer-year, importer-industry-year			
Observations	1,230,699	902,582	105,501	72,326

Notes: The dependent variable is the time difference of the natural logarithm of exports from Chinese city c to destination country d in industry i between the year 2006 and 2000. The change in female share of a city is calculated between age cohort 18-21 and 12-21. Standardized beta coefficients are reported. Robust standard errors in parentheses are clustered by city-industry. All specifications include city-destination and industry-destination fixed effects. * significant at 10%, ** significant at 5% and *** significant at 1%. The results in columns (2)-(4) are estimated using the OCP violation fine and the number of city-level OCP amendments as instrumental variables for $\triangle$ *Female Share*.

Table 11: Decomposition of the dynamic effect.

	(1)		(2)	
	IV		IV	
Time period of occupation share	1990 - 2006		1980 - 2006	
Time period of skills level	1998 - 2006		1998 - 2018	
	Social Skills	Physical Skills	Social Skills	Physical Skills
Change in industry occupational structure	0.014	-0.097	-0.117	-0.107
	(0.055)	(0.064)	(0.160)	(0.074)
Change in occupational skill importance	0.065	0.093	-0.361	0.278
	(0.049)	(0.100)	(0.519)	(0.425)
Change in city's female share	0.136**	-0.178**	0.074	-0.099*
	(0.056)	(0.086)	(0.054)	(0.060)
$Capital\ Intensity_i \times Capital_c$	0.079		-0.031	
	(0.068)		(0.060)	
$Skilled\ Labor\ Intensity_i \times Skilled\ Labor_c$	0.000		0.019	
	(0.022)		(0.015)	
First Stage F-stat for Skill Structure	7.1	8.1	8.3	10.2
First Stage F-stat for Skill Level	3.0	3.2	4.7	5.1
First Stage F-stat for Skill Stock	23.4	18.5	24.4	33.1
Hansen J Test P-Value	0.074		0.069	
Observations	47,320		47,320	

Notes: The dependent variable is the time difference of the natural logarithm of exports from Chinese city c to destination country d in industry i between the year 2006 and 2000. Standardized beta coefficients are reported. Robust standard errors in parentheses are clustered by city-industry. All specifications include city-destination and industry-destination fixed effects. The time difference of occupation structure and O*NET skills importance measures are indicated in the header of each column. The time difference of the female population share is obtained from the difference between 18-21 and 12-21 age groups in 2000 census. * significant at 10%, ** significant at 5% and *** significant at 1%. All results are estimated using the OCP violation fine and the number of city-level OCP amendments as instrumental variables for $\triangle\ Female\ Share$.

Appendix

8.1 A1. Background on China's one-child policy

China's OCP was officially introduced in 1979 as part of the policy to slow down population growth, and was relaxed in 2016 when the government allowed households to have two children. Figure A1 plots the annual fertility rate in China and the world between 1960 and 2016, and illustrates the evolution of population growth in China before and after the OCP. One can see that in the first half of 1960-s, following the famine of late 1950-s, the fertility rate in China was growing steadily and peaked at over six births per woman in 1965. Between 1965 and 1975, the fertility rate was in decline but remained higher than the world average. To curb population growth and promote human capital investment, in 1970s the Chinese government began to implement population control measures. In 1971, the government launched a family-planning campaign, encouraging later marriages, longer time laps between the first and the second children, and fewer children (two per couple at most). This largely voluntary family planning campaign was quite successful and fertility declined steadily over 1970s. However, it did not reach the target for the population growth rate reduction, and in 1979 the Chinese government moved to directly controlling the number of children per family by formalizing the official OCP (Wang and Zhang, 2018; Zhang, 2017; Liao, 2013). The policy imposed heavy fines on violators, typically 10-20 percent of the household income for a period lasting from 3 to 14 years, while also providing subsidies to single-child families (Ebenstein, 2010). As shown in Figure A1, the average fertility rate decreased from 2.75 in 1979 to 1.49 in 1999 and remained fairly constant since then, staying well below the global average of 2.69 children per woman over the same time period.

While successfully reducing the fertility rate, the OCP had also lead to a significant gender imbalance due to the presence of cultural preference for sons among Chinese parents.[19] During 1960s and 1970s, the fertility rate was high and the infant mortality low, making it likely for an average household to have at least one surviving son without resorting to gender selection. From early 1970s the gender selection begin to occur, albeit on a small scale due to unreliability of existing methods of determining sex in uterus (Ebenstein, 2010). This situation changed in early 1980s when portable ultrasound machines were introduced across the nation to improve the quality of prenatal care, but the same technology also introduced a reliable method of determining the sex in uterus from between 11-13 weeks of gestation (Guo et al., 2018; Piccini et al., 2018). In the presence of a dual need to have a son and to comply with the OCP, the sex determination technology allowed mothers to abort and reconceive with less time, increasing the prevalence of sex-selection behavior among parents. As a result, the share of boys among newborns started to increase: by 2000 almost 120 boys were born for every 100 girls, and there is a clear evidence that sex-selective abortion is the main reason for this imbalance. With approximately five percent of girls that should be born each year being missing, an estimated 30 millions "surplus" men under 21 were present in the population by 2000 (Edlund et al., 2013). Figure A2 illustrates the extent of gender imbalances by plotting the female population share for different age cohorts using 2000 Census data. It shows that in cohorts born prior to 1979 the female share varies around 0.49,[20] but the share began to decline following the introduction of the OCP. Between 1979 and 2000

[19] This preference is even reflected in the OCP policy itself, which, in some provinces, allowed mothers of a daughter to have a second child (Zhang, 2017).

[20] Normally, the naturally higher proportion of boys at birth, around 0.51, is compensated by their higher mortality rate, and one would expect to see higher share of women in older cohorts. However, the female share in China is decreasing through ages. It may speak to the presence of son preference long before the OCP, whereby girls are more likely to be neglected and receive fewer medical treatments during childhood than boys.

it decreased from 0.50 to 0.45, or by 0.23 percentage points per year on average, and there is a strong evidence that the gender-selective abortion is the main cause.[21]

Figures 2 and 3 demonstrate the extent of spatial variation in the sex ratio at birth across provinces and cities, respectively, using data on locally born residents from the 2000 Census data. The imbalances in spatial distribution of female share among residents are clear in the figures. In more rural Northern and Western regions with larger presence of ethnic minorities, the share is close to biologically natural 0.5. In contrast, the highly populous provinces in the center and the south, for which Poston Jr et al. (1997) and Das Gupta et al. (2003) find stronger son preference, have the female share of less than 0.465.

Figure 4 illustrates variation in the female share before and after introduction of the OCP. In the figure, we plot the histograms of the female population share across cities for age groups 0-21, born after the introduction of the policy (left panel), and 22-65, born prior to the policy (right panel), along with the fitted normal distribution densities. By comparing the female share distributions of the two population groups, we see that the OCP affected not only the mean of the female share, which was the main target of the policy, but also the variance. The cross-city coefficient of variation of the female share in post-1979 cohorts is twice as large as in the pre-1979 cohorts.[22] As the previous studies demonstrate, this increased variation is systematically related to spatial variation in son preference and the stringency of the OCP.

Consistently with the above findings, we observe that gender imbalances across provinces are persistent over time. In Figure A3, we split all cities into two categories based on whether the female population share is below or above the sample median for 1989 to 1991 cohorts.[23] The figure plots the average female share by the year of birth for these two groups of cities. One can see that for 1989-91 time period the difference in the female share between the two groups is stark, which follows directly from the way the two sub-samples were constructed. The gap in the female share falls considerably for birth cohorts 1992-2000. However, the difference in the female share between the two groups remain consistently positive and persistent over time, reflecting importance of time-invariant factors of gender imbalances, such as son preference, the variation in fine rates and OCP enforcement, ethnic composition, and the share of parents with urban registration across cities. The persistence of the sex ratio imbalances across cities in the "post-policy" period implies that some cities accumulate excess female labor supply relative to other cities, altering comparative advantage in trade in the presence of gender-dependent skills.

8.2 A2. Robustness tests

For the baseline results, we constructed the skill intensity measures using 6 social skills and 9 physical skills from the O*NET database. In the column (1) of the Table A2, the results are estimated using different measures of industry-level intensities by four social skills that contributed the most variation to the PCA (Coordination, Negotiation, Persuasion, and Social Perceptiveness) and two physical abilities (Dynamic Strength and Explosive Strength). The estimation

[21] For example, using 2000 Chinese census data, Ebenstein (2010) shows that sons among second children are preceded by longer intervals between pregnancies, thus ruling our biological factors as a possible explanation for sex distortions. Also, he shows that the variation in OCP stringency across time and provinces is linked to gender imbalances.

[22] The standard deviation of the cross-city female share distribution increased from 0.018 for people born during 1935-1978 to 0.028 for those born during 1979-2000.

[23] The main reasons that we choose the birth cohorts of 1989-1991 for categorizing cities into two groups is that the three age cohorts lie in the middle of the birth year interval affected by the OCP, and the three age groups provide enough observations to construct female share for all 340 cities in the data. We also try other birth year groups which are at least five years away from 1979 to reduce the initial OCP effect and the results are similar to Figure A3.

results are consistent with the baseline IV results not only in terms of the magnitude and statistical significance of the key coefficients, but also in terms of the strength of the first stage results.

Next, we demonstrate the robustness of our results are not driven by a small number of cities/industries with extreme values of skill intensities or demographic composition. First, we present estimation results from the regressions that exclude seven industries with the highest and seven industries with the lowest intensities in social skills (column 2), thus reducing the sample of industries from 40 to 26. In column (3), we perform the same sensitivity analysis for physical skills, and in column (4) we exclude the top and bottom seven industries in terms of both social and physical skills. The results reveal that the magnitudes of the coefficients of interest are consistent with the benchmark results, although statistical significance declines to 10% for both skill variables.

Lastly, we check the sensitivity of the results to excluding cities with extreme gender ratios. In column (5) we exclude 10 cities with the highest and 10 cities with the lowest female population share from the sample. The magnitudes of both coefficients change notably, with the estimate on social skills nearly doubled relative to benchmark, and the estimate on physical skills declining by a third. Furthermore, both coefficients are estimated with much lower precision, and the one on physical skills is becoming insignificant.

A3. Decomposition of the dynamic effect

In this section, we decompose over-time changes in the main explanatory variables into three parts: the change in female population share of a city, the change in occupational importance of social and physical skills, and the change in occupational composition of an industry. Allowing for two time periods, labelled as t and 0, the time difference of the interaction of the industry's skill intensity and the city's female share can be written as:

$$\sum_j \left(OS_{ij}^t \times SI_j^t\right) \times FS_c^t - \sum_j \left(OS_{ij}^0 \times SI_j^0\right) \times FS_c^0 \tag{11}$$

where OS_{ij} is the share of occupation j in industry i, SI_j is the measure of importance of a gender-specific skill for occupation j, and FS_c is the female population share of city c. To start, we expand (11) to get:

$$\frac{1}{2}\left(\sum_j \left(OS_{ij}^t SI_J^t\right) FS_c^0 - \sum_j \left(OS_{ij}^t SI_j^t\right) FS_c^0 + \sum_j \left(OS_{ij}^0 SI_j^0\right) FS_c^t - \sum_j \left(OS_{ij}^0 SI_j^0\right) FS_c^t\right) + \sum_j \left(OS_{ij}^t SI_j^t\right) FS_c^t - \sum_j \left(OS_{ij}^0 SI_j^0\right) FS_c^0$$

After simplification, we can write the above expression as follows:

$$\frac{FS_c^t + FS_c^0}{2}\left(\sum_j \left(OS_{ij}^t SI_j^t\right) - \sum_j \left(OS_{ij}^0 SI_j^0\right)\right) + \frac{\sum_j \left(OS_{ij}^t SI_j^t\right) + \sum_j \left(OS_{ij}^0 SI_j^0\right)}{2}\left(FS_c^t - FS_c^0\right) \tag{12}$$

In equation (12) the first term shows the portion of the change in the explanatory variable due to the change in OS and LS, and the second term shows the effect of the change in female share of a city. Decomposing the first term further into changes in OS and LS, we arrive at the following expression:

$$\frac{FS_c^t + FS_c^0}{2} \sum_j OS_{ij}^t \left(SI_j^t - SI_j^0\right) + \frac{FS_c^t + FS_c^0}{2} \sum_j LS_{ij}^0 \left(SI_j^t - SI_j^0\right) + \frac{\sum_j \left(OS_{ij}^t SI_j^t\right) + \sum_j \left(OS_{ij}^0 SI_j^0\right)}{2} \left(FS_c^t - FS_c^0\right) \quad (13)$$

Equation (13) separates the full dynamic effect into three effects which come from changes in the importance of skills (the first term), changes in occupation composition of industries (the second term), and changes in gender composition of cities (the third term).

The empirical model corresponding to decomposition equation (13) is

$$\begin{aligned} \triangle\, lnX_{cpi} = \sum_{k \in K} \beta_k^1 \frac{FS_c^t + FS_c^0}{2} \sum_j OS_{ij}^t \left(SI_j^t - SI_j^0\right) + \\ + \beta_k^2 \frac{FS_c^t + FS_c^0}{2} \sum_j LS_{ij}^0 \left(SI_j^t - SI_j^0\right) + \\ + \beta_k^3 \frac{\sum_j \left(OS_{ij}^t SI_j^t\right) + \sum_j \left(OS_{ij}^0 SI_j^0\right)}{2} \left(FS_c^t - FS_c^0\right) + \\ + \sum_{f \in F} \left(\phi_f I_i^f \times FC_c^f\right) + \nu_{cp} + \nu_{pi} + \varepsilon_{cpi} \end{aligned} \quad (14)$$

Figure A1: The average annual fertility rate in China.

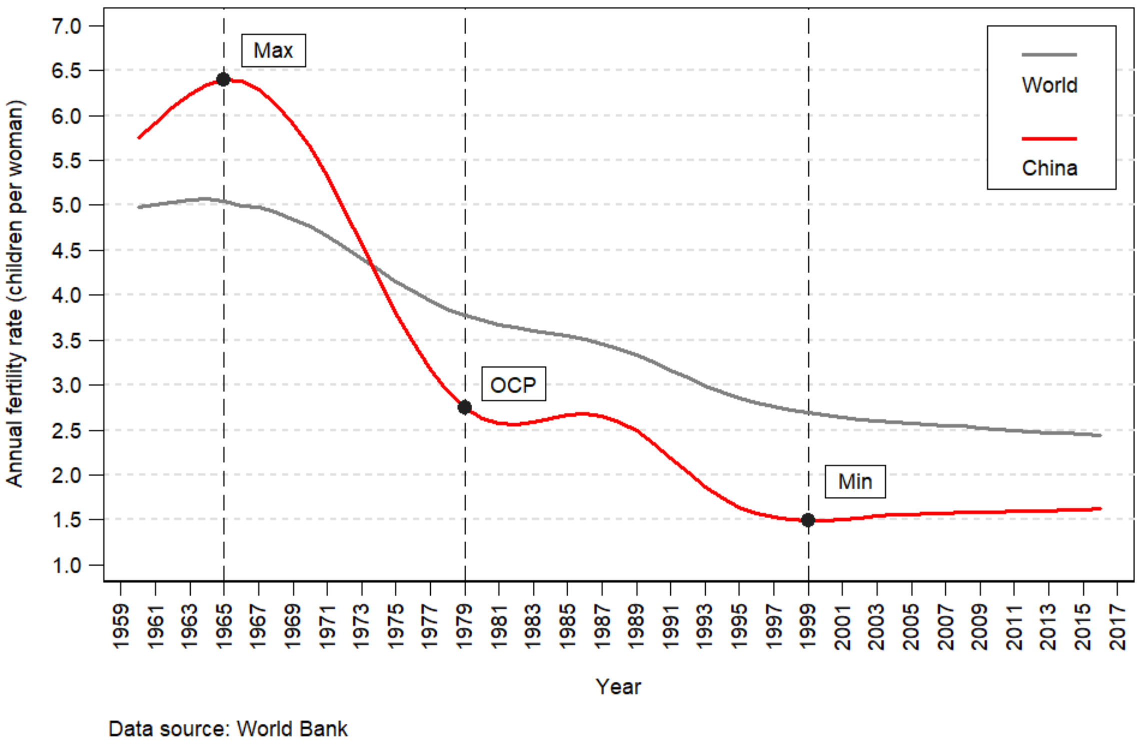

Figure A2: The female population share in China by the year of birth.

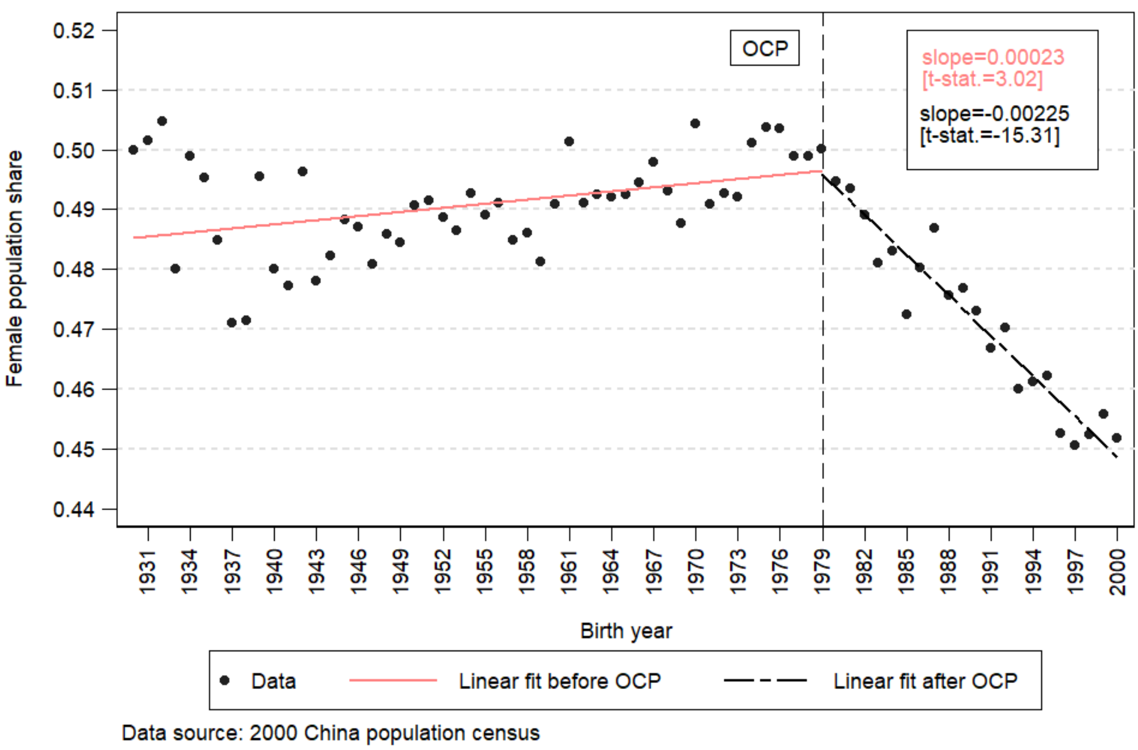

Figure A3: The locally born female population share in China by the year of birth in cities with the share above and below the median in 1989-1991.

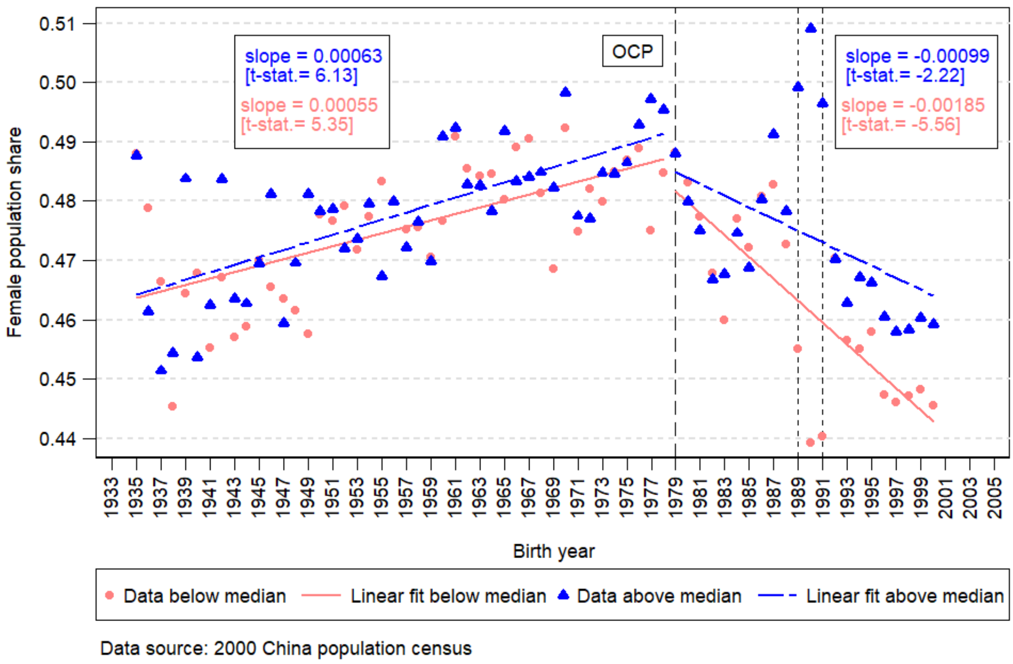

Table A1: Occupational employment shares by industry.

		NAICS Code	Quartile of social skill intensity	Quartile of physical skill intensity	Advertising, Marketing, Promotions, Public Relations, and Sales Managers	Top Executives	Supervisors of Sales Workers	Other Management Occupations	Operations Specialties Managers	Supervisof Installation, Maintenance, and Repair Workers	Sales Representatives, Wholesale and Manufacturing	Sales Representatives, Services	Business Operations Specialists	Supervisors of Production Workers	Other Sales and Related Workers	Life Scientists	Engineers Occupations	Art and Design Workers	Physical Scientists	Plant and system Operators	Assemblers and Fabricators	Motor Vehicle Operators	Food Processing Workers	Textile, Apparel, and Furnishings Workers	Cooks and Food Preparation Workers	Electrical and Electronic Equipment Mechanics, Installers, and Repairers	Other Production Occupations	Metal Workers and Plastic Workers	Material Moving Workers	Other Installation, Maintenance, and Repair Occupations	Woodworkers Occupations	Vehicle and Mobile Equipment Mechanics, Installers, and Repairers	Building Cleaning and Pest Control Workers	Construction Traders Workers	Other
	3-Digit SOC Occupation Code				112	111	411	119	113	491	414	413	131	511	419	191	172	271	192	518	512	533	513	516	352	492	519	514	537	499	517	493	372	472	-
	Quartile of social skills importance				4^{th}	4^{th}	4^{th}	4^{th}	4^{th}	4^{th}	4^{th}	4^{th}	3^{rd}	3^{rd}	3^{rd}	3^{rd}	3^{rd}	3^{rd}	3^{rd}	2^{nd}	1^{st}	1^{st}	1^{st}	1^{st}	1^{st}	2^{nd}	1^{st}	1^{st}	1^{st}	2^{nd}	1^{st}	1^{st}	1^{st}	1^{st}	
	Quartile of physical skills importance				1^{st}	2^{nd}	2^{nd}	2^{nd}	1^{st}	3^{rd}	2^{nd}	1^{st}	1^{st}	3^{rd}	2^{nd}	2^{nd}	1^{st}	2^{nd}	2^{nd}	3^{rd}	3^{rd}	3^{rd}	4^{th}	4^{th}	4^{th}	4^{th}	4^{th}	4^{th}	4^{th}	4^{th}	4^{th}	4^{th}	4^{th}	4^{th}	
1	Grain and Oil seed Milling	3112	1^{st}	3^{rd}		1.7			2.7				3.0	4.5		1.6	1.6				1.2		18.4				25.4		12.0	8.4			1.4		18.1
2	Sugar and Confectionery Product Manufacturing	3113	2^{nd}	3^{rd}		1.8			2.0		1.4		2.0	3.3							1.3		19.6				18.2		14.7	6.3			1.3		28.1
3	Dairy Product Manufacturing	3115	2^{nd}	4^{th}		1.1			2.2		1.7		1.7	3.9								5.8	16.2				26.6		12.0	6.5			1.1		21.2
4	Seafood Product Preparation and Packaging	3117	1^{st}	3^{rd}		1.8			1.3		1.4			3.9							1.6	2.4	39.9		1.3		13.0		11.8	4.4					17.2
5	Other Food Manufacturing	3119	1^{st}	3^{rd}		1.8			2.1		2.0		2.3	3.4		1.1					1.5	3.9	16.2		2.8		22.4		14.5	4.9			1.4		19.7
6	Beverage Manufacturing	3121	3^{rd}	4^{th}		2.2	1.0		1.8		4.4		2.2	2.4	3.5			2.2			1.1	7.4	1.4				24.2		7.4	5.4					33.4
7	Tobacco Manufacturing	3122	2^{nd}	4^{th}		1.6			3.7		2.9		1.8	2.1			1.1				1.1		11.8				35.8		10.3	9.3				4.4	14.1
8	Fabric Mills	3132	1^{st}	4^{th}		1.7			1.8		1.3		1.0	4.3			1.2							49			12.8		4.3	7.7					14.9
9	Other Textile Product Mills	3149	1^{st}	2^{nd}		2.9			1.4		4.5		1.3	4.0				2			3.6			42.5			6.9	3.1	4.4	2.4					21.0
10	Leather and Hide Tanning and Finishing	3161	1^{st}	2^{nd}		2.3			1.8		1.2			5.6								1.6		27.9			26.4		10.0	3.6					19.6
11	Veneer, Plywood, and Engineered Wood Product Manufacturing	3212	1^{st}	4^{th}		1.5			1.5		2.5		1.6	4.1							13.5	3.3					13.4		14.4	5.4	20.2			4.3	14.3
12	Other Wood Product Manufacturing	3219	1^{st}	4^{th}		2.1			1.1		2.7		1.2	4.1							16.5	3.1					8.3	1.5	9.9	2.8	28.2			5.4	13.1
13	Converted Paper Product Manufacturing	3222	2^{nd}	4^{th}		2.0			2.1		3.3		1.9	3.9			1.3	1.1			1.9	1.6					41.1	2.2	11.6	5.1					20.9
14	Printing and Related Support Activities	3231	4^{th}	2^{nd}		3.0			1.5		4.0	1.5	2.0	3.9				4.3				1.1		1.4			9.1		6.1	1.5					60.6
15	Basic Chemical Manufacturing	3251	4^{th}	3^{rd}		2.0		1.4	3.1	1.1	1.8		3.8	4.9			7.1		3.4	11.3		3.8					24.3		3.5	7.9					20.6
16	Resin, Synthetic Rubber, and Artificial Synthetic Fibers and Filaments Manufacturing	3252	3^{rd}	2^{nd}		1.7		1.1	2.8		2.2		4.2	4.4			7.5		2.3	7.0	1.5			5.7			25.6	4.1	2.9	7.4					19.6
17	Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing	3253	3^{rd}	3^{rd}		2.8			3.0	1.1	3.2		2.2	4.7			3.6		1.1	11.8		3.6					24.5		8.5	8.1					21.8
18	Soap, Cleaning Compound, and Toilet Preparation Manufacturing	3256	3^{rd}	2^{nd}	1.4	2.7			3.2		3.2		4.0	4.0			1.8		2.1		4.3						34.7		8.4	5.3					24.9
19	Other Chemical Product and Preparation Manufacturing	3259	3^{rd}	2^{nd}		2.9			3.0		4.3		3.2	4.3			3.7		1.9	2.0	6.5	1.1		1.6			30.8	2.7	4.2	4.6					23.2
20	Rubber Product Manufacturing	3262	1^{st}	4^{th}		1.5			1.9		1.7		1.7	4.0			2.7				7.8						43.9	10.2	3.3	5.3		1.5			14.5
21	Boiler, Tank, and Shipping Container Manufacturing	3324	2^{nd}	4^{th}		2.2			2.3		1.7		2.3	4.6			3.9				10.1	1.0					10.5	32.2	4.8	6.5				3.3	14.6
22	Other Fabricated Metal Product Manufacturing	3329	3^{rd}	3^{rd}		2.0			2.4		2.4		2.8	3.7			4.8				12.9						8.8	29.9	4.0	3.8				2.0	20.5
23	Industrial Machinery Manufacturing	3332	4^{th}	1^{st}	1.2	2.9		2.1	2.9		3.7		4.2	3.2			11.3				13.2						5.4	21.0	2.0	3.6					23.3
24	Commercial and Service Industry Machinery Manufacturing	3333	4^{th}	1^{st}	1.2	2.6		1.7	3.1		3.6		4.6	3.0			7.8				17.8						9.0	13.3	2.9	2.9					26.5
25	Ventilation, Heating, Air-Conditioning, and Commercial Refrigeration Equipment Manufacturing	3334	2^{nd}	2^{nd}		1.8			2.0		2.6		2.5	3.3			4.9				29.9						5.5	18.5	4.2	4.0				2.6	18.2
26	Metalworking Machinery Manufacturing	3335	3^{rd}	3^{rd}		2.9			2.0		2.4		2.0	4.1			5.4				5.7						6.3	47.3	1.3	2.8					17.8
27	Engine, Turbine, and Power Transmission Equipment Manufacturing	3336	3^{rd}	2^{nd}		1.4		2.0	2.5		1.6		42	3.2			10.2				20.0						6.3	23.9	2.2	4.4					18.1
28	Other General Purpose Machinery Manufacturing	3339	3^{rd}	2^{nd}		2.2		1.1	2.6		3.4		3.4	3.5			7.5				18.3						5.3	23.0	2.9	4.1					22.7
29	Computer and Peripheral Equipment Manufacturing	3341	4^{th}	1^{st}	2.8	1.4		2.1	5.5		3.0		8.5	1.2			12.3				8.3						2.4								52.5
30	Communications Equipment Manufacturing	3342	4^{th}	1^{st}	1.8	3.1		2.2	4.3		3.6		5.7	1.8			14.5				14.6					1.1	3.7	4.3	1.3						38.0
31	Semiconductor and Other Electronic Component Manufacturing	3344	4^{th}	1^{st}	1.1	1.9		2.3	3.3		1.7		4.4	2.6			17				17.9						11.6	5.4	1.4	2.1					27.3
32	Navigational, Measuring, and Control Instruments Manufacturing	3345	4^{th}	1^{st}	1.4	2.5		3.2	4.4		2.7		6.3	1.9			15.9				16.2					1.1	4.1	4.9	1.1	1.6					32.7
33	Manufacturing and Reproducing Magnetic and Optical Media	3346	3^{rd}	1^{st}		3.3		2.0	3.2		4.1		4.6	1.5			9.1	1.7			6.9						6.4	6.0	4.9	2.6					43.7
34	Motor Vehicle Body and Trailer Manufacturing	3362	2^{nd}	4^{th}		1.2			1.4		2.1		1.7	3.3			1.8				35.4						8.6	19.6	4.5	2.6		1.6		2.3	13.9
35	Motor Vehicle Parts Manufacturing	3363	2^{nd}	3^{rd}		1.2			2.2				2.4	3.9			5.9				29.0						8.2	22.1	4.6	4.7				1.0	14.8
36	Aerospace Product and Parts Manufacturing	3364	4^{th}	1^{st}		1.1		2.0	2.8				9.1	2.1			17.2				12.7					1.4	6.7	11.3	1.0	2.0		4.1			26.5
37	Ship and Boat Building	3366	2^{nd}	3^{rd}		1.1		1.0	1.7				3.2	4.7			5.9				13.9						7.1	18.8	2.8	4.4		1.1		14.1	20.2
38	Other Transportation Equipment Manufacturing	3369	1^{st}	2^{nd}		1.9			2.3		2.5		3.0	3.9			4.9				33.6						6.5	13.3	7.3	2.8					18.0
39	Medical Equipment and Supplies Manufacturing	3391	4^{th}	1^{st}	1.1	2.1			2.6		2.4		3.8	3.0			6.1				13.3	1.1		1.2			23.8	10.2	2.6	1.9					23.2
40	Other Miscellaneous Manufacturing	3399	2^{nd}	1^{st}		3.0		1.6	1.9		4.2		2.5	3.9			2.1	3.9			18.5			1.4			14.1	11.5	4.0	3.3	1.4			1.1	23.2

Notes: Occupational shares of less than 1% of industrial employment are not reported in the table.

Table A2: Robustness tests.

	(1)	(2)	(3)	(4)
Social Skill Intensity$_i$	0.064***	0.065*	0.047	0.140*
$\times [12-21]$ *Female Share*$_c$	(0.022)	(0.036)	(0.053)	(0.074)
Physical Ability Intensity$_i$	-0.133***	-0.107***	-0.250***	-0.173*
$\times [12-21]$ *Female Share*$_c$	(0.031)	(0.035)	(0.091)	(0.102)
Capital Intensity$_i$	0.030*	0.021	0.021	0.058**
$\times$*Capital*$_c$	(0.017)	(0.018)	(0.018)	(0.025)
Skilled Labor Intensity$_i$	0.075***	0.069***	0.034***	0.047***
$\times$*Skilled Labor*$_c$	(0.009)	(0.010)	(0.011)	(0.017)
Sample	benchmark	64/74 NAICS4 (social skills)	64/74 NAICS4 (physical skills)	57/74 NAICS4 (5 soc-5 phy)
6 or 4 social skills for PCA	4	6	6	6
9 or 2 physical abilities for PCA	2	9	9	9
First Stage F-stat for Social Skills	9.8	10.9	8.4	9.3
First Stage F-stat for Physical Skills	7.8	4.6	10.8	9.1
Hansen J Test P-Value	0.178	0.016	0.353	0.081
Observations	242,551	213,952	213,952	195,619

Notes: The dependent variable is the natural logarithm of exports from Chinese city c to destination country d in industry i in year 2006. Standardized beta coefficients are reported. Robust standard errors in parentheses are clustered by city-industry. All specifications include city-destination and industry-destination fixed effects. * significant at 10%, ** significant at 5% and *** significant at 1%. In columns (2) and (3), industries with 5 highest and lowest intensities in social and physical skills, respectively, are excludes from the sample. In column (4), 17 industries with 5 highest and lowest intensities in social and physical skill are excluded from the sample. All results are estimated by using the OCP violation fine and the number of city-level amendments as instrumental variables.

Table A3: Baseline OLS results with possible more interaction controls.

	(1)	(2)	(3)	(4)
$Social\ Skill\ Intensity_i$	0.020***	0.050***		0.038***
$\times[12-21]\ Female\ Share_c$	(0.007)	(0.014)		(0.012)
$Physical\ Ability\ Intensity_i$	-0.040***		-0.037***	-0.030***
$\times[12-21]\ Female\ Share_c$	(0.008)		(0.010)	(0.010)
$Capital\ Intensity_i$	0.052***	0.054***	0.033***	0.040***
$\times Capital_c$	(0.012)	(0.013)	(0.013)	(0.014)
$Skilled\ Labor\ Intensity_i$	0.063***	0.053***	0.060***	0.053***
$\times Skilled\ Labor_c$	(0.007)	(0.010)	(0.007)	(0.010)
$Capital\ Intensity_i$		-0.025*	-0.005	-0.007
$\times[12-21]\ Female\ Share_c$		(0.013)	(0.013)	(0.013)
$Skilled\ Labor\ Intensity_i$		-0.029**	0.002	-0.028***
$\times[12-21]\ Female\ Share_c$		(0.012)	(0.008)	(0.011)
$Social\ Skill\ Intensity_i$		-0.032***		-0.019*
$\times Capital_c$		(0.009)		(0.011)
$Social\ Skill\ Intensity_i$		0.018		0.014
$\times Skilled\ Labor_c$		(0.012)		(0.012)
$Physical\ Ability\ Intensity_i$			0.040***	0.030**
$\times Capital_c$			(0.011)	(0.013)
$Physical\ Ability\ Intensity_i$			-0.016*	-0.013
$\times Skilled\ Labor_c$			(0.009)	(0.009)
R^2	0.437	0.437	0.438	0.438
Observations	246,038	246,038	246,038	246,038

Notes: The dependent variable is the natural logarithm of exports from Chinese city c to destination country d in industry i in year 2006. Standardized beta coefficients are reported. Robust standard errors in parentheses are clustered by city-industry. All specifications include city-destination and industry-destination fixed effects. * significant at 10%, ** significant at 5% and *** significant at 1%.